Conceptualisation of an Australasia Open Biomedical Repository from a Knowledge Management System Perspective

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Lisa Kruesi

Lisa Kruesi

30 June 2021

Abstract

Open research repositories throughout the world have become trusted platforms for storing and accessing scholarly research outputs. The ultimate aim of biomedical repositories is to help make the route from basic research results to healthcare solutions as effective as possible (McEntyre & Lipman, 2001). In 2000, the PubMed Central (PMC) was commenced as an open disciplinary repository of full-text biomedical research literature, making the results of the National Institutes of Health's research freely and permanently accessible (Roberts, 2001). The PubMed aggregator database linked to the PMC repository makes research evidence in the life sciences accessible worldwide, with millions of people undertaking billions of searches on the site annually (US National Library of Medicine, 2021). In late 2000, in Europe and Canada, PMC mirror sites of the US PMC were established and known as PMC International (US National Library of Medicine, National Institutes of Health, 2018). However, in the Australasian region there has not been a concerted effort to address the problems of fragmentation, accessibility, discoverability, interoperability, reusability and permanency of biomedical research outputs. This research fills a unique gap by assessing the opportunity for a distributed, networked Australasia Open Biomedical Repository (OBR) and developing a knowledge management system (KMS) conceptual framework as a mechanism for biomedical knowledge management (KM).

Within a constructivist paradigm, action research was the methodology adopted. Three research cycles took place. The purpose of Cycle One was to undertake a systematic analysis of the potential interest in a biomedical repository for managing openly accessible research outputs for the Australasian region. Cycle One had a qualitative approach with semi-structured interviews and a

focus group engaging forty-four stakeholders located throughout Australia and New Zealand. Themes identified from the interview transcripts were coded as Strengths or Opportunities towards the establishment of an Australasia PMC or Weaknesses and Threats against the establishment of a potential Australasia PMC. (Kruesi, Burstein & Tanner, 2019).

Around this time, with the Australian library sector devising a national open access strategy at a time when the wider world was dealing with the COVID-19 pandemic, the natural course for Cycle Two was to devise a future approach. Based on this, the purpose for Cycle Two was to assess the opportunity for a distributed, networked OBR using a KMS conceptual framework. The framework's genesis was from an Australian KM standard (Standards Australia, 2005) and was further developed from a literature review and the analysis of interviews and a focus group. The Evidence-Based Healthcare pyramid was an additional model to convey the role of biomedical repositories (Kruesi, Tanner & Burstein, 2019; Kruesi, Tanner & Burstein, 2018). KM processes of discovery, creation, representation, classification, storage, retrieval, dissemination, transfer and translation were aligned with the people, process, technology and content to form the basis of the framework. These concepts formed the basis of the KMS framework for an OBR (Kruesi, Burstein & Tanner, 2020). The purpose of Cycle Three was to investigate any gaps in the design of the framework and to determine if the framework could be used to evaluate and analyse information systems. The framework was applied to critique four diverse systems, including Europe PMC, Epistemonikos, Trove and ResearchGate. A workshop concluded Cycle Three to obtain feedback from twenty higher degree participants on the KMS framework's adoption as an evaluation tool for open systems.

In Cycle One, a SWOT analysis identified significant interest in an investigation for an Australasia OBR (Kruesi, Burstein & Tanner, 2019). In Cycle Two, the KMS framework was identified as a means to achieve a coordinated approach and break down the silos that have formed over many decades and cement vital connections required to achieve a productive KM cycle for an OBR. It was found that identifying the relationships and linkages between elements in the framework enables removal of redundant historical organisational boundaries can occur. Within the collaborative, distributed open science network, the repository is an integral cog, although its effectiveness depends on achieving a fine balance as part of the discovery, creation, representation, classification, storage, retrieval, dissemination, transfer and translation processes that underpin biomedical knowledge. This network needs to be aligned to achieve quality and reproducibility throughout the complex system as the means to advance open science. The research will assist the future development of disciplinary or regional open science infrastructure through its systematic analysis, that aims to optimise existing services and resources present in the system to achieve a sustainable approach. The final, Third Cycle found that the KMS framework can be applied to analyse and evaluate a range of designs for repositories and platforms. As a tool, the workshop participants agreed that the framework was suitable for critically evaluating systems. The KMS framework was found to be a useful means to identify and compare the elements within processes, some of which are exemplary and others that can detract from the overall suitability of a system that underpins the advancement of open scholarship.

Keywords: open scholarship, open access, disciplinary repositories, knowledge management, knowledge management systems, librarianship, critical appraisal

Publications during enrolment

Kruesi, L. (2021). *A Knowledge Management System framework to critique open science platforms and repositories.* Paper presented at the MLA '21: Transforming Our Diversifying Communities Annual Meeting, Virtual. Retrieved from https://www.mlanet.org/mla21

Kruesi, L. (2021). Future directions in digital information; predictions, practice, participation (Book review). Journal of the Australian Library and Information Association, 70(2), 225-226. https://doi.org/10.1080/24750158.2021.1920103

Kruesi, L., Burstein, F., & Tanner, K. (2020). A knowledge management system framework for an open biomedical repository: communities, collaboration and corroboration. *Journal of Knowledge Management, 24(10), 2553-2572.* doi.org/10.1108/JKM-05-2020-0370

Author accepted open access version: https://doi.org/10.26180/5f7a5c30dd71c

Kruesi, L. M., Burstein, F. V., & Tanner, K. J. (2019). With open science gaining traction, do we need an Australasia PubMed Central (PMC)? A qualitative investigation. *PLOS ONE, 14*(2), e0212843. doi.org/10.1371/journal.pone.0212843

Kruesi, L. M., Tanner, K., & Burstein, F. (2019). Advancing scholarly publishing through open access biomedical repositories: A knowledge management perspective. *IFLA Journal, 45*(3), 233-245. https://www.ifla.org/files/assets/hq/publications/ifla-journal/ifla-journal-45-3_2019.pdf

Kruesi, L. M. (2018). PubMed Central International (PMCI): Is it time for an Australasia member? *Adapting, transforming, leading, Medical Library Association 118th Annual Meeting & Exhibition.* Atlanta, GA, USA. https://bit.ly/3gXQMmz

Kruesi, L. M. (2018). *To be or not to be? The prospects for an Australasia PMC*. Paper presented at the Health Libraries Australia Professional Development Day: Keynote presentation, Royal North Shore Hospital, Sydney.
https://www.alia.org.au/sites/default/files/documents/HLA_Kruesi_Keynote_16.9_3.pdf

Kruesi, L. M., Burstein, F. V., Tanner, K. J., & Todd, H. (2018). Ensuring value of Australasia research from improving knowledge management processes [poster]. *National Health and Medical Research Council, The Reward Alliance. Seventh Annual NHMRC Symposium on Research Translation: Ensuring Value in Research, held 27-28 November*. https://www.nhmrc.gov.au/event/2018-nhmrc-symposium-research-translation

Kruesi, L. M., Tanner, K. J., & Burstein, F. V. (2018). *Knowledge Management Theory and the Evidence-Based Healthcare Model to Guide the Design for an Australasia Open Biomedical Repository*. Paper presented at the IFLA WLIC 2018, Transform Libraries, Transform Societies, 84th IFLA General Conference and Assembly Kuala Lumpur, Malaysia
http://library.ifla.org/id/eprint/2184

Kruesi, L. M., & Macdonald, H. (2017). *Do we need an Australasia PMC?* Paper presented at the Open Repositories Conference, Brisbane.
https://web.archive.org/web/20171119044524/https://or2017.net/

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Abbreviations

ALIA	Australian Library and Information Association
AOASG	Australasian Open Access Strategy Group (*This group became Open Access Australasia in 2021)*
APC	Article Processing Charge
API	Application Programming Interface
CAUL	Council of Australian University Librarians
COAR	Confederation of Open Access Repositories
COREQ	Consolidated Criteria for Reporting Qualitative Research
DOAR	Directory of Open Access Journals
DTD	Document Type Definition
FAIR	Findable, Accessible, Interoperable, Reusable
FHIR	Fast Healthcare Interoperability Resources

IFLA	International Federation of Library Associations and Institutions
KM	Knowledge Management
KMS	Knowledge Management System
NHMRC	National Health and Medical Research Council (Australia)
NLA	National Library of Australia
OA	Open Access
OAI-PMH	Open Archives Initiative Protocol for Metadata Harvesting
OBR	Open Biomedical Repository
PMC	PubMed Central
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
VoR	Version of Record
XML	Extensible-Markup Language

Glossary

Analytical resources:	Web-based analytical resources are used to benchmark institutional research performance and impact. These resources comprise commercial analytical databases such as InCites, which takes data from the Web of Science, and SciVal, which uses data from Scopus (Hicks, Wouters, Waltman, De Rijcke, & Rafols, 2015). In addition, software is available to analyse researcher citation profiles using Google Scholar, known as Publish or Perish (Hicks, Wouters, Waltman, De Rijcke et al., 2015). ImpactStory is an open source, web based analytical resource that provides altmetrics to assist researchers identify the impacts of their research outputs, including journal articles, blog posts, datasets, and software (Priem & Piwowar, 2012).
Australasia PMC	In the thesis Australasia PMC is also referred to as an Australasia Open Biomedical Repository (OBR). To officially use the name 'PMC' requires an agreement with the US National Library of Medicine.
Closed article status	Published version of an article that is paywalled.
Diamond journals	Journals that publish without charging authors and readers, in contrast to APC Gold OA or subscription journals.
e-Research	The use of information technology to undertake current and new forms of research.

Evidence based healthcare (EBHC):	From the early 1990s, researchers at McMaster University, in Ontario, Canada, introduced the phrase 'evidence-based medicine,' and would later be known as evidence-based healthcare (EBHC). It involves combining clinician knowledge with the best available clinical evidence from systematic research to achieve the best possible patient care (Salisbury, Glasziou & Del Mar, 2007).
Explicit knowledge:	Explicit knowledge is knowledge communicated using words and numbers, and shared in the form of data, manuals, patents, drawings and computer programs (Nonaka, 1994).
Gold open access	Researchers publish in open access journals which usually involves a fee, though not always, for providing freely available immediate access to the final version of the article.
Governance	Governance is represented by controls and mechanisms of operations that include compliance, administration and ethics (Governance Institute of Australia, 2021).
Green open access	Researchers submit to a journal and then self-archive their author manuscript in a repository such as PMC or an institutional repository, such as Monash University's myResearcher (Pure) repository or The University of Queensland's eSpace. A website named SHERPA/ROMEO provides details on publisher embargo restrictions and whether a self-archived output in a repository may be made open access.
Hybrid open access	Hybrid open access occurs when a journal requires a subscription and also provides gold open access to an article if the author pays a fee.

Knowledge Management (KM):	KM is defined as getting the right knowledge to the right user, and using this knowledge to improve organizational and/or individual performance (Jennex, Smolnik & Croasdell, 2009). KM is doing what is needed to get the most out of knowledge resources (Becerra-Fernandez & Sabherwal, 2015).
Knowledge Management System (KMS)	KMS is a combination of KM practices, such as a set of methods to support learning and organizational processes of KM development, and KM tools, such as IT-based systems supporting the practices (Centobelli, Cerchione & Esposito, 2019).
Open Access Australasia	Previously known as the Australasian Open Access Strategy Group
Open science	Is the practice of making everything in the discovery process fully and openly available, creating transparency, and driving discovery by allowing others to build on existing work (Watson, 2015). 'May take on different shades according to according to geographic different perspectives across nations and regions or it can differ according to the stakeholders and actors involved and according to different perspectives given by science users' (Sarcina, 2019).
Platform	A platform is a group of technologies that are used as a base upon which other applications, processes or technologies are developed (Techopedia, 2021).
PMC International	Operated by the NLM, PMC International is a framework to manage the PMC corpus of knowledge in other reliable international archives that commit to the goals and adhere to the same principles of PMC (US National Library of Medicine, National Institutes of Health, 2018).

PubMed Central (PMC) also referred to as PMC & US PMC	PMC is a free full-text archive of biomedical and life sciences journal literature from the U.S. National Institutes of Health's National Library of Medicine (NIH/NLM). PMC is a digital journal collection that helps the NLM meet their legislated role to collect and preserve the biomedical literature (US National Library of Medicine, 2020b).
Repository	A digital repository is a set of systems and services that ingest, store, manage, display, retrieve and allow reuse of digital objects (Pinfield et al., 2014). Throughout the world, institutional, aggregating and disciplinary repositories co-exist (University of Nottingham (UK), 2005-).
Reproducibility	Reproducibility refers to occurrences when the original researcher's data and computer codes are used to regenerate the research results (National Academies of Sciences, 2019) and is a subset of quality.
Research	The Australian Code for the Responsible Conduct of Research states that the meaning of 'research' is an original investigation undertaken to gain knowledge, understanding and insight (National Health and Medical Research Council (Australia) Australian Research Council & Universities Australia, 2007). The Code refers to the research definition taken from the United Kingdom Research Assessment exercise for universities, to illustrate what research can cover: '…work of direct relevance to the needs of commerce, industry, and to the public and voluntary sectors; scholarship; the invention and generation of ideas, images, performances, artefacts including design, where these lead to new or substantially improved insights; and the use of existing knowledge in experimental development to produce new or substantially improved materials, devices, products and processes, including design and construction.' (National Health and Medical Research Council (Australia) Australian Research Council & Universities Australia, 2007).

Research output	Can include digital full text or abstracts of scientific refereed journal articles, refereed conference proceedings, chapters in research books and authored research books (Australian Research Council, 2017). Research output in aggregator databases, such as PubMed and repositories, such as PMC, increasingly has metadata linking the research output to the underpinning research data (Aoki-Kinoshita et al., 2015).
Research quality	The six *quality* principles, as identified by the NHMRC include respect, rigour, transparency, accountability, innovation and efficiency (National Health and Medical Research Council (Australia), 2019a).
Resources	In web architecture entities (known as "resources") are accessible and identified unambiguously by URLs (Confederation of Open Access Repositories, n.d.)
System	A system is a collection of processes, elements and/or components that are organized for a common purpose.
Tacit knowledge	Is insight, intuitions, hunches and is knowledge that is difficult to express and formalize (Nonaka, 1994).
Transformative agreements	Agreements that shift the system from a journal or journal package subscription model to an open access, pay-for-publication model.

Chapter One: Why an Open Biomedical Repository? The problem

'Without libraries what have we? We have no past and no future.' Ray Bradbury

Prelude: The Librarian and the Library at my Primary School

In the 1970s I was a student at Tottenham Primary School, which was a co-educational Victorian State School, number 4707. The School had a multi-cultural population of approximately 200 students. Following those years, spent with my good friend, Lauren and her mother our School Librarian, Mrs Margaret Woods, I became interested in the role of a librarian. Lauren was a high performing student, achieving Dux of the school and I sat next to her throughout most of the seven years of my elementary education. Lauren had the ability to get approval from our teachers, for her and I to be sent to the School's library to undertake extra duties at various times. It was those times spent returning books to shelves, doing odd jobs and attending story time that I felt so inspired being surrounded by knowledge that was available in the library. A photo of Lisa and Lauren during the 1970s is in Figure 1.1.

The primary school was near Stredna Street where I lived. Our kind and generous parents worked in a carpet factory at the end of the street. My father was a loom tuner and my mother a weaver of the carpets. This was my very happy world for myself and my sibling, Craig Belkin, throughout the first decade of our lives.

Who would have known that my very humble beginning in life, was the start of an extraordinary journey working in some of Australia's most outstanding biomedical academic and research libraries? I have witnessed some incredible developments in biomedical knowledge creation and management over the three decades of my career. Over this period biomedical library print collections were replaced by expansive digital repositories and systems made accessible from any place at any time using the Internet. The entire way biomedical researchers interact and access research output over this period has been transformed.

Figure 1.1 During the 1970s, friendship and inspiration for a future librarian role.

In the photo, Lisa (on the left) and Lauren (on the right).

1.1 Introduction and chapter outline

'The average time for translating biomedical and health sciences research into benefits for society can take 17 years.' (Morris, Wooding & Grant, 2011)

This thesis provides research on the conceptualisation of an open biomedical repository (OBR) for the Australasian region from a Knowledge Management System (KMS) perspective.

Open repositories worldwide have emerged as trusted platforms for accessing and managing scholarly research. In late 2000, institutional repositories were set up in Australian universities to provide access to research collections (Steele, 2013). In line with the US and Europe, in pursuing open publishing, the requirement of key Australian funding bodies for authors to publish the results of their research openly put the pressure on universities to manage this process using institutional repositories. Another significant repository development occurred in 2000, when the US PubMed Central (PMC) commenced as a disciplinary repository of full-text biomedical research, making the results of the National Institutes of Health's (NIH) research openly and permanently available (Roberts, 2001). A decade later international biomedical PMC nodes in Europe and Canada were established. PubMed linked to PMC makes research evidence in the life sciences accessible throughout the world (Williamson & Minter, 2019).

Whilst Australian university institutional repositories exist, the Australasian region lacks a consolidated repository to make biomedical and health sciences research accessible, discoverable, interoperable and permanently findable. This PhD study addresses a unique gap by investigating the concept and potential of an Australasia OBR repository from a KMS perspective.

Within a constructivist paradigm, action research is the methodology adopted. The KM processes of discovery, creation, representation, classification, storage, retrieval, dissemination, transfer and translation aligned with the people, process, technology and content model, derived from an Australian KM standard, are the concepts used to investigate the purpose and role of OBR (Standards Australia, 2005). The Evidence-Based Healthcare (EBHC) pyramid, which assigns biomedical research at its base, is an additional model to convey the role of biomedical repositories.

In this chapter, the problem is defined and the research ecosystem and focus are described to set the scene. Open repositories and their different types are detailed, along with an explanation for the focus of the thesis on biomedicine. My three research propositions are introduced and the scope of the work detailed. The chapter also reports on how this research contributes to existing knowledge, in addition to details on the structure of the thesis.

1.2 The research ecosystem and focus

The aim of my PhD research was to explore the potential for establishing an Australasia OBR. An Australasia OBR could mirror and contribute to PMC and include biomedical research output with an Australian, New Zealand and Pacific Islands focus. It could potentially be a 'child' of PMC. The research output in an Australasia OBR could include journal literature, guidelines, conference proceedings, reports, patents, books, images and research datasets and also link to other datasets, such as the world clinical trial registries.

The focus of my research was the Australasian region, although the research has an Australian bias. In examining open biomedical and health sciences repositories, this research addresses the deeper question of their theoretical significance.

An Australasia OBR could consolidate biomedical research findings and provide an outlet for linking research and data to clinical outcomes. The core of an Australasia OBR could be the US PubMed and PMC. There are various options available to populate an Australasia OBR. Harvesting citations from existing repositories and inviting Australasian researchers to deposit their research papers directly in an Australasia OBR are options for consideration. The complexities to achieve efficient processes for an Australasia OBR would need to be resolved. Author submissions can be onerous and only manuscripts that meet selective criteria will be accepted to PMC. It would be necessary to have certain zones within the repository for content excluded from PMC. Removing the research content out of silos and locating it in discoverable zones could be achieved through the application of the KMS framework to design the OBR.

An Australasia OBR could be a permanent repository of a high standard for present and future generations to access quality research output. It could provide a basis for linking clinical trials,

genomic data, patents and clinical guidelines. Translational medicine could benefit from an Australasia OBR based on the integration of biomedical data and research output.

1.3 Why the focus on biomedicine?

Biomedical research is research conducted to increase fundamental knowledge and understanding of the physical, chemical and functional mechanisms of human life processes and diseases (US National Library of Medicine, 2004). The major reasons for the focus on biomedicine is firstly because the field generates a prolific amount of world research output and Australia is in the top twenty countries with the most biomedical publications (National Science Board, 2019; Xu, Boggio & Ballabeni, 2015). Additionally, in matters of life and death, access to health research output should have no barriers (Global Healthcare Information Network, 2017). This research builds on the worldwide effort to reduce barriers, in particular paywalls to health knowledge. There are internationally established classification and information management schemes available to build upon (Cornet & de Keizer, 2008). Further to this, an OBR proof of concept can potentially expand to other disciplinary areas to achieve a future regional, multidisciplinary or interdisciplinary repository. The focus on scholarly knowledge in biomedicine was also because I had spent over thirty years working in the field and it was a means to narrow the scope of my research.

1.4 Research propositions and scope

Ring the bells that still can ring,
Forget your perfect offering,
There is a crack in everything,
That's how the light gets in

Leonard Cohen, 'Anthem' 1992

Based on the unsustainable and escalating costs of library subscriptions, developments with open repositories, the significant investment in biomedical and health sciences research in Australia and the establishment of PMC International, it is timely to investigate a conceptual OBR for the Australasian region.

The motivation for my PhD research relates to my deep curiosity to determine whether theoretical evidence exists to indicate if an Australasia OBR could be viable. This results in the following propositions to guide this PhD research:

- There is stakeholder interest in an investigation on the opportunity for an Australasia open biomedical repository, as a potential member of PMC International.

- A Knowledge Management System (KMS) approach provides a sound basis for developing a conceptual framework for an OBR.

- KMS provides an effective theoretical framework for analysing and evaluating designs for repositories and platforms that support the advancement of open scholarship.

A KMS is a combination of KM practices, such as a set of methods to support learning and organizational processes of KM development, and KM tools, such as IT-based systems supporting the practices (Centobelli, Cerchione & Esposito, 2019). Further details are available on the KMS in Chapter Five.

1.5 Research motivation

Motivation for this research developed when I was working at The University of Queensland (UQ) over the period 2000–2014. At this time, I was managing seven of the health sciences libraries and leading forty staff. My UQ Director and I often raised the need for an Australian version of PubMed. UQ is a member of the Group of Eight (Go8) major research universities in Australia and undertakes studies in areas of tropical medicine and indigenous health and these fields are not extensively covered by systems, such as PubMed, and it appeared there was potential for a system that captured and promulgated research output for the Australasian region. I would later work at two other Go8 Australian universities and my interest in undertaking this research piqued whilst at Monash University, when open science was gaining further traction around 2015.

In 2016 I established a small group, known as the Australasia PMC Working Group. The objective of the group was to investigate an Australasia OBR or PMC. Members considered that a regional OBR had the potential to achieve a number of goals, such as reducing the duplication of effort and the fragmented and incomplete access to health research output that presently exists with institutional repositories. Establishing a PMC for sites without repositories and expanding the corpus of knowledge within PMC International were other goals. In addition, preserving health research and associated data for present and future generations of users throughout the world by becoming a node of an internationally proven PMC system, which produces quality metadata that is widely discoverable, were other important incentives. I was a member of the Australasian PMC Working Group, that comprised senior members from four Go8 libraries, a member from the University of Auckland and the Director from the Australasian Open Access Strategic Group. The group was active over the period 2016–2019 and provided input to the direction of Cycle One of my research.

In Australia in early 2020, devastating bush fires occurred throughout the nation in regional areas and then the COVID-19 pandemic followed. I had resigned in late 2019 from my library position at The University of Melbourne. The Australasian PMC Working Group was no longer active due to key members either retiring or changing jobs. With the world in pandemic crisis, the timing was not right to pursue the establishment of an Australasia OBR. At this time, it was apparent that there were a diversity of approaches to establishing repositories and this lead me in the direction of delving more deeply using a KMS lens.

The planning for an OBR came about from a desire to remove knowledge from silos, and to improve the poor coordination of people, process, technology and content in the biomedical information profession. These factors result in a costly disconnect through to the pipeline that delivers the point-of-care evidence for patient care (Australian Living Evidence Consortium, 2018). Insights gained from the researcher's extensive experience working in leading Australian research universities reinforced the view that an institutional approach to repository management leads to unnecessary duplication of effort and major inefficiencies.

1.6 Contributions to knowledge

There are six areas that demonstrate the contribution this PhD research makes to advancing knowledge. A summary is provided in Table 1.1 of the original contribution and impact to theory and practice of this work.

The research published in a quartile one journal, PLOS ONE, advances the understanding of the strengths, weaknesses, opportunities and threats (SWOT) related to the establishment of disciplinary repositories (Kruesi, Burstein & Tanner, 2019). As a unique study, the SWOT analysis of PMC, the world's leading open science, full text biomedical repository, can influence the future development of an open science infrastructure for the Australasian region.

Development of a conceptual framework for an OBR based on theoretical KM processes is another novel contribution resulting from my research. The framework demonstrates the dependencies and interplay of elements and processes to sustain an OBR. It makes a theoretical and developmental contribution to the fields of KM, biomedicine, health sciences librarianship and the wider field of open scholarship (Kruesi, Burstein & Tanner, 2020; Kruesi, Tanner & Burstein, 2019).

The conceptual framework, which is based on an Australian KM Standard (Standards Australia, 2005), informed a submission made by the CEO of the Australian Library and Information Association (ALIA) and sourced from my research. Demonstrating the influence of my research, the creation of an open Australian biomedical repository, as a member of PMC International, was put forward as a 'number one opportunity' by the ALIA CEO (Australian Library and Information Association, 2020).

The conceptual framework that I developed for an OBR was presented at various forums—four were held nationally and hosted by key Australian health authorities and ALIA, and another was at a major international librarians' conference. My contribution on an OBR informed and raised the current debate underway by the library profession.

Table 1.1 Impact and original contribution to knowledge

Contribution	**1. The findings from the investigation contribute to knowledge by determining the strengths, weaknesses, threats and opportunities related to the establishment of disciplinary repositories.**
Details of research impact	PMC was the focus, based on it being the world's leading open science, full text biomedical repository. The research can influence the development of an open science infrastructure through its systematic analysis of the potential interest in, and viability of a biomedical repository for managing openly accessible research outputs for the Australasia region.
Publications & presentations	Kruesi, Burstein & Tanner, 2019
Contribution	**2. Development of a conceptual framework for an OBR based on theoretical KM processes aligned with the Australian KM standard elements: people, process, technology and content.**
Details of research impact	This is a unique contribution, as the framework demonstrates the dependencies and interplay of elements and processes to sustain an OBR. It makes a theoretical and developmental contribution to the fields of KM, biomedicine, health sciences librarianship and the wider field of open scholarship.
Publications & presentations	Kruesi, Burstein & Tanner, 2020; Kruesi, Burstein, Tanner, & Todd, 2018; Kruesi, Tanner & Burstein, 2019; Kruesi, Tanner & Burstein, 2018
Contribution	**3. Submission to the Australian Government's National Health Information Strategy informed by the KMS framework.**
Details of research impact	The submission made in 2020 by the CEO of the Australian Library and Information Association (ALIA), was sourced directly from my research. ALIA put forward the 'number one opportunity' as the creation of an open Australian biomedical repository, as a member of PMC International.
Publications & presentations	Australian Library and Information Association, 2020
Contribution	**4. Raised the debate on establishing a regional OBR as a member of an international group of biomedical repositories.**
Details of research impact	Three presentations, a paper and a poster have raised the debate on the concept and potential for a regional OBR. In particular, the Australasia PMC Working Group supported the recommendation I put forward to the Council of Australian University Librarians on pursuing an Australasia OBR. This would be as the foundation for a future national or regional multidisciplinary open access repository, as a member of PMC International.
Publications & presentations	Australasia PMC Working Group, 2019; Kruesi, Burstein & Tanner, 2019, Kruesi, 2018a; Kruesi, Burstein, Tanner & Todd, 2018, Kruesi, Burstein & Tanner 2020
Contribution	**5. Proposed a KMS framework as a basis for analysing and evaluating knowledge systems.**
Details of research impact	A basic version of the framework was introduced in a course for library students presented in October 2019. Due to COVID-19 the course was postponed in 2020.
Publications & presentations	The course was on Digital Health Information Services (HLTH90020) and was established by ALIA and hosted by The University of Melbourne.
Contribution	**6. The KMS framework provides the basis for teaching future information professionals about open science based on KM principles.**
Details of research impact	In Cycle Three, the KMS framework was tested with European librarians and information experts. The aim of the session was to test whether the KMS framework can be used effectively for analysing and evaluating repository designs. A short presentation on the framework and the results from the workshop was given at the US Medical Library Association's annual meeting held virtually in 2021.
Publications & presentations	Kruesi, 2021 and a future journal article is planned.

The KMS framework was introduced to information science students enrolled in the Digital Health Information Services course in 2019. My contribution was to design the four-week module, prepare and present a lecture for the students, assist with and at times lead the hosting and facilitation of the module and set the students an assignment to apply a basic version of the KMS framework.

Validation of the KMS framework as a tool for analysing and evaluating repositories and information systems took place during a workshop with higher degree library and communications students based at the University of Bucharest in Romania. The European location was chosen based on open science being more developed in research practice in this location. My contribution was in providing the students, from undergraduate, masters and PhD levels who participated at the session, with a new mode of evaluating information platforms using my KMS framework. The students endorsed the tool as an effective way of critiquing information the platforms assigned at the workshop.

1.7 Thesis structure

This thesis comprises seven chapters (see Figure 1.2 Chapter Outline on the following page). Each chapter begins with my personal prelude. In Chapter One I have set the scene with an introduction to the research ecosystem and explained why the focus of this thesis is on biomedicine. The propositions and the contribution to knowledge are introduced in the first chapter. Chapter Two presents my literature review, covering repositories, PubMed, PMC, the evolution of knowledge databases for biomedical research, the relationship of my thesis with clinical and evidence-based healthcare (EBHC) information resources, including the EBHC pyramid model, and the move from information silos to open scholarship. The focus on Knowledge Management (KM), explaining who owns knowledge, the different types of knowledge, how knowledge databases for biomedical research have evolved and the theoretical constructs that relate to this PhD, along with the KM Systems (KMS) framework are introduced in Chapter Two.

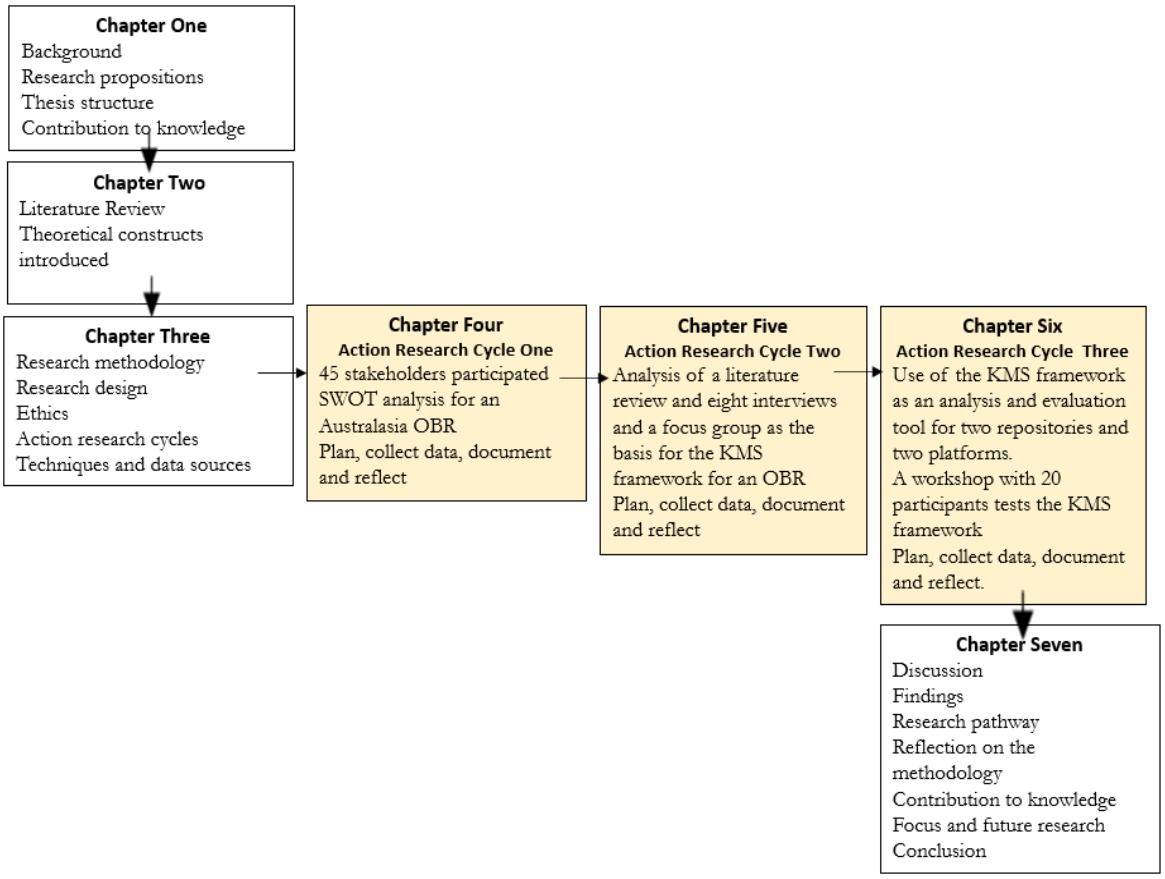


Figure 1.2 Chapter Outline

Following this, Chapter Three covers the research methodology and research design, along with information on the ethics approval for this research. The action research cycles, data sources and techniques adopted are also described in Chapter Three. In Chapter Four, the stakeholder interest in an Australasia OBR is reported based on thematic analysis and reflection from findings derived from the action research cycles. In Chapter Five, research undertaken to devise the KMS framework for an OBR is detailed. Following this in Chapter Six, the use of the KMS framework for assessing and evaluating differing repositories and information systems is covered. In Chapter Seven, the discussion and the findings are followed by a section on the research pathway, which explains the research outcomes and context. Reflections on the methodology, the contribution to knowledge, the focus of the thesis, the future research recommendations and a thesis conclusion.

Chapter Two: Literature review

'The project started with the philosophy that much academic information should be freely available to anyone. It aims to allow information sharing within internationally dispersed teams, and the dissemination of information by support groups.'

Tim Berners-Lee, inventor of the Internet, 1991

Prelude: My gap year

Acceptance of my first choice, the RMIT University Librarianship Program (Bachelor of Social Science in Librarianship), was a dream come true. When this happened, I had just spent six weeks touring New Zealand and I had returned home with depleted savings. Without a great deal of consideration, I followed-up an administrative job advertised in *The Age*. I was invited for an interview. I was eighteen and I didn't even know how to 'catch a tram,' so my Mum accompanied me to the interview held at VACC House 464 St Kilda Road, Melbourne. The job was with General Motors Acceptance Corporation (GMAC), a global finance company. The role was to type-up cheques for loans and relieve at times for the receptionist on the switchboard. At the close of my interview I was offered the job. Following this, I deferred my position in the librarianship program and commenced my first ever full-time role. My year with GMAC was the gaining of wisdom. It didn't take me long to decide that an office role was not for me. It was comforting to know I had an opportunity to take another pathway and I couldn't wait until 1983 when I would commence the librarianship program. Gaining parental support to quit a well-paid job was not straightforward. My father argued, why bother when you'll just get married and have children? My dear mother was worried I would become too full of my own self-importance. Today I still appreciate their honest responses and acknowledge they gave me their complete support throughout my years of study. Two lessons I gained from my GMAC experience were the importance of employing people with a positive attitude and finding a good mentor.

Figure 2.1 GMAC team out the front of VACC House, 28 January 1982

'A 'medlar' is also a fruit that in earlier times was used as a medicine' (*ref: Miles, W.D. A history of the National Library of Medicine. Bethesda, MD: National Library of Medicine, 1980.*)

2.1 Chapter outline

This literature review highlights key research papers that explain and distinguish the roles of repositories to provide research output. The status of research repositories in Australia and the world are summarised. Key research articles on PubMed and PubMed Central (PMC) provide a perspective on their role in advancing scholarly publishing. In addition, this chapter touches on who owns knowledge, KM processes and biomedical workflow. This is followed by evolution of KM databases for biomedical research, the evidence-based healthcare model and the move from information silos to open scholarship.

2.2 Background

For over 350 years, scholarly journal articles have been the chosen means to disseminate new knowledge, register research findings, review and certify results, preserve a record, add to the existing body of knowledge and act as a measure for determining academic promotion (Fyfe, McDougall-Waters & Moxham, 2015). From the period from 1970 until the 1990s, there was a shift from personal subscriptions towards library-provided journal access for researchers (Tenopir & King, 1998). ArXiv (an open access e-prints repository in Physics, Mathematics, Computer Science, Quantitative Biology, Quantitative Finance and Statistics) was created in 1991 as a central disciplinary repository (Poynder, 2016). Steven Harnad in 1994 challenged others to extend the ArXiv self-archiving example to other disciplines, signalling the emergence of open access (Harnad, 1995). Around 2001, sales of large portfolios of electronic journal content sold through consortia arrangements to libraries was the major means to acquire research collections (Frazier, 2001). Figure 2.2 provides a chronology of scholarly publishing trends and developments since 1970.

Academic libraries throughout Australia spent approximately $282 million in 2017 on access to subscription journals to support students, researchers and practitioners (Council of Australian University Librarians and Australasian Open Access Strategy Group, 2018). Since the late nineties

many academic libraries have needed to cancel subscriptions in order to free up funds for new titles. In addition to the struggle to maintain subscriptions, library managers are required to sign contracts that forbid them disclosing publisher fees (Sample, 2012) therefore the costs of the existing scholarly publishing system are not transparent.

Aggregator online library discovery platforms that evolved from library catalogues are set up to adhere to publisher contracts. The library search systems lock down collections and databases, ultimately restricting access, reading, citing and translating of research into practice.

With the European Union having declared that scientific research will be freely accessible from 2021, a significant effort to make open access the scholarly publishing norm in this region is underway (European Science Foundation, 2021). Unfortunately, in the Australasian region despite many calls for a more collective approach, efforts to act and contribute globally to the open science movement are fragmented (Barbour & Borchert, 2020).

In 2021, examples of the merging of 'new' library discovery platforms with other organisational systems to provide access to open and proprietary subscription resources have emerged (Dahl, 2021). The inability to search the titles of articles within journals from a catalogue is finally now a thing of the past with the advent of library discovery systems (Breeding, 2018).

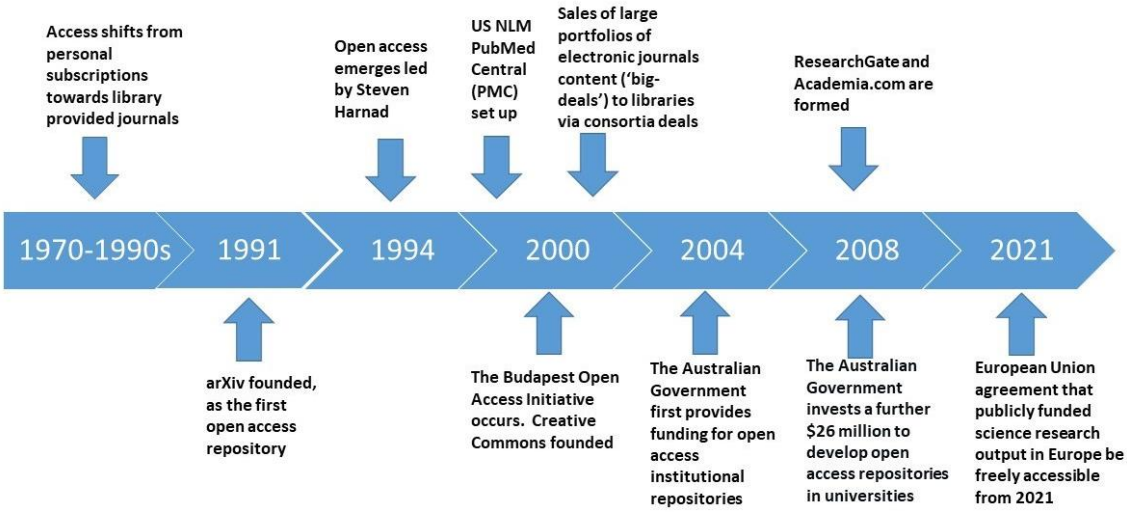


Figure 2.2 Chronology of scholarly publishing trends and developments

2.3 Advancing scholarly publishing literature review

2.3.1 Repositories

In early 2000, around the time of the Budapest Open Access Initiative, the focus was on making peer reviewed scholarly journal articles accessible via the Internet from institutional and subject repositories such as PMC (Sequeira, McEntyre & Lipman, 2001). By late 2000, in addition to journal articles, the content of books and book chapters, conference papers, theses, working papers, preprints, learning objects and rich media files were becoming openly accessible from repositories. The fundamental goals of opening up research output relate to pursuing transparency of research methods, reusability of research processes, open communication and public accessibility via the Internet (Gezelter, 2009).

A digital repository is a set of systems and services that ingest, store, manage, display, retrieve and allow reuse of digital objects (Pinfield, 2009). Institutions, subject communities and research funders predominantly set up repositories to provide access to digital objects (Pinfield, 2009). Aggregators actively harvest data from multiple sources such as repositories, and make repositories searchable and available in a uniform way (Przybyła et al., 2016). Open access literature is content that is online, digital, free of charges and without most of the copyright and licensing restrictions (Suber, 2004).

A subject or disciplinary repository is defined as a repository 'that collects and provides access to the literature of a single subject or a set of related subjects.' (Huber, 2014: 71) According to Björk, subject repositories may contain article metadata, as well as research data and full text of scholarly publications which is available free of charge and is searchable by web robots (Björk, 2014).

Subject and national repositories help scholars to navigate the vast amount of knowledge, although institutional repositories have been less successful as outlets for this endeavour (Armbruster & Romary, 2009). Institutional repositories, such as those developed in Australia, do aggregate with the National Library of Australia's repository TROVE. Most institutional repositories harvest quality metadata and full text articles from subject repositories such as Europe PMC and commercial publisher databases. Repositories exist to provide value, relevant research and to

archive an organisation's intellectual property; they do not exist to archive every research output (Armbruster & Romary, 2009). In Australia, the development of 'green' repositories was encouraged in particular by funding bodies and universities, whereas the trend in the UK was for funding bodies to prefer the 'gold' format which usually required a significant upfront Article Processing Charge (APC). The 'green' format was a means to avoid the upfront payment and usually involved an embargo period before the author could post the accepted version of their article on a subject or institutional repository. Open access diamond journals are journals that publish without charging authors and readers (Bosman, Frantsvag, Kramer, Langlais, & Proudman, 2021). In the case of diamond journals, it is the university, the association, or the authors that subsidise the cost of the publication.

An institutional repository is a recognition that scholarship of universities and organisations is in digital form. An institutional repository is a means to make research output available to members of their communities and the public (Huber, 2014, p. 71). Examples of subject repositories that work effectively alongside institutional repositories, include ArXiv (arXiv.org), PMC (https://www.ncbi.nlm.nih.gov/pmc/), and RePEc (Research Papers in Economics http://repec.org/).

Online research data repositories have also emerged and require large database infrastructures to manage, share, access, and archive researchers' datasets (Uzwyshyn, 2016).

2.4 Status 'down under' and world perspective

Library services in the medical sector are a small part of a massive healthcare system in Australia that consumes over $195.7 billion a year (Australian Institute of Health and Welfare, 2020). It is currently difficult to report comprehensively on the state of health sciences research output throughout Australian universities, hospitals, medical institutes and health care centres. Australian health practitioner information is stored in silos and because of this doctors, nurses and allied health professionals make clinical decisions based on an array of sources (Four Corners ABC, 2015). Australia publishes on average 50,000 biomedical and health sciences research articles annually (Elsevier B.V., 2017). Medical research consumes a significant investment of $7.9 billion annually of Australian public money (Research Australia, 2019).

In 2004 the Australian Government allocated funds on a competitive basis for open access institutional repository development and experimentation in universities–a number of university library consortia won them (Kennan, 2008). Following this in 2007–2009, the Australian Government administered the Australian Scheme for Higher Education Repositories (ASHER) program, during which Australian universities received $26 million towards developing their digital institutional repositories. 'Enhancing access to research through the use of digital repositories' was the aim of ASHER, although at the time much of the allocation was assigned to developing closed collections for the Excellence in Research Australia (ERA) project (Steele, 2013).

Regardless of the vast investment in establishing and operating repositories throughout Australia, most of the university repositories, according to the Director of the Australian Open Access Strategy Group, achieve around 20–25% compliance with open access mandates (Barbour, 2017). Europe PMC achieves much higher compliance with making research papers openly available on behalf of their 33 research funders (e.g., Wellcome Trust reports compliance of around 80%) (Lariviere & Sugimoto, 2018).

There is no government long term funding for Australian university institutional repositories and no oversight of their development at a national level (Barbour, 2017). Heriyanto reports on the difficulties authors experience in complying with funder mandates (Heriyanto, 2018). He explains that authors are confused by the concept of publication versions (e.g., preprint, post print, publisher versions) and this hinders their ability to submit publications to their institutional repository. Other challenges include low author motivation and limited participation in submitting content to institutional repositories (Cullen & Chawner, 2011; Joo, Hofman & Kim, 2018). Fragmentation is another issue highlighted in Cycle One of my research (Kruesi, Burstein & Tanner, 2019). For instance, a user locating a reference without the accompanying full-text article in an institutional repository may need to search in numerous repositories. This fragmentation creates flow on challenges with accessibility, discoverability, interoperability and permanency (Kruesi, Burstein & Tanner, 2019).

At a time when major world universities and institutions are taking the initiative and developing an 'open' infrastructure, it is important to undertake studies on the open biomedical repositories to help guide the future direction for library services and the wider research ecosystem (Dizikes,

2016; Science Europe Working Group on Open Access, 2015). From 2006 onwards, major world institutions have introduced open access mandates and plans, such as the:

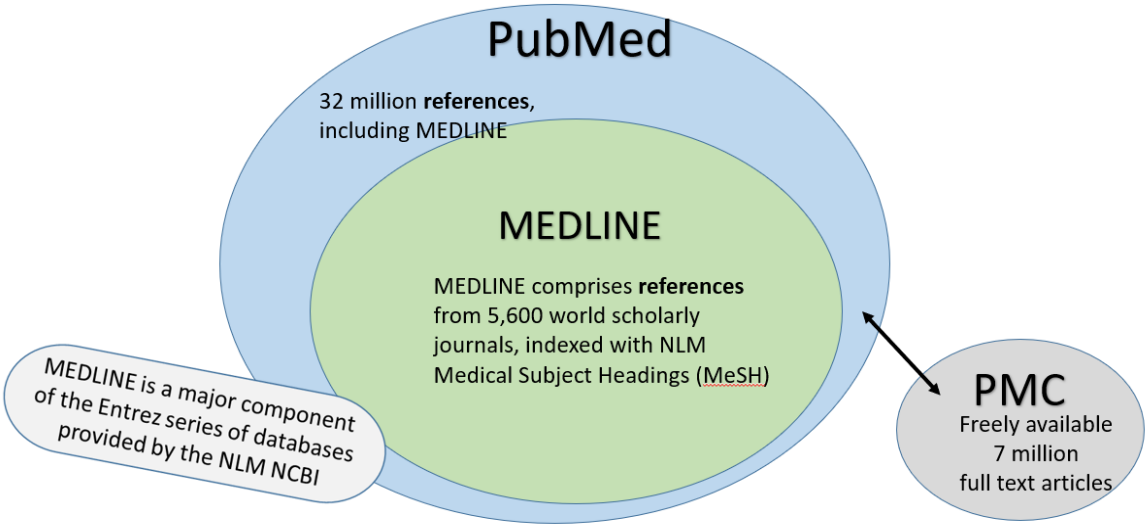
- Wellcome Trust (introducing their first mandate in 2006) (Wellcome Trust, 2020),
- US National Institutes of Health (US Department of Health and Human Services, 2008),
- NHMRC (National Health and Medical Research Council (Australia), 2018),
- ARC (Australian Research Council, 2013),
- European Union (Science Europe Working Group on Open Access, 2015), and
- COAlition S, Plan S (European Science Foundation, 2021).

In 2015, the importance of Findable, Accessible, Interoperable and Reusable (FAIR) data and research output principles were established by a group at a workshop in Leiden in the Netherlands and later adopted by major world bodies (Wilkinson et al., 2016; Wilkinson et al., 2019). The principles stress 'machine-actionability (i.e., the capacity of computational systems to find, access, interoperate, and reuse data with none or minimal human intervention) because humans increasingly rely on computational support to deal with data as a result of the increase in volume, complexity, and creation speed of data (GO FAIR, 2019).'

A leader in the field has argued that the most successful repositories are disciplinary or national in scope rather than institutional repositories (Poynder, 2016). Two Australian PhD studies (Kennan, 2008; Kingsley, 2008) traced the open access scholarly publishing transformation over earlier decades and the role of institutional repositories. Whereas Kennan's research focused on the introduction of institutional repositories, Kingsley raised the need for institutional repositories to 'adapt dramatically' in order for the academic community to adopt them into practice and suggested the alternative is for communities to develop subject-based repositories (Kingsley, 2008, p. 210).

2.5 PubMed and PMC

Developed and managed by National Center for Biotechnology Information (NCBI) at the US National Library of Medicine (NLM) and located at the National Institutes of Health (NIH), PubMed is an openly accessible aggregator database with over 32 million biomedical literature citations from MEDLINE, life science journals, and online books (see Figure 2.3). The precursor of PubMed was the printed Index Medicus that began in 1879 (Greenberg & Gallagher, 2009). PubMed citations may include links to full text, peer reviewed articles that are available from the repository PMC. The NCBI established PMC as an open biomedical and life sciences repository of freely accessible full-text journal literature in 2000.



Source: : National Library of Medicine https://www.ncbi.nlm.nih.gov/ (Graphic by L. Kruesi, updated June 2021)

Figure 2.3 PubMed, MEDLINE and PMC relationship

MEDLINE and PMC as a subset of PubMed, which are part of the Entrez series of repositories, is one of the world's largest and freely available biomedical databases (Yoo & Marinov, 2010). Healthcare practitioners rely on PubMed as an important and trusted digital biomedical library (Nankivell, Wallis & Mynott, 2001). A major objective of PubMed 'is to make the path from basic research findings to clinical applications as smooth as possible' (McEntyre & Lipman, 2001; US National Library of Medicine, 2018).

A US study of 625 clinical questions that occurred during an in-hospital general medicine rotation found that MEDLINE (a subset of PubMed) provided answers to 77 percent of the questions and the information from the answers changed patient management 47% of the time (Crowley et al., 2003). Another US study found that MEDLINE contains information relevant to more than half of the clinical questions raised by primary care clinicians (Gorman, Ash & Wykoff, 1994).

The international reliance upon PubMed knowledge is evident from the widespread reuse of PubMed citations. When formal arrangements were necessary, more than 500 licences to MEDLINE, PubMed's subset, were issued, with 200 of them to providers outside the United States. There are 28 freely available biomedical online tools reliant on PubMed content (Lu, 2011). These figures are likely to be conservative, as after 2016 the US National Library of Medicine discontinued licensing the system and opened PubMed up freely to all (US National Library of Medicine, 2016).

PMC enables the publications resulting from the funded research of the NIH, the Health Research Alliances (90 non-profit research funders) and other private and international partners to be openly and permanently available from the NLM's website (US National Library of Medicine, National Institutes of Health, 2019). Implemented in 2000, PMC was an initiative of the Nobel laureate NIH Director, Harold Varmus, (National Center for Biotechnology Information, 2020; Sequeira, McEntyre & Lipman, 2001) and is dependent upon PubMed for bibliographic metadata. In 2021, there were over 7 million articles in PMC. According to Richard Roberts, the Nobel Prize winner for medicine in 1993, the goal of PMC is not to replace the journal. The objective of a PMC is to distribute knowledge as widely as possible (Roberts, 2001). The NLM PMC is the parent site of Europe PMC. The purpose of Europe PMC established in late 2000, is to expand the participation in the PMC repository and add to the increasing corpus of open access research. PMC Canada was operational over the period 2009–2018, as another child site of PMC.

In 2018, PMC Canada ceased operation and institutional repositories took over the management of author submissions. Europe PMC in contrast to PMC Canada, continues to expand functionality and content. Europe PMC is one of the few repositories that has most of the technical requirements specified by the open access publishing initiative Plan S (European Science Foundation, 2021). In addition, many of the cOAlition S funders use Europe PMC as their

repository for managing their publication outputs from life science funding projects (Europe PMC, 2019).

My literature review has not found any studies that provide a theoretical justification for the establishment of PubMed and the associated NLM repositories. Based on a thorough search of the literature and discussions with leaders in healthcare, biomedical research and open access fields, there are also no previous academic studies on the concept, viability and potential for an Australasia PMC repository from a KMS perspective. There is a vast amount of academic research on repositories and on open access publishing, the underlying precepts of which has had a role in inspiring the development of PMC.

2.6 Knowledge Management System (KMS) perspective

2.6.1 Who owns knowledge?

Universities have become a critical force for defining who owns, pays for, and benefits from knowledge (Stevens & Bagby, 2001). Leaders in university governance roles oversee intellectual property policies that guide the ownership of knowledge in society. University research is the 'causeway between the world of pure and unapplied knowledge and the world of real economic impacts' (Deloite Access Economics, 2015). Figure 2.4 illustrates university research as the source of knowledge for business and society (Stevens & Bagby, 2001).

Historically, at the point of acceptance of a research article, 90% of publisher agreements asked for copyright transfer (based on a study of 80 scholarly journal publishers) (Gadd, Oppenheim & Probets, 2003). Restrictive traditional copyright laws were challenged in December 2002, when Creative Commons released its first set of copyright licenses for free access to the public (Creative Commons, n.d.). In 2021 Creative Commons licences provide a means to share materials in a simple, standardised way, allowing authors to provide permission for the sharing and use of their digital works based on conditions set by Creative Commons (Creative Commons, n.d.)

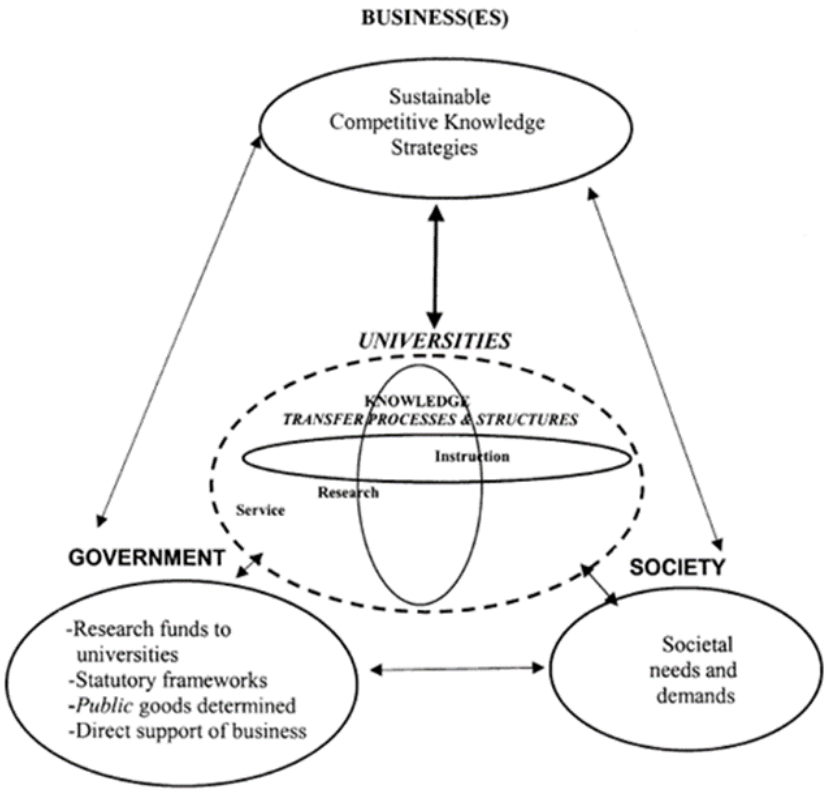


Figure 2.4 University research as the source of knowledge (Stevens & Bagby, 2001, p. 261)

2.6.2 KM processes and biomedical research workflow

KM is getting the right knowledge to the right user, and using this knowledge to improve organizational and/or individual performance (Jennex, Smolnik & Croasdell, 2009). KM is doing what is needed to get the most out of knowledge resources (Becerra-Fernandez & Sabherwal, 2015). There is a prolific amount of research on KM with a focus on achieving competitive advantage for organisations (Argote & Ingram, 2000; Halawi, Aronson & McCarthy, 2005; Mårtensson, 2000). A KMS is a combination of KM practices, such as a set of methods to support learning and organizational processes of KM development, and KM tools, such as IT-based systems supporting the practices (Centobelli, Cerchione & Esposito, 2019).

This PhD research focuses on the KM processes related to biomedical research and innovation. According to Tuomi, when we explicitly address processes that underpin the establishment of shared understanding, it is then we develop KM systems (Tuomi, 1999).

KM processes are important throughout key research activities (Saito, Umemoto & Ikeda, 2007). The conduct of clinical trials is a major biomedical research activity and they require registration of data and report planning at an early stage of the research. KM is not directly concerned with data, although the exception to this is when knowledge discovery occurs through data mining techniques (Becerra-Fernandez & Sabherwal, 2015, p. 40). KM is concerned with the discovery of tacit and explicit knowledge from data and information or from the synthesis of prior knowledge (Becerra-Fernandez & Sabherwal, 2015, p. 59). The discovery activity of research involves iterations of searching and reading (Kramer & Bosman, 2017).

Knowledge creation modes identified by Nonaka, includes:

1. Socialization, involving conversion of tacit knowledge to new tacit knowledge through social interactions and mutual experiences, such as participating at conferences;
2. Externalization, entailing the conversion of tacit knowledge to explicit knowledge, such as procedures;
3. Internalization, which is the conversion of new tacit knowledge from explicit knowledge, such as new learning from reading; and
4. A combination of each (Nonaka, 1994).

Each of the knowledge creation modes identified by Nonaka are vital to the transformation of research by health practitioners, industry, or consumers to adopt the findings as knowledge. A social process, which often involves checking with other practitioners and gaining insight from a range of sources occurs to form part of a 'mindline,' the knowledge in context that is used in practice. This social activity underpins the constant and repeated process to transform research into knowledge (Gabbay & le May, 2010, p. 102).

Information systems that support collaboration, coordination and communication processes can increase a researcher's contact with colleagues. These systems underpin KM creation activities (Alavi & Leidner, 2001). Open biomedical aggregators and repositories, such as PubMed and PMC exemplify sophisticated KM processes and work as platforms for researchers worldwide to access biomedical research evidence.

2.7 Evolution of knowledge databases for biomedical research

With the flurry of internet technologies and database advancements over recent decades, there has been a proliferation in the number of search platforms, repositories and databases for accessing knowledge.

Thousands of proprietary databases that index and abstract journal articles have been made available since the 1970s (Regazzi 2015, p.131). A few of the key biomedical databases that index the top world journals and grey literature include MEDLINE, Embase, CINAHL, Ovid Emcare, Biosis and Cochrane Library. Some of the databases index the same publications, although each will have a distinguishing feature; for example, the Embase database has a focus on drug and pharmaceutical research. All of the different biomedical databases provide a unique perspective and search features. For example, when undertaking a systematic review there are search standards such as those published in the Cochrane Handbook, that indicate it is mandatory for researchers to search The Cochrane Central Register of Controlled Trials (CENTRAL) and MEDLINE, together with Embase if available, when undertaking a Cochrane Review (Lefebvre et al., 2021).

From the mid-1990s, some databases of publishers such as Ovid and Elsevier evolved into full-text services; their role moved from simply providing an indexing service to acting as aggregators (Burrows, 2006).

The quality of biomedical literature that is deposited in biomedical repositories, is concerned with excluding research publications that do not achieve and maintain set publishing standards. Bodies such as the Committee on Publication Ethics (COPE) and the International Committee of Medical Journal Editors (ICMJE) define best practice in the ethics of scholarly publishing and assist editors and publishers to achieve this (Committee on Publication Ethics, 2021). Achieving a consistent quality approach involves setting out to avoid promulgation of misinformation that can occur because of inadequate peer review or research fraud. Research practices need to be tailored to the needs of the discipline, along with services and tools created for reusability as part of daily researcher work (Chen et al., 2019). It is argued that predatory journals must be denied the 'legitimacy afforded by inclusion in prestigious databases like PubMed' (Harvey & Weinstein, 2017).

2.8 Clinical and evidence-based healthcare information resources

Evidence-based practice is much more than finding suitable knowledge to respond to clinical questions: it is the explicit, conscientious and judicious use of the best available research evidence, along with clinical experience and patient needs, to guide healthcare decisions (Haynes, Devereaux & Guyatt, 2002; Sackett, Rosenberg, Gray, Haynes, & Richardson, 1996). The evidence-based healthcare (EBHC) pyramid, developed by Haynes in 2001, has been widely adopted internationally as a model to help determine which resources to consult for answering clinical queries (Haynes, 2001, 2006; Murad, Asi, Alsawas & Alahdab, 2016). The model is also a framework for teaching EBHC and providing a perspective of the wide array of health sciences information resources available from commercial databases and institutional and subject repositories. PMC predominantly comprises individual, primary research studies that are the foundation of the EBHC pyramid. Sites such as Accessss, Epistemonikos, SUMSearch and Trip are meta-search platforms that retrieve evidence across multiple resources and content from all levels of the pyramid (Health Sciences Library, 2020).

2.9 Evidence-based healthcare pyramid model

An understanding of the evidence-based healthcare (EBHC) pyramid model can help users with navigation of open biomedical literature repositories. The primary studies form a pyramid within the EBHC pyramid (Figure 2.5) attributed to the author Haynes and adapted by the thesis author (Haynes 2006). The studies hierarchy commences with laboratory research, followed by expert opinion in the form of case reports and case series, case-control studies, cohort studies and randomised controlled trials (RCT), and has systematic reviews and meta-analyses above the individual studies (Petrisor & Bhandari, 2007; Sackett, 2000; Shaneyfelt, 2016). RCTs are the gold standard in clinical research, based on a rigorous methodology that helps to eliminate bias (Grimes & Schulz, 2002). Progressing beyond systematic reviews in the pyramid, the next level includes synopses, such as critically appraised primary studies. Continuing upwards in the pyramid, evidence-based guidelines, and then synthesised summaries (evidence-based textbooks) and systems are at the apex. The apex represents the integration of evidence within hospital clinical decision systems, which along with digitised patient health records help to achieve individualised healthcare.

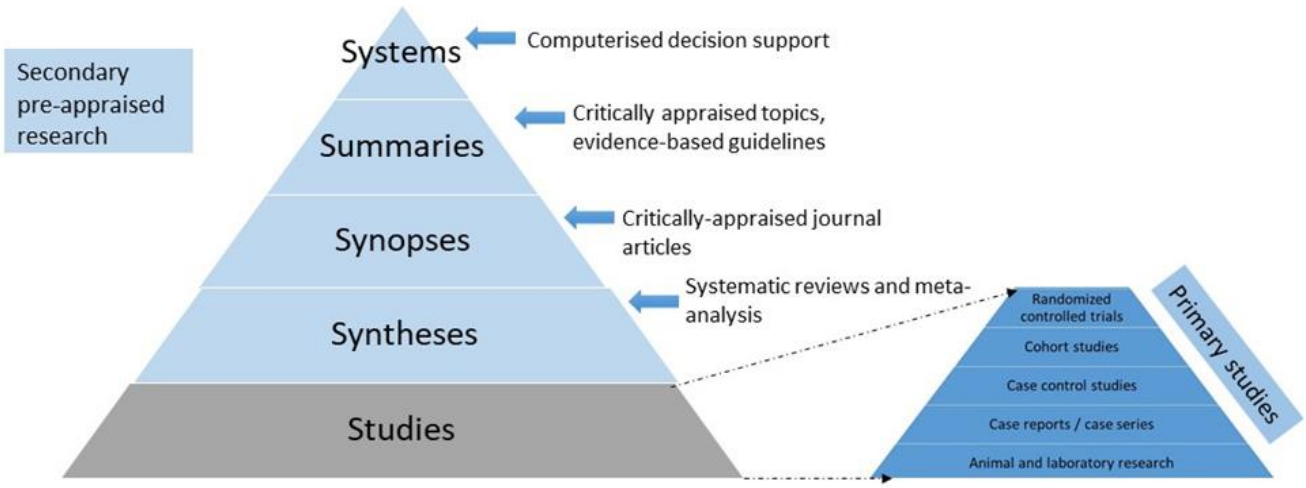


Figure 2.5 Evidence-based healthcare (EBHC) pyramid

PMC predominantly comprises individual, primary research studies that are the foundation of the EBHC pyramid. For example, Europe PMC, when accessed on the 26 October 2017, comprised 4.4 million articles of which 430,168 were reviews, 11,060 were books and documents, and the remainder were primary studies (Europe PMC, 2017). On 18 June 2021, the same search in Europe PMC found 7 million articles of which 736,309 were reviews, 20,102 were preprints linked to articles and 6,211,657 were research articles. Since 2017 preprints have been made accessible from Europe PMC. On 18 June 2021, 309,538 preprints were in addition to those pre-prints linked to articles (Europe PMC, 2021d).

Librarians, repository staff, publishers and researchers make content discoverable. A disciplinary repository like PMC meets the process requirement of major organisations' open access policies, such as the Wellcome Trust, US National Institutes of Health (NIH), the National Health and Medical Research Council (NHMRC), the Australian Research Council and the European Union as a means to disseminate research findings (Australian Research Council, 2013; National Health and Medical Research Council (Australia), 2018; Science Europe Working Group on Open Access, 2015; US Department of Health and Human Services, 2008; Wellcome Trust, 2020). Most researchers retrieve PMC articles from searches undertaken using internet search engines, such as Google Scholar. PMC has more than a billion articles retrieved from the NLM website each year, and according to the PMC Project Manager, this demonstrates how important this repository is for research discoverability (NLM Program Manager, 2018).

Discovery is underpinned by the Open Archives Initiative Protocol for Metadata Harvesting (OAI-PMH) which enables a repository, journal or publisher to register with an OAI harvester (search engine) to be discoverable ("Open Archives Initiative Protocol for Metadata Harvesting," 1999). Discovery is also enhanced by technology systems employed by the NLM such as PubMed Link Out, which enables links directly from PubMed and other NCBI databases to a wide range of information and services beyond the NCBI systems.

An Australasia open biomedical repository could be a platform to find related research data. 'Good data management is not a goal in itself, but rather is the key conduit leading to knowledge discovery and innovation, and to subsequent data and knowledge integration and reuse by the community after the data publication process' (Wilkinson, Dumontier, Aalbersberg, Appleton et al., 2016). Europe PMC has made numerous biomedical knowledge databases discoverable and their services for researchers are constantly improved. The Europe PMC model splits costs over 33 different funders and this is a strength. Publishers make funder-attributed research available through the repository and this allows services to be built on top. For example, Europe PMC biostudies reports are created to extract the underlying data. 'Much more is achieved than just a repository of articles' (Kiley, 2018).

2.10 From information silos to open scholarship

Bibliographic and full text databases have many limitations, and some of these have impacted on the design of present knowledge repositories. Proprietary bibliographic and full text databases are usually organised by publisher preferences; they vary in design, with some requiring individual login. Most of these databases are standalone systems and their usage is restricted by subscription and licensing conditions (McLean & Lynch, 2004). Navigating database silos is challenging and such resources can require a high level of expertise in order to find relevant content (McLean & Lynch, 2004). Open scholarship seeks to address some of these limitations by making research output discoverable.

Based on existing trends, it is estimated that by 2025, 44% of all journal articles will be available as open access and 70% of article views will be to open access articles (Piwowar, Priem & Orr, 2019). 'The declining relevance of closed access articles is likely to change the landscape of scholarly

communication in the years to come' (Piwowar, Priem & Orr, 2019). The debate on who owns research output is being hotly disputed (Piwowar, Priem & Orr, 2019). Various social networking services for researchers, such as ResearchGate and Academia.edu introduced in 2008, now challenge traditional approaches to disseminating research.

Research has identified that subject and national repositories help scholars to navigate the vast amount of knowledge, although institutional repositories have been less successful as outlets for this endeavour (Armbruster & Romary, 2009). Institutional repositories, such as those developed in Australia, do aggregate with the National Library of Australia's platform TROVE, and link to other subject repositories such as ArXiv and PMC. Repositories exist to provide value and relevance of research; they do not exist to archive every research output (Armbruster & Romary, 2009).

2.11 Chapter summary

Chapter Two has provided background on scholarly publishing trends. A summary of the research reporting on advancing scholarly publishing literature is covered, with the status 'down under' and a world perspective reported. A potted history and the significance of PubMed and PMC in relation to this thesis is reported. The KM perspective of this research is introduced, which has a focus on KM processes and the biomedical research workflow. Context in relation to knowledge databases for biomedical research and the role of the EBHC pyramid model for this research is given. The scene is set for the following chapters to provide research proposing a means to transition biomedical information silos to open scholarship.

Chapter Three:

Research methodology and design

Prelude: Research-Informed Practice

A standout experience from my undergraduate years at RMIT was working on the mini-thesis titled: Permanent part-time employment in Victorian special libraries. The research was informed by the subject LI 420 Advanced Librarianship presented by Dr Tanner (formerly Grosser). The project would become the basis of my first conference presentation and paper published in a 1987 issue of The Australian Library Journal (see Figure 3.1 for the article citation). I was able to combine my work experience with my library studies. Throughout the four years of the program at RMIT University, I was very fortunate to have worked part-time whilst studying. I gained part-time library roles at the Royal Australian Nursing Federation (1983-1987), ICI Australia Operational Pty Ltd (1985-1987), and the CSIRO Division of Food Research Laboratory (1986-1987). These roles were my entrée for future managing knowledge, working in a scholarly environment, and undertaking research-informed practice. This period also marked the commencement of my professional networks and gave me an insight into a diversity of different organisations.

On my graduation in 1987 from RMIT University, I was job-ready and commenced a library role directing the CSIRO Protein Chemistry branch library, located in Parkville, Victoria. My career in the world of biomedical research was underway.

Figure 3.1 My first journal article.

Belkin, L. (1987). Permanent Part-time Employment in Victorian Special Libraries: The Employee's Perspective. The Australian Library Journal, 36(3), 148-154.

As a biomedical librarian, I spent my professional career on the receiving end of research questions from scientists. Working at CSIRO, the majority of the questions were answered with quantitative evidence derived from articles published in the world's top scientific journals. Eventually, my career moved to a healthcare practice environment when I managed a library located in Queensland's largest biomedical and healthcare site comprising the Royal Brisbane and Women's Hospital, the Royal Children's Hospital and the University of Queensland's Schools of Medicine, Nursing and Midwifery, Public Health and Dentistry. It was during this period of my career that I commenced learning and supporting evidence-based healthcare practice. There are suitable study types that are appropriate for answering healthcare questions (Howick, 2002) and such practice is the basis of the residential one-week program that I helped to establish in 2011, known as the Australian Evidence-Based Librarians' Institute; the Institute continues in 2021 and has a website that is available from https://sites.google.com/site/australianebpli/home

'The true method of knowledge is experiment.'
William Blake

3.1 Chapter outline

This chapter discusses the choice of research approaches and methodology adopted in this thesis. It commences with background on the research paradigm, which details the ontology and epistemology for my research. The methods, techniques and data sources, the action research cycles and the research ethics that were utilised to assess stakeholder interest in an Australasia OBR and develop and test a KMS Framework are explained.

3.2 Research approach and methodology

It is from research that we expand knowledge and extend the understanding of phenomena that occur in developing, deploying and using information systems and KMSs in organisations and communities (Cecez-Kecmanovic & Kennan, 2013). A research approach and methodology explain a researchers' existing assumptions in relation to the research process (Cecez-Kecmanovic & Kennan, 2013).

This research follows the constructivist philosophy. Positivists argue that knowledge is generated through scientific method, whilst constructivism maintains that knowledge is constructed by scientists and it opposes the idea that there is a single methodology to generate knowledge (Dudovskiy, 2018; Williamson, 2013b). As a social constructivist, the interpretations of my findings have not been in isolation. Shared meanings have developed over years through social processes involving *people, process, technology* and *content*.

This research has investigated the KM processes that are the basis of biomedical knowledge. In addition, the EBHC pyramid process of transfer and dissemination, introduced in Chapter 2, was another lens used to explore the significance of biomedical research from a KM perspective.

This qualitative research project has analysed how people interpret their experiences and the meaning they attribute to their experience and this is aligned with KM processes throughout the three cycles of research undertaken for this thesis.

3.2.1 Research paradigm: ontology and epistemology

Ontology is concerned with the study of being (Scotland, 2012). My research is based on a relativist ontology, whereby truth flows from experiences, an understanding of the situation and systematic analysis of data. The research paradigm adopted is outlined in Figure 3.2. Relativism presents the perspective that reality can differ from person to person (Guba & Lincoln, 1994). Constructivism, one of the several interpretivist paradigms, emphasises that research is an outcome of the values held by researchers and cannot be independent of them (Mertens, 2020, p. 16). Through proactive and purposive interaction, knowledge is constructed by scholars from interactions with respondents (Guba & Lincoln, 1994, p. 111; Morçöl, 2001). This research has used a combination of inductive and deductive logic as its modes of inquiry. The work has entailed starting with a proposition, followed by testing KM theory from gathering data and reporting on the outcomes which have occurred, by applying an array of techniques and from accessing a wide range of data sources. Inductive reasoning was applied to determine stakeholder interest in an investigation on the opportunity for an Australasia OBR, as a potential member of PMC International as general principles were derived from specific interactions and observations from the research data. An example of the deductive logic undertaken for this research relates to the research to determine that a KMS provides an effective theoretical framework for analysing and evaluating designs for repositories. Action research was the method applied, through the three cycles of research.

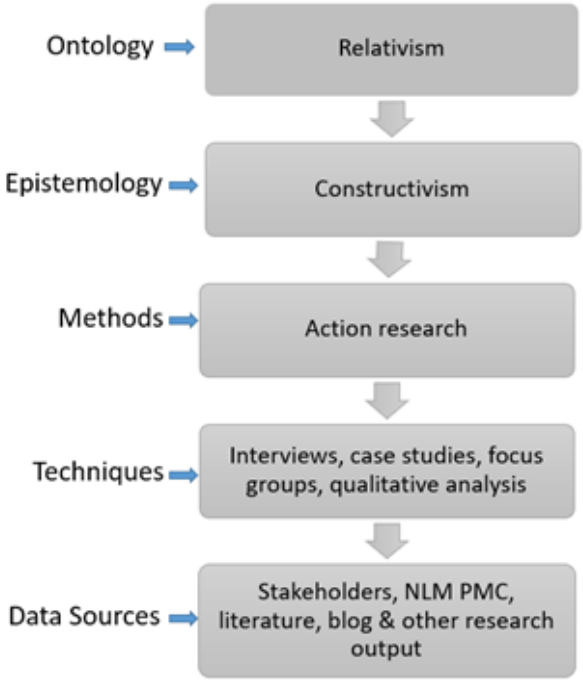


Figure 3.2 Research paradigm

3.3 Aims of this research

My research propositions were introduced in Chapter One and are also given in Table 3.1, aligned with details of their associated action research cycles.

Table 3.1 Action research cycles and research propositions

Cycle Number	Cycle Theme	Research Proposition
One	A strengths, weaknesses, opportunities and threats (SWOT) analysis to assess the support for investigating membership of PMC International	There is stakeholder interest in an investigation on the opportunity for an Australasia open biomedical repository, as a potential member of PMC International.
Two	Conceptual framework of an Australasia open biomedical repository	A KMS approach provides a sound basis for developing a conceptual framework for an OBR.
Three	Use of the KMS framework to analyse and evaluate designs for open scholarship repositories	KMS provides an effective theoretical framework for analysing and evaluating designs for repositories and platforms that support the advancement of open scholarship.

3.3.1 Research setting

The setting for three cycles of research took place with academics, librarians, executives, publishers and health practitioners undertaking or working in the field of biomedical research and open scholarship. The specific setting details related to the action research cycles follow in Table 3.2 Research setting. Videoconferencing technology (Zoom) was used to interact with research participants locally and globally during all of the cycles of research. Where possible during Cycle

One face to face meetings were conducted. However, for pragmatic reasons such as distance, travel limitations and for the convenience of the participant, Zoom was also used during Cycle One. I undertook Cycles Two and Three entirely from home because of restrictions imposed due to the COVID-19 pandemic.

Table 3.2 Research setting

Cycle	Setting
Cycle One	Universities, healthcare sector, research bodies, National Library of Australia, one academic publisher representing Australia and New Zealand, and academic and hospital libraries in Australia and New Zealand.
Cycle Two	Biomedical research bodies located in the UK., Canada and the USA and the National Library of Australia in Canberra, Australia.
Cycle Three	Biomedical academic at The University of Melbourne, Victoria Australia. Academic and higher degree students from The University of Bucharest in Romania.

3.4 The position and role of the researcher

At the commencement of this research in 2016, I was a library manager and team leader for the Faculty of Medicine, Nursing and Health Sciences at Monash University Library. From 2017–2019, I worked as the Faculty Librarian, Health and Life Sciences for The University of Melbourne. Prior to these roles I had worked in the biomedical library field at The University of Queensland and CSIRO for over twenty years. Vignettes of my academic and research career that relate to this thesis are in the Chapter Preludes.

3.5 Methods

Action research was the method adopted for this research. The aim of action research is to produce new general knowledge and address practical problems. It is particularly relevant for practitioner research because it involves the people who are experiencing the organizational or social challenges being addressed (Elden & Chisholm, 1993). The dual aims of action research are: as a means for practical problem solving, and for testing and potentially developing a model or theory. *'Action research (AR) is defined as a cyclical inquiry process that involves diagnosing a problem situation, planning action steps, and implementing and evaluating outcomes. Evaluation results in diagnosing the status quo anew based on findings from the previous research cycle.' (Elden & Chisholm, 1993)*

Action research involves an interlinked, cyclical approach to research. It is a means to combine practice and theory. The steps in action research usually include 'diagnosing a problem situation, planning action steps, and implementing and evaluating outcomes' (Lewin, 1946).

Examples of action research approaches, according to a key journal in the field, *Educational Action Research* include: the promotion of reflective practice; professional development; empowerment; understanding of tacit professional knowledge; individual, institutional and community change; and development of democratic management and administration (Williamson, 2013a).

It is widely accepted that participation by stakeholders during design and development of a system can result in a successful outcome (Markus & Mao, 2004). The dual aim of action research is a means for practical problem solving and for testing and potentially developing a model or theory (Elden & Chisholm, 1993). Figure 3.3 is a sketch created at the commencement of this action research for an Australasia OBR.

The knowledge and expertise of user participants can affect the progress of information systems development projects (He & King, 2008). A challenge of action research is determining how to deal with findings that do not meet the research community's expectations or results that are controversial (Evans, Faulkhead, Manaszewicz & Thorpe, 2012). In terms of my research, investigating an Australasia OBR, the controversy could be that a major funding body may prefer

Australasian research outputs to remain behind a paywall, rather than having them openly accessible by consumer groups and private enterprise.

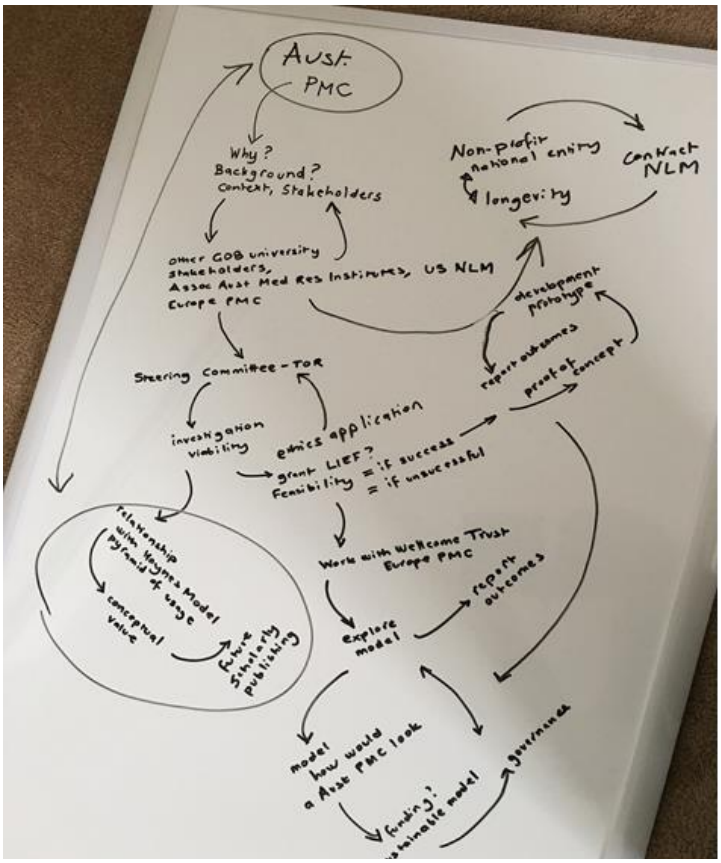


Figure 3.3 Sketch at the commencement of my action research for an Australasia OBR, 2016

3.5.1 Techniques, data sources and rigour

A variety of techniques were applied during my research, including interviews, case studies, focus groups and a workshop. Some of the data collected during Cycle Two was consolidated during Cycle Three; this is detailed in Table 3.3 Data collection for research cycles.

Table 3.3 Data collection for the research cycles

Organisations	Session details	Cycle	Session Format
University of Queensland, Monash University, QUT, Charles Sturt University, Curtin University, University of Melbourne, NHMRC, NLA, Gosford Hospital, Freemantle Hospital, *Journal Editor* from a Wiley medical journal, public hospital clinical director, Ballarat Base Hospital, Bond University, General Practice (Public), Ovarian Cancer Australia, Open Access Australasia, Australian Evidence-Based Practice Librarians' Institute	17 interviews and a focus group with 28 health sciences librarians	One	Video-conference interviews, and a focus group held on-site with the 28 librarians attending the Australian Evidence-Based Practice Librarians' Institute hosted at Flinders University, South Australia.
Europe PMC	Two interviews and email correspondence with Mr Robert Kiley, Head of Open Research at the Wellcome Trust. Dr Ginny Barbour, Executive Director, Open Access Australasia attended one of the interviews conducted.	Two	Video-conference interviews and email correspondence
Canada PMC	Three interviews were held with Dr Eveline Landa, Manager, Reference and Library Services (responsible for Canada PMC).	Two	Video-conference interviews

Table 3.3 Data collection for the research cycles - continued

Organisation	Session details	Cycle	Session Format
US PMC	Two interviews with Ms Katie Funk, Program Manager, PMC, National Library of Medicine	Two	Video-conference and in person interviews
University of NSW and University of Technology Sydney	One interview with Ms Hero Macdonald, Director, Digital Library Services University of NSW, and Dr Belinda Tiffen, Director Library Resources Unit University of Technology Sydney	Two	Interview in person held in Sydney, NSW
National Library of Australia (NLA), Executive Team	Focus group with Libby Cass (Director- Curatorial and Collection Research), Amelia McKenzie (Assistant Director General), Julia Hickie (Assistant Director of Trove Data, Discovery and Delivery) and Aileen Weir, Director, Digital Services Collaboration. Discussion and presentation given to the group by Lisa Kruesi and Heather Todd on the opportunities for an Australasia PMC.	Two	A focus group was held at the NLA in Canberra.
Epistemonikos	Dr Daniel Capurro, Board Member, Epistemonikos Foundation	Three	Video-conference interview

In accordance with action research methodology the planning stage of each research cycle includes the detail on the research, the techniques utilised and the population engaged for the data collection. A summary of where the techniques (instruments) adopted and the population selected is in Table 3.4 and the full detail is available from the following sections of this thesis:

Cycle One, Section 4.3.2 reports in detail on the 17 interviews and the focus group. Purposive sampling was undertaken to achieve comprehensive and authoritative feedback on the proposal to establish an Australasia PMC. Research participants were either colleagues or known by their professional reputation to the thesis author. The selection of participants ensured gender diversity and geographic spread across Australia. Potential stakeholders of an Australasia PMC where recruited based on their professional roles as leaders in their field, to participate in the research. Participant representation from fields of biomedical research, clinical practice and healthcare organisations, medical societies, publishing, universities and libraries was required.

Cycle Two, Section 5.3.1 reports in detail on the planning and meticulous effort undertaken to develop a KM framework. The techniques applied included interviews and a focus group. Interview and focus group participants were selected that were leaders in the field and senior authorities working with the information system of interest. Transcripts of sessions were compiled and analysed. The data gathered was used to develop and populate a KMS framework. Many iterations were devised before the latest version was compiled.

Cycle Three, Section 6.3.1-6.3.2 expands on the plans, including the methodology for the KMS framework that was applied to evaluate two information platforms and two repositories. The procedure developed is reported in Section 6.3.4. Techniques applied included literature reviews, an interview with a senior expert and consolidation of previous findings from Cycle Two. Analysis and evaluation of four information systems was undertaken to identify any gaps in the KMS framework.

Rigour is a requirement of interpretivist research (Guba, 1981). The trustworthiness of the findings of this research can be explained by the following four constructs:

1. Credibility, achieved from ensuring the analysis and findings reflect the array of realities conveyed by research participants. This research was presented at multiple professional forums, which are detailed in the section on publications during enrolment on pp. vi-vii of this thesis, where questions and discussion took place, and feedback was given by local and international audiences;

2. Transferability, whereby there are some similarities between systems and environments therefore the findings may be transferable. The four systems: Europe PMC, Epistemonikos, Trove and ResearchGate were evaluated to test the transferability of the conceptual KMS framework and is reported in Cycle Three, Chapter 6;

3. Dependability, with multiple realities and varying context, variance is inevitable though this needs to be tracked and explained, requiring research design to be reported in detail. In each of the action research cycles the detail of this research has been comprehensively recorded. In communicating with key authorities such as leaders at Europe PMC, the US NLM, IFLA, the National Library of Australia, feedback from experts was documented and reported over a period of four years; and

4. Confirmability, from transparent research activities and presenting the findings to relevant experts and wide-ranging audiences for feedback and checking. In addition, multiple sources of research data have been used, such as interviews, literature reviews, focus groups, case evaluations and a workshop.

Triangulation has been achieved from the application of a range of methods of data collection, multiple sources of data, and theoretical constructs. From the adoption of triangulation, trustworthiness of this research is demonstrated (Williamson, 2017, p. 16). A brief description of the activities undertaken during the Plan, Collect Data, Document and Reflect Cycles is summarised in Table 3.4.

3.5.2 Data analysis

This section explains the sense-making process for the qualitative and unstructured data collected. Extensive and thorough effort was undertaken to make sound knowledge claims on the basis of my findings. The process of data analysis involved:

- Meticulously transcribing interview files;
- Closely reading each data source or set and identify any points which seemed to be emerging;
- Identifying any points and themes emerging between the sources and connecting these with the research proposition being addressed;
- Thoroughly checking the data sets for differing points to challenge an emerging understanding; and
- Highlighting any unexpected data.

Manual effort was undertaken during each research cycle to analyse the data. During Cycle One, the verbatim data was imported to NVivo to test the SWOT analysis. NVivo was used to code the data transcripts into the final version of the SWOT analysis.

3.6 The action research cycles

My action research was conducted over the following periods: Cycle One from 2016–2018; Cycle Two from 2017–2020; and Cycle Three from 2019–2020 (Figure 3.4 Action research cycles).

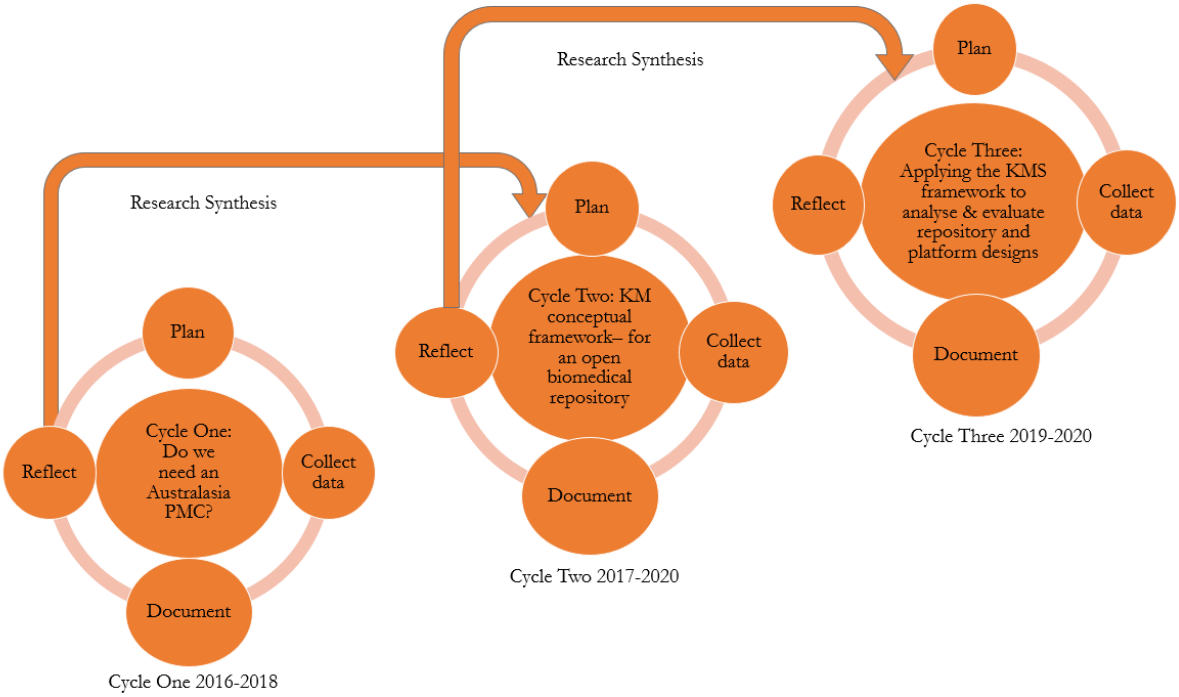


Figure 3.4 Action research cycles

3.6.1 Description of action phases

Each action research cycle was a continuous cycle of planning, collecting data, documenting and reflection. The action produced experience which at times changed the thinking related to the transition to the next cycle; one example was the decision to evaluate the KMS framework on different types of platforms and repositories in Cycle Three, following the development of the conceptual OBR in Cycle Two. A brief description of the activities undertaken during the Plan, Collect Data, Document and Reflect Cycles is summarised in Table 3.4.

Table 3.4 Brief description of the activities undertaken during the Plan, Collect Data, Document and Reflect Cycles

Phase of Cycle	Activities	Cycle One	Cycle Two	Cycle Three
Plan	Developing a strategy for collecting data, devising a procedure and action planning	Member of the Australasia PMC Working Group. Plan to consult stakeholders to gain feedback on interest in pursuing an Australasia OBR	Ongoing effort as a member of the Australasia PMC Working Group to gain an understanding of PMC International. Literature review undertaken on knowledge repositories.	A procedure for testing the KMS framework was developed. Two platforms and two repositories were identified to be analysed and evaluated.
Collect data	Collecting data, reviewing the literature, evaluating and analysing	Seventeen one-hour interviews and a focus group with 28 participants	Four interviews and a focus group that informed development of the KMS framework for an OBR	Literature reviews on two platforms and two repositories were undertaken, as was an interview with a system owner. Previous cycle findings were consolidated. Analysis and evaluation of the four systems was undertaken to identify any gaps in the KMS framework.
Document	Making sense of the experience; describing, explaining,	Transcripts of sessions were compiled and analysed using the NVivo software	Transcripts of sessions were compiled and analysed	Evaluation of one detailed case and three brief summaries of system findings. Analysing the testing and feedback from the workshop.
Reflect	Developing theory and knowledge; and drafting conclusions	Results from the data analysis were reported to the Australasia PMC Working Group, national and international conferences and library committees.	The data gathered was used to develop and populate a KMS framework. Many iterations were devised before the latest version was compiled.	The feedback from the workshop confirmed that the KMS framework could be applied effectively to assess and evaluate systems.

3.6.2 Change interventions

A change intervention is a key component of action research. For Cycle One, the intervention was the activities and recommendations of the Australasia PMC Working Group, which was set up in 2016 originally as a Steering Group for my research (Kruesi, 2016). The investigation's objective was to determine if an Australasia OBR, such as a PMC, offers a major improvement to the processes underway in the region to manage biomedical knowledge. Senior librarians who were responsible for managing biomedical knowledge participated in the action investigation. The minutes and documentation from seven Australasia PMC Working Group meetings were made available for members from a group website. The Australasia PMC Working Group ceased activity in 2019, after I put forward recommendations to the Australian Group of Eight (Go8) University Librarians, on behalf of members of the Group. Around this time, the Go8 University Librarians' along with the Council of Australian Academic Librarians (CAUL) and the Open Access Australasia group (known at the time as the Australasian Open Access Strategy Group), had commenced pursuit of an Australian National Strategy for Open Research. This is reported in more detail in Chapter Four of this thesis.

With the move to expand stakeholder and multi-disciplinary consultation by CAUL and AOASG, along with a re-elected Australian Liberal Government, which was unlikely to support a repository proposal, and the dramatic impact of the COVID-19 pandemic, the timing was not ideal to pursue an Australasia PMC implementation. The focus of the Cycle Two research was pivoted towards a deeper understanding of an OBR, through applying a KMS lens. This is reported in detail in Chapter Five. The outcome of Cycle Two was the KMS framework for an Australasia OBR.

For Cycle Three, the outcome was the finding establishing that the KMS framework was a suitable approach for analysing and evaluating designs for repositories and platforms that support the advancement of open scholarship. The evaluations to test for any gaps in the conceptual design of the OBR, by applying the KMS framework on four information systems, is reported in Chapter Six.

3.7 Research ethics

Adherence to the requirements of Monash University Human Research Ethics policies was maintained throughout the three cycles of this research project. In particular, this research entailed potentially sensitive content from interview, focus group and workshop transcripts. Approval was obtained from the Monash University Human Research Ethics Committee (MUHREC) for Cycle One and the Committee was kept informed of the research with regular reports. During Cycle Two and Cycle Three, the project's ethics application was updated based on the data collection needs, and approval was granted by MUHREC in response to these requests. The ethics approval dates and the documentation are listed in Table 3.5.

As the project involved research with humans, the ethics application included supporting documentation, including a plain language statement providing background to stakeholders about the research, explanatory statements for library staff, clinicians and researchers and consent forms (see Table 3.5 for the documentation details).

Prior to the interviews and the focus groups, participants were provided with the supporting documentation and they were encouraged to ask any questions about the research prior to or at the interview. The interest in the study was demonstrated by all of the participants who were contacted during Cycle One agreeing to be interviewed.

Table 3.5 Ethics approval dates and documentation

Cycle One	**Cycle Two**	**Cycle Three**
Ethics approved 2016 **Supporting documents:** • Appendix A1.1 Monash University Human Research Ethics Committee approval • Appendix A1.2 Email invitation to participants • Appendix A1.3a Consent form for researchers and clinicians Appendix A1.3b Consent form for library staff • Appendix A1.4 Plain language statement • Appendix A1.5 Explanatory statement for researchers and clinicians (sample) • Appendix A1.6 Interview and focus group questions	Ethics amendment 2017 **Supporting documents:** • Appendix A2.1 Monash University Human Research Ethics Committee amendment approval • Appendix A2.2 Updated plain language statement • Consent form and explanatory statements distributed for Cycle One were reused for Cycle Two with minor edits, see Appendix A1.3a, A1.3b and A1.5 • Appendix A2.3 Interview arrangements • Appendix A2.4 Interview questions	Ethics amendment 2019 **Supporting documents:** • Appendix A3.1 Monash University Human Research Ethics Committee amendment approval • Consent form and explanatory statements distributed for Cycle One were reused for Cycle Three with minor edits, see Appendix A1.3a, A1.3b and A1.5

3.8 Conceptual KMS framework: background

The initial KMS framework was developed following many iterations. It was based on the Australian KM standard. AS 5037-2005(Standards Australia, 2005). As discussed in Chapter Five, Section 5.3., the KMS framework was an adaptation of *The continuum of the knowledge ecosystem,* is taken from the Australian KM standard. This is shown below as Figure 3.5. The continuum image is in Figure 3.6 and was designed for mapping an organisation's stage of development across the knowledge ecosystem. The conceptual KMS framework adopted the elements: *people, process*, *technology* and *content* from the KM standard and further developed the framework by aligning the elements with KM processes. The conceptual KMS framework conceived by this research goes beyond organisational limits. Biomedical knowledge is a collaborative process and, whilst researchers are bound by organisational constraints, the processes from creation to translation of biomedical knowledge is not bound by such constraints.

Elements	Standalone	Connected	Networked	Adaptive
People	Individualised work functions, autonomous decision making and hierarchical structures	People work in groups or teams	Cross functional teams work together, sharing information is part of normal work activity, trust is developed in work interactions and activities	Embrace change as a normal state, high situational awareness, high levels of trust
Process	No standard processes, knowledge activities not rewarded, high levels of duplication, mistakes are hidden	Knowledge is contained in objects, processes are documented and standardised, duplication is identified and reduced	Continuous improvement, knowledge is a flow	Senior management embrace knowledge management, mistakes viewed as learning opportunities
Technology	Non-existent, information held on individual computers, lack of standards for interoperability, independent legacy systems	Email, e-business, limited use of intranets, shared drives	Collaborative tools, groupware, interoperability standards for hardware and software, customer relationship management, enterprise portals	Sophisticate intelligent search engines
Content	Messy chaotic and unstructured, ad hoc and in silos, independent pools of information held locally	Document and record management systems, decentralised and trained authors for intranet, ad hoc codification of knowledge, some content available on the intranet		Easy access to information, integrated sharing of content with suppliers and customers

Figure 3.5 The continuum of the knowledge ecosystem, from AS 5037-2005

3.9 Chapter summary

Chapter Three has discussed the research approach and methodology undertaken for this research. It includes: the aims of this research and the research setting; the position and role of the researcher; research methods, techniques and data sources utilised, and data analysis processes. Application of the research methodology for three action research cycles and the subsequent change interventions as a consequence are explained. The research ethics stages and approval process are detailed. The chapter concludes with some background on the development of the conceptual KMS framework that is expanded upon in Chapter Five.

Chapter Four:

Stakeholder interest in an Australasia PMC as an open biomedical repository

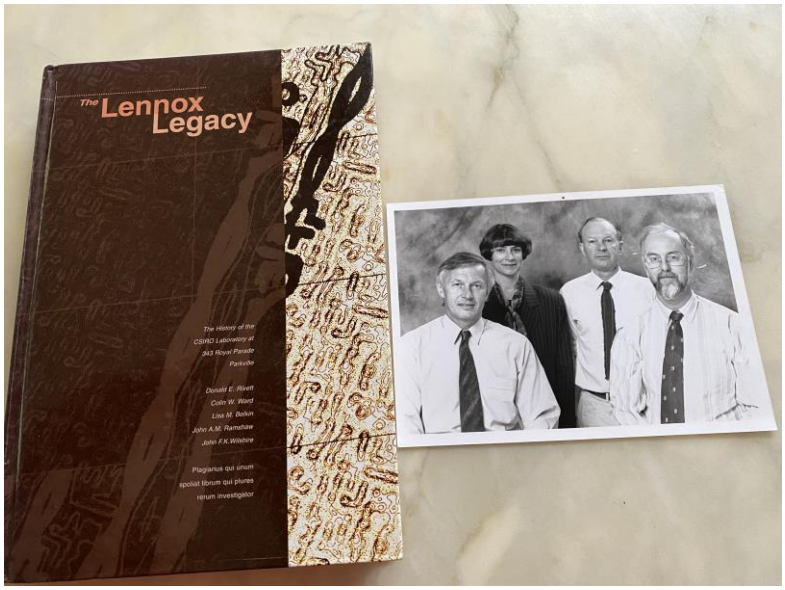


Figure 4.1 Cover of the Lennox Legacy and a photo of the authors

(details are in the Chapter Four prelude)

Prelude: The CSIRO years

I remember the interview for my first full time position at CSIRO vividly. It was early in 1986, Deputy Chief and the Human Resources Manager were on the panel. Not long after, I was offered the role, which was at the CSIRO Division of Protein Chemistry. The appointment was as a full-time Library Assistant. It turned out the Librarian-in-Charge was on leave when I commenced so I acted in her role. My predecessor had been in the role for 16 years and had done an outstanding job of establishing a comprehensive biomedical print collection. As the Librarian never returned, I took over the role in 1987. At that time there was an appointment of a new Library Officer and together we collaborated with the network of CSIRO librarians to implement the first automated CSIRO Library Network System known as CLINES. This was followed closely by my introduction of online database searching for researchers at the Parkville laboratory. During the late 1980s Current Contents became available via disks that we loaded on a computer available in the library and print journal issues were no longer circulated throughout the laboratory. Massive-size volumes of Chemical Abstracts, published by the American Chemical Society, were received weekly and we added these to the shelves in our library annex and whilst this resource was accessible as an online database it was not available directly to researchers because it was prohibitively expensive and complicated to search. Using the bibliographic software, Pro-Cite, I implemented a publications database for the Division. Whilst at the Division, over the period 1990-1991, I completed a Master of Business Information Technology at RMIT University. Over the period 1993-1995 I took on the role as a CSIRO Information Technology Awareness Trainer for the CSIRO IT Services Branch, during a major renovation of the Divisional Library. In 1997 I resigned from the Division to move to Brisbane.

A rewarding experience was working on the book, *The Lennox Legacy: The history of the CSIRO Laboratory at 343 Royal Parade* with Don Rivett (lead author) along with Colin Ward, John Ramshaw, John Wilshire (four of the Division's leading scientists) and myself (née Belkin) as co-authors (Rivett, Ward, Belkin, Ramshaw, & Wilshire, 1996). From this I gained my understanding of the production process and potential of published bibliographic datasets on research performance. Using *Proc-Cite* reference software I produced part three of the book, reporting on the patents and publications for the laboratory.

'The best way to predict the future is to create it.'
Peter Drucker

4.1 Chapter outline

This chapter analyses Cycle One of my action research. The method, the plan, the approach to collecting data, my approach to documenting the responses from participants and the thematic analysis for Cycle One are reported. A comprehensive synthesis of the strengths, weaknesses, opportunities and threats (SWOT) analysis is provided. The threads of action, new knowledge and learning are woven together in the discussion section. How Cycle One inspired plans for going forward to Cycle Two of my action research completes this chapter.

4.2 Introduction to Cycle One

The guiding proposition for Cycle One of this action research project was '*There is stakeholder interest in an investigation on the opportunity for an Australasia open biomedical repository (OBR), as a potential member of PMC International*'. The topic had not been formally addressed in the literature. This chapter expands upon my research undertaken to identify the opportunities for an OBR, based on stakeholder feedback. The research adopted a qualitative approach based on semi-structured interviews and a focus group. Forty-four stakeholders located throughout Australia and New Zealand participated in the research. Participants expanded upon their experience of PubMed, MEDLINE, PMC and their use of information resources for research and clinical practice.

4.3 Method

Action research is particularly relevant for practitioner research because it involves the people who are experiencing the organizational or social challenges being addressed (Elden & Chisholm, 1993). The dual aims of action research are for practical problem solving, and for testing and/or potentially developing a model or theory. The EBHC pyramid and KM model, introduced in Chapter Two, were the theoretical lenses for this research. The change intervention for Cycle One, which is a key component of action research, comprised the activities and recommendations made by the Australasia PMC Working Group (Kruesi, 2019; Williamson, 2013a). The data collection, research techniques included semi-structured interviews and a focus group.

The EBHC pyramid, was the theoretical model adopted to explain the use of research output contained in a PMC (Haynes, 2001). The EBHC has been widely adopted to help determine which resources to consult for answering clinical queries and to provide a perspective on the wide array of health sciences information resources available from library databases and repositories (Alper & Haynes, 2016).

This Chapter's format mirrors the continuous cycle of planning (4.3.1), collecting data (4.3.2), documenting (4.3.3) and reflection (4.4), as illustrated in Figure 4.2 The action research Cycle One. Earlier experiences gained during the Cycle are continually recycled. With all experiences systematically reviewed and analysed before the research is synthesised and progresses to Cycle Two.

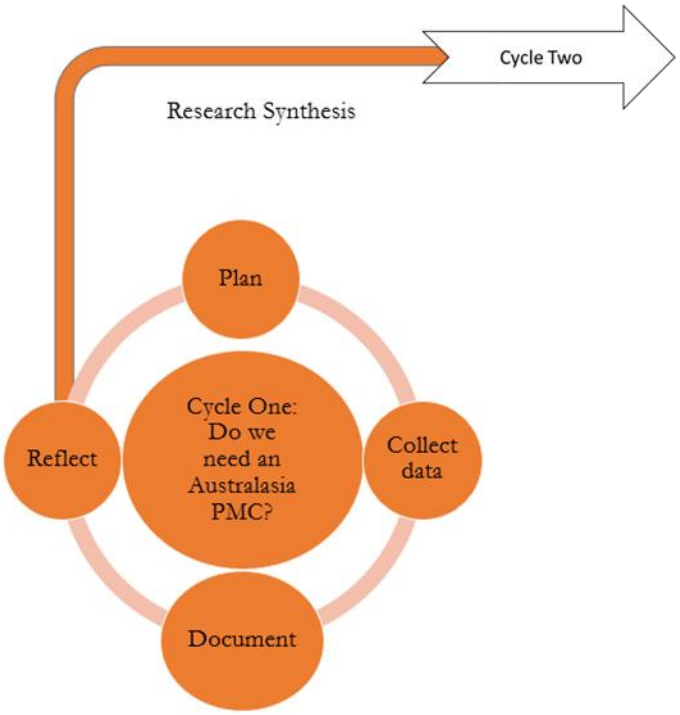


Figure 4.2 The action research Cycle One

4.3.1 Plan

Assessing the potential interest of key stakeholders in an Australasia PMC, was the objective for Cycle One. This phase of the research commenced in 2016. Members of an Australasia PMC Working Group (originally set up as an Australia PMC Steering Committee to provide advice and feedback on an Australia PMC investigation) gave feedback on the draft interview questions. When a member joined the PMC Working Group from the University of Auckland, the name of the group became the Australasia PMC Working Group. The Monash University Human Research Ethics Committee approved the study and the associated documentation; more details on the ethics application are available from Chapter Three and Appendix A.

4.3.2 Collect data

The research used purposive sampling to seek comprehensive and authoritative feedback on the proposal to establish an Australasia PMC. Research participants were either colleagues or known by their professional reputation to the interviewer. As shown in Table 4.1 Interview Groups, the selection of participants ensured gender diversity and geographic spread across Australia. The research team chose potential stakeholders of an Australasia PMC based on their professional roles as leaders in their field, to participate in the research. Participant representation was required from fields of biomedical research, clinical practice and healthcare organisations, medical societies, publishing, universities and libraries. Participants each received a study explanatory statement, a plain language briefing document and interview questions prior to either an interview or the focus group (See Appendices A1.4-A1.6). All potential 17 stakeholders accepted their interview invitation and the 28 health sciences librarians consented to participating in a focus group session. These librarians included 20 working in university libraries and 8 working in hospital libraries located throughout Australia. The focus group took place on the last day of a four-day, Evidence Based Practice Librarians' residential workshop.

Table 4.1 Interview Groups

No	Occupation	Gender	Location of interviewees	Colleague of interviewer	Interview mode
Group 1. Biomedical Researchers					
1	Head biomedical researcher	Male	Queensland, Australia	No	Zoom
2	Head biomedical researcher	Male	Victoria, Australia	Yes	Meeting on site
Group 2. Senior Executives and Open Access Leaders					
3	Senior executive (leader in open access)	Female	Queensland, Australia	Yes	Zoom
4	Senior executive (leader in open access)	Male	Queensland, Australia	No	Zoom
5	Senior executive (leader in open access)	Male	Queensland, Australia	Yes	Zoom
6	Senior executive (leader in open access)	Female	Canberra, Australia	No	Zoom
7	Senior executive & biomedical researcher (leader in open access)	Female	Victoria, Australia	No	Zoom
Group 3. Clinicians					
8	Hospital clinician & editor in chief of a medical journal	Male	Wellington, New Zealand	No	Zoom
9	Clinician & academic	Male	New South Wales, Australia	Yes	Phone

Table 4.1 Interview Groups - continued

No	Occupation	Gender	Location of interviewees	Colleague of interviewer	Interview mode
10	Clinician & academic	Male	Queensland, Australia	Yes	Zoom
11	Nursing academic	Female	New South Wales, Australia	Yes	Zoom
12	Hospital clinician & allied health practitioner	Female	Victoria, Australia	Yes	Zoom
Group 4. Health Sciences Librarians and Repository Managers					
13	Senior repository manager	Male	Western Australia, Australia	No	Zoom
14	Senior repository manager	Male	Victoria, Australia	Yes	Zoom
15	External relations, medical society	Female	Victoria, Australia	No	Zoom
16	Senior librarian	Female	New South Wales, Australia	Yes	Zoom
17	Senior librarian	Female	Western Australia, Australia	Yes	Zoom
18-45	Health sciences librarians (28)	Mixed	Adelaide, Australia	No	Focus Group

The semi-structured interviews and the focus group occurred between December 2016 and February 2017. Interview questions related to participants' experience of PubMed, MEDLINE, PMC and their use of information resources for research and clinical practice (See Appendix A1.6 for the interview and focus group questions). The 45 participants included two Head biomedical researchers, a senior executive from the Australian Research Council (ARC), a senior executive and biomedical researcher from Australia's National Health and Medical Research Council

(NHMRC), executive directors, prominent clinical academics and practitioners, university repository managers, medical library leaders located throughout Australia and a medical journal editor and retired hospital director from New Zealand. According to Creswell, a sample size of 20–30 is adequate to obtain feedback for most or all perceptions and to achieve saturation on the topic. The sample generated a sufficiently informative range of opinion on the subject matter (Creswell, 1998). There were no participant dropouts. Interviews were in person or captured using the Zoom videoconferencing system. All of the interviews took place in a workplace setting and took approximately one hour each. Twenty-eight health sciences librarians provided input in a focus group setting to the same questions answered by interview participants. Consent authorisation for use of the interview findings was obtained.

4.3.3 Documenting and thematic analysis

The first actions to document the interviews involved transcribing the Zoom video files verbatim. For the focus groups, a health librarian who was present during the session recorded the health sciences librarians' responses. Manual effort occurred in the initial stage of the research documenting and thematic analysis to group the responses in to SWOT categories. To test the SWOT grouping the verbatim files were imported into NVivo, which was used to code the transcripts in to the final form of a SWOT analysis. The trends identified using NVivo were used to finalise the SWOT analysis.

4.4 Reflect: SWOT analysis

4.4.1 Background

Interviews and a focus group with key Australian and New Zealand stakeholders revealed the strengths and weaknesses, opportunities and threats related to joining PMC International (PMCI) and establishing an Australasia OBR. Themes identified from the interview transcripts were coded as Strengths or Opportunities towards the establishment of an Australasia PMC or Weaknesses and Threats against the establishment of a potential Australasia PMC. Table 4.2 is a summary of the major themes identified.

Table 4.2 Summary of the major themes identified

PMCI Strengths & Weaknesses	**Strengths** 1. Established PMC system 2. Research linked to grant details 3. Means to achieve compliance with funding bodies 4. Promote repository services & expertise 5. Encourage retention of intellectual property by researchers 6. Consolidation of international biomedical research 7. Remove pay-wall to quality research 8. Importance of primary resources to researchers 9. Get information out of research silos	**Weaknesses** 1. Many clinicians do not read primary research 2. Information overload 3. Adequately served by existing resources 4. No guarantee of funding or means to ensure longevity of a PMC 5. Significant amount of biomedical research methodologically unsound
Australasia PMC Opportunities & Threats	**Opportunities** 1. Regional content 2. Increasing the availability & number of Australasian biomedical open access research papers, along with synthesized & filtered content 3. Lobby for regional needs & desired features in PubMed/PMCI 4. Access to repository expertise & system features 5. Reduce gap between translation of research into practice 6. Make content more discoverable 7. Foundation of Australasia Medical Library 8. Establish online collections to complement PMC 9. Means to raise quality of research 10. Source for engagement & impact evidence 11. Consolidate & integrate data-sets & increase mineable content 12. Partner with PMCI & national libraries	**Threats** 1. Institutional repositories adequately meet present needs 2. Need for a national body to make a long term commitment to establish & fund a PMC 3. Inability for sectors to work together to establish & manage a PMC 4. Convenience of present access to university online journal subscriptions to eligible clinician researchers

4.4.2 Strengths

For biomedical researchers, PubMed, MEDLINE and PMC are the foundation, primary research repositories. As funders, such as the ARC and the NHMRC, have open access policies that encourage researchers to make their articles available from open access outlets, considering an Australasian PMC for reporting on research performance is a means to achieve funding body compliance. Institutional executives and open access leaders view the PMC system, such as the Europe PMC, as a means to manage and review the output of biomedical research linked to grant details and a means to help avoid duplication of research and link related findings.

Health sciences librarians and biomedical researchers commented that an Australasia PMC might be a way of reducing the fragmentation of university repository systems by consolidating biomedical research output. They mentioned that particular areas of research could benefit, such as tropical health, indigenous health and other regional priorities. Heightening opportunities for research collaboration is another benefit raised by the librarians. (Focus group, health sciences librarians, 28 participants, Adelaide).

A key strength of an Australasia PMC for biomedical researchers specifically relates to opening up more full-text manuscripts linked to research data. A Head biomedical researcher for example, indicated that having one site would allow the data to be richly annotated and discoverable to allow researchers to download large sets and mine the content. (Interview participant, biomedical researcher, male, Victoria).

A librarian commented that there are groups that do not have access to subscription journals, proprietary bibliographic databases and other collections, such as general practitioners, clinicians outside the state and territory health service, private industry and not-for-profit community groups who would benefit significantly (Interview participant, senior librarian, female, New South Wales). According to the focus group participants, an Australasian PMC would provide ease of access and remove obstacles to full text papers.

All of the biomedical researchers interviewed indicated the importance of using primary research outputs. The clinical academics interviewed did use primary literature and commented that many of their peers did not. A participant commented that lack of access to research resources is a huge

problem for some clinicians and pointed out that some do not even know how or where to find the research output (Interview participant, senior executive & biomedical researcher, female, Victoria). A hospital librarian highlighted the importance of searching the primary studies and non-commercial publications for research on redesign of service delivery and health technology applications. She commented that, 'health technology applications is another area where we go back to the primary literature usually indexed by MEDLINE.' (Interview participant, senior librarian, female, New South Wales).

According to the librarians 'PubMed is at the base of the Evidence Based Healthcare pyramid and without that you cannot build upon the rest of the pyramid to achieve higher quality clinical information resources.' (Interview group, health sciences librarians, 28 participants, South Australia).

4.4.3 Weaknesses

Findings about the opinions on usage of full text research articles was uneven. Clinicians and biomedical researchers interviewed mentioned that the sheer volume of primary research outputs and the work required to synthesise papers is a major reason why many general practitioners do not read primary papers. A senior executive and biomedical researcher claimed that they discourage clinicians from reading the raw evidence. Based on the vast amount of subscription and other content available from libraries and societies, a PMC maybe of limited value to many Australasian healthcare practitioners. An allied health practitioner claimed, 'MEDLINE is exclusive and doesn't cover enough of the allied health sciences.' (Hospital clinician/allied health practitioner, female, Victoria).

A clinician responded that they would not use a PMC, although indicated they did use Google Scholar for answering clinical queries. The first Google Scholar landing page will usually retrieve papers from PMC, so inadvertently many clinicians already rely upon PubMed and PMC.

A repository manager explained that in Australia principles and practices of repository interoperability need to occur in order to avoid the duplication of effort taking place throughout institutional repositories. Based on the investment in repositories, according to an institutional repository manager, Australian researchers appear to be ambivalent about satisfying open access

dissemination requirements in gold and green modes; this is demonstrated by researchers' lack of enthusiasm to submit 'green' approved versions of their research manuscripts to institutional repositories in response to funder and institutional open access policies (Cullen & Chawner, 2011).

Some opportunistic predatory journals have given open access publishing a bad reputation (Hansoti, Langdorf & Murphy, 2016). Even so, the onus is on researchers to be familiar with quality research outlets in their field and avoid publishers who do not have high academic standards, as predatory research outlets should not diminish the benefits of open access scholarship (Lalu, Shamseer, Cobey & Moher, 2017; Munn et al., 2021). Most of the interviewees raised the importance of safeguarding the high standards traditional publishers have achieved over hundreds of years.

Two of the senior executives interviewed argued that Australia simply lacks the funding for PMC type projects; one executive stated, 'We don't have Wellcome Trust funding in Australia.' (Senior executive, female, Canberra). Biomedical researchers and a clinician raised the point that half of the content in journals is not reproducible and that this is a strong weakness of the published biomedical literature; this weakness only heightens the need to manage knowledge more effectively.

4.4.4 Opportunities

Health sciences librarians supported the notion that an Australasia PMC could mirror and contribute to PMCI and include biomedical content from Australian and New Zealand national libraries. The participants confirmed that the content in an Australasia PMC could include preprints, guidelines, government reports, patents, books, images and research data, such as the world clinical trial registries. An allied health practitioner argued that a PMC presents an opportunity to remove biomedical research out of silos, link to quality sites, and other core resources. The greater accessibility of resources would aid research engagement and provide an avenue for obtaining evidence of impact, which are priorities for research evaluation, such as the Excellence in Research for Australia process. A further possibility is the establishment of a regional network of medical libraries, to collaborate with a PMC; the US National Library of Medicine has

achieved this, with membership of over 6,500 libraries in their support network (US National Library of Medicine, 2021).

There is potential to leverage a PMC for hospitals and health care organisations that do not have research repositories or the expertise to set them up. According to a senior hospital library manager: 'If there was an Australasia PMC harvesting citations it may even take away the need for every small health service to have their own and this would be excellent.' (Interview participant, senior librarian, female, New South Wales). For researchers not affiliated with a university, an Australasia PMC would provide a suitable outlet to make their research openly available.

PMC can help make research more discoverable, for example, PMC contains the largest proportion of articles with open access copies, based on a sample of articles published since 2009 (Piwowar et al., 2018). Systems such as PMC provide infrastructure to discourage authors from signing away their copyright to the publishers, who resell it to agencies that have funded it in the first place. User education on Creative Commons and promotion of the system to upload manuscripts become a possibility.

Bringing together suitable authorities to determine system protocol, screen quality resources and processes based on international principles, is a benefit of managing a regional PMC. A Head biomedical researcher proposed that an Australasia PMC could be a trusted site for promulgating significant research developments that are notable for healthcare practice.

Researchers interviewed described the opportunity for an Australasia PMC to be a single portal through which to open federated datasets and a means to get beyond restrictive journal subscription paywalls. A leading biomedical researcher explained that richly annotated content would ensure discoverability and provide researchers with datasets for mining content. This effort would complement the work currently underway to develop living systematic reviews and guideline creation (Elliott et al., 2014).

Based on the EBHC pyramid design, researchers work down the levels of this model to seek relevant output to meet their research needs. Some biomedical researchers expressed difficulties with mastering specialised language for searching repositories, such as Boolean logic.

Establishment of an Australasia PMC presents an opportunity to develop a repository system with greater search and retrieval precision. It may also be possible to tackle the indexing of studies whereby the research output is unreliable or not reproducible.

The National Library of Australia (NLA) has responsibility for making national digital content available, including Australian health and medical journals, books and reports that are of potential relevance to an Australasia PMC (National Library of Australia, 2018). Using the NLA's sophisticated data aggregation processes records from university repositories could be transferable to a PMC from the NLA's Trove system.

Establishment of an Australasia PMC may be a means to transfer some of the traffic away from the 'Wild West' sites, such as Sci-Hub, where the pirating of research papers takes place and ResearchGate where users at times ignore or misunderstand copyright restrictions (Interview participant, senior repository manager, male, Victoria).

4.4.5 Threats

To become a node of PMCI requires a permanent commitment to maintain a digital archive. The commitment to open up the results of research that are publicly funded has been extensively debated and resulted in open access policies by the ARC and the NHMRC (Australian Research Council, 2013; National Health and Medical Research Council (Australia), 2018). An interview with a senior executive leader in open access provided positive endorsement for an Australasia PMC on the basis that a PMC is a proven framework and as he described 'only mundane matters such as how it would be financially supported and the longevity commitment would need to be sorted out.' (Interview participant, senior executive, leader in open access, male, Queensland).

A Head biomedical researcher, described clinical practice as 'incredibly complex and more complex with the passing of time as it tries to deal with multi-diseases in the same patient, who are treated with multiple different systems for looking after the different diseases. What might be right for a patient in a clinical trial in South Africa may be very wrong for another patient with a different set of problems, who happens to live in outback Australia. An intelligence system to screen and look at the data, so you can ask meaningful questions of it, so you are not limited to just searching a topic is required.' (Interview participant, Head, biomedical researcher, male,

Queensland). An Australasia PMC is not an immediate panacea to the information overload challenges, although it is a positive way to commence working cooperatively to contribute to a world medical library for long-term needs.

There are significant challenges in pioneering developments such as an Australasia PMC. It requires leaders from a range of fields to work together, to develop policies and infrastructure. There is the threat of organisations' inability to work together to establish and maintain a PMC.

Based on the large number of clinicians with academic titles, entitling them with access to university library collections, the present lack of motivation from this sector in changing the scholarly publishing system is another threat.

4.5 Discussion

Most interviewees agreed with exploring the opportunity to become a partner with Europe PMC as a means to capitalise on the strengths of PMCI. This is an attractive option given efficiencies gained from Europe PMC are reported to be worth around £1 billion per annum worldwide, or 20 times the direct operational cost (Beagrie & Houghton, 2016).

There are no formal measures of university compliance with open access requirements of funding bodies in Australia. Concern has been raised by researchers in studies reporting on low compliance with open access mandates in Australia (Kirkman & Haddow, 2020) and New Zealand (White et al., 2021). PMCI has been able to achieve high levels of compliance, as publishers submit author content to the repository in most cases. This removes the submission burden from the researcher and may be a key reason the PMC model is effective. It will be important for Australasian funding bodies, such as the NHMRC, ARC and the Health Research Council of New Zealand to consider the opportunities made possible from investing in a permanent and sustainable PMC.

The closure of PMC Canada suggests that some of the challenges for sectors within the healthcare industry, government and universities, to work together are difficult to resolve. The success of establishing a PMC in the European region is counter to the experience in Canada (Canadian Institute of Health Research, 2019; Ferguson et al., 2021).

An agreement with Europe PMC to establish an Australasia PMC may be the viable solution to overcome the identified threats of lack of commitment from a national body and inability to strike a deal with the US NLM.

Improving Australasian biomedical knowledge management processes may be possible from adopting a PMC for consolidated storage, retrieval and transfer processes of research linked to its underlying data. This in turn could put regional biomedical research under a stronger spotlight and potentially lead to improvements with research quality. The amount of content available from an open consolidated PMCI repository, in particular for data and text mining, will grow if Europe PMC and an Australasia PMC can combine forces (Fig 4.3 Diagram of PMC International with a potential Australasia PMC). This in turn contributes to the range of bio-reports that are possible, with flow-on benefit to industry and those groups often excluded from public research due to journal subscription paywalls.

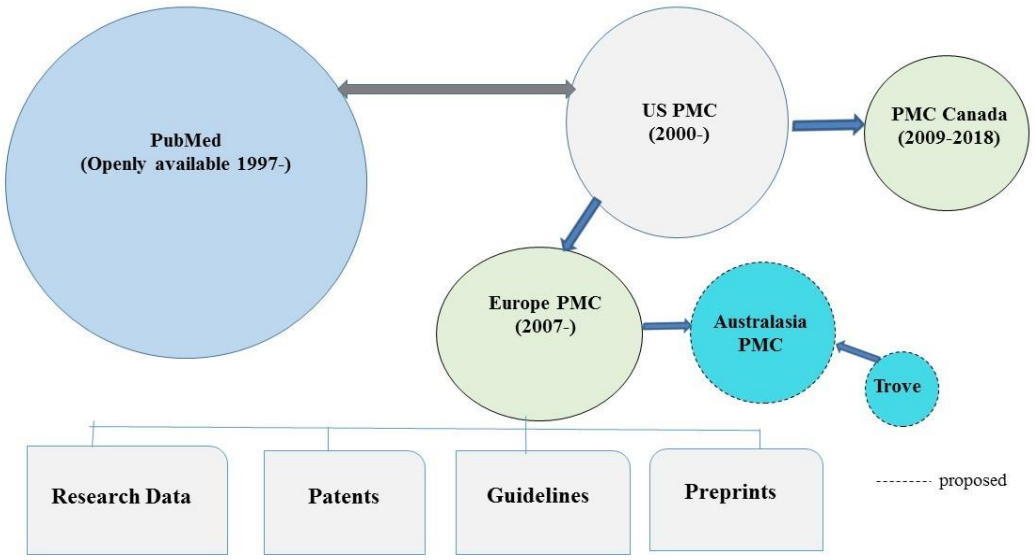


Figure 4.3 Diagram of PMC International with a potential Australasia PMC.

An Australasia PMC fits with the objective of making Australia's publicly funded research outputs F.A.I.R. (Findable, Accessible, Interoperable, Reusable) (Australian F.A.I.R. Access Working Group, 2017). It presents opportunities to enhance the clinical research cycle process and optimise

Australasian biomedical research through the establishment of a permanent archive available to all.

4.6 Inspiration for Cycle Two

The research for Cycle One was published in a leading scientific open access journal, PLOS ONE (Kruesi, Burstein & Tanner, 2019). Around this time the Australasia PMC Working Group encouraged me to seek adoption of recommendations by the Australian Group of Eight (Go8) University Librarians' Committee to proceed with the following:

- To negotiate to include all ARC and NHMRC funded research in Europe PMC
- To submit a project plan for Go8 member endorsement
- To compile a grant application, such as a Linkage Infrastructure, Equipment and Facilities grant application
- For the Go8 Librarians, Council of Australian University Librarians (CAUL) and the Australasian Open Access Strategic Group to establish governance and a project team to implement the Australasia open biomedical repository as the basis for a regional repository.

The following response was received from the Chair of the Go8 University Librarians' Group, Mr. Martin Borchert, in June 2019: *'At the Go8 University Librarians' Committee meeting I tabled the information sources you provided for a re-cap. There was a comment that maybe the CAUL review of Australian Repository Infrastructure could pick this up for comment / scope. But that's me also. I'm currently waiting for the CAUL Board to provide direction on this project since the report was tabled in March. At the meeting with the ARC & NHMRC I spoke briefly to your project and provided your resources. Both funders expressed interest to have a look at the resources, and also said funding for such an initiative would be the issue.'*

An election in May 2019 resulted in a re-elected Liberal/National coalition and library leaders at the time were not confident that this government would adopt an open science repository. Dr Barbour, Executive Director of the AOASG argued it was critical to get the timing for a regional or national open science initiative right because there would only be one chance for success and a carefully crafted approach was essential for this.

The Cycle One investigation has contributed to the development of open science infrastructure through its systematic analysis of the potential interest in, and viability of a biomedical repository

for managing openly accessible research outputs for the Australasian region. Developments in scholarly communications and digital infrastructure, along with a lack of previous reports on the topic made this work useful and timely.

Based on the need to determine the most sustainable repository system, for Cycle Two it was decided to investigate PMC International as a model and work on a conceptual design for an OBR applying a KM lens. Chapter Five provides an account of Cycle Two of the action research that entailed planning, collecting data, documenting and deep reflection upon my findings to produce a conceptual model of an OBR. Cycle Two involved the analysis of interviews, the literature and personal experience in the field, married with KM principles to create different iterations of a conceptual KMS to finally arrive at a version of the framework that is synthesised in the reflection section of Chapter Five.

4.7 Chapter summary

This research Cycle determined stakeholder interest in an investigation to establish an Australasia OBR. Research participants were representatives from key stakeholder groups, such as biomedical researchers, clinicians, open science experts, repository managers and librarians. A SWOT analysis of the interviews and focus group was undertaken and reviewed in this chapter. Sufficient interest from stakeholders validated a further investigation on a suitable OBR and/or a potential membership of PMC International.

The political environment and the uncertainty of the COVID-19 pandemic for many organisations did not provide a suitable setting or timing for the implementation of an Australasia OBR or the establishment of a relationship with PMC International. At this time, CAUL was pursuing a national open science strategy and signalling a slow and steady approach with a focus on lobbying and open scholarship educational campaigns as a priority.

Based on the environment and with the lack of ongoing activity of the Australasia PMC Working Group, Cycle Two of the research took a natural evolutionary pathway, that led to the development of a conceptual KMS framework for an OBR. The framework was a means to explore how to

develop a future open scholarship platform, either disciplinary or national, that would be sustainable and optimise existing services and resources available in the system.

Chapter Five: Knowledge Management System Framework for an Open Biomedical Repository (OBR)

Figure 5.1 The inscription Knowledge, Learning and Achievement at the entrance to the UQ Duhig Library

Prelude: Expanding networks

This prelude sums up a period of constant change and development. It was when I moved from working with an expansive network of colleagues at CSIRO to private enterprise, with smaller staff numbers and then transitioning to the university sector. This period provided a strong insight to the dynamics of *people, process, technology* and *content* as the foundations for an OBR that is the focus of Chapter Five.

I continued working for CSIRO when I moved to Queensland in 1997. I was based at the CSIRO Long Pocket Laboratories at Indooroopilly. My role was to continue leading a senior group of CSIRO librarians to undertake a review of the CSIRO Library Network. The final report was endorsed by the CSIRO Board and became the blueprint for taking the CSIRO Library Network into the 21st Century. With a need to transition to life in Brisbane, I applied for a position locally and accepted a role as the manager of a library and information service at a petroleum company. I worked at Southern Pacific Petroleum (SPP) for three years. A key project for SPP was to select and implement a records management system for the Company. I then moved on to another private company, Knowledgeone Corporation, where I worked as a software trainer. It wasn't long before I joined the company, Fisher Adams Kelly (patent and trade mark attorney) as a full-time online searcher. After one year at Fisher Adams Kelly, I met Janine Schmidt (The University of Queensland Librarian) at a networking event and she invited me to apply for a role at The University of Queensland (UQ). In late 2000 I joined UQ Library as a senior manager responsible for staff and library facilities located throughout Queensland, with a focus on medicine and the health sciences.

From the CSIRO, SPP and Fisher Adams Kelly roles, I gained a strong awareness of the importance of working beyond organisational boundaries. On reflection, it was the balance of *people*, *process, technology* and *content* elements being aligned to achieve organisational goals and outcomes that had a lasting impression. When I commenced my university library career at The University of Queensland, it was then that I embarked on supporting academics and students with knowledge creation, improved learning and ongoing achievement.

'Haste makes waste' Isogaba Maware.

5.1 Chapter outline

This chapter analyses Cycle Two of my action research. An introduction sets the scene and restates the proposition being addressed, along with the importance of the action research method and how it was applied. The plan for my Cycle Two is detailed. The section on documenting and thematic analysis is evaluated under the nine KM processes, including discovery, creation, representation, classification, storage, retrieval, dissemination, transfer and translation. The chapter closes with a reflection on Cycle Two and explains the transition to Cycle Three.

5.2 Introduction to Cycle Two

The proposition for Cycle Two was that *a KMS approach provides a sound basis for developing a conceptual framework for an OBR*. With the interest from stakeholders determined from Cycle One, I proceeded with evaluating an OBR. My action research focus applied a KM theoretical lens to tease out the nine KM processes, with each process being analysed by each of the *people*, *process*, *technology* and *content* elements. Definitions of the elements are in this chapter (Table 5.2) and the basis for this approach is described in the method section 5.3 that follows. Background to the documenting and thematic analysis is provided (Section 5.4.1) before the synthesis of the key findings from Cycle Two.

5.3 Method

Consistent with the action research approach (see Chapter Three), each Cycle of research can adopt an approach to data collection and analysis, aligned with the objectives of that cycle. In undertaking this research, reference is made back to KM theory reflecting the basis of action research, as described by Lewin, who pointed out that the results of an experiment must not only express theory but the experiment must be fed directly back to the theory (Lewin, Lippitt & White, 1939). In undertaking action research, a framework of the essential elements and KM processes was created to establish a sustainable OBR. The framework's genesis was from an Australian KM standard (Standards Australia, 2005) and was further informed from the analysis of interviews and a focus group. This chapter's format follows from Cycle One, with the

continuous cycle of planning (5.3.1), collecting data (5.3.2), documenting (5.4) and reflection (5.5), as illustrated in Figure 5.2 The action research Cycle Two.

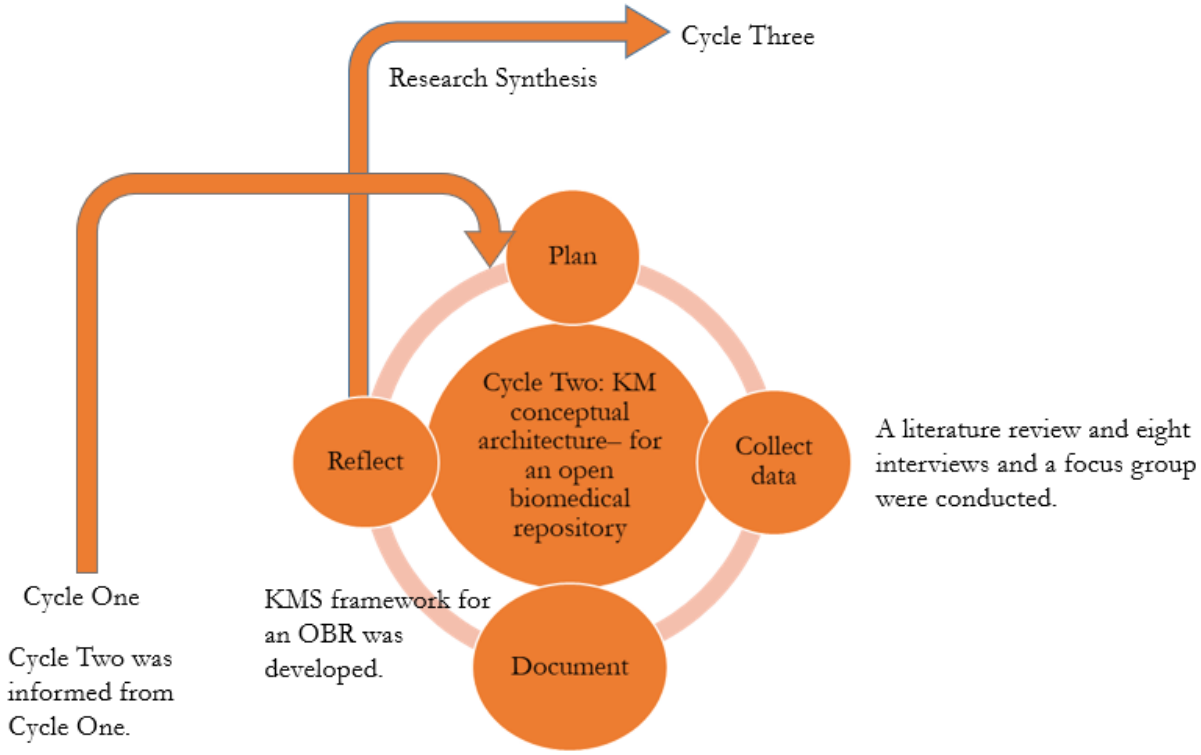


Figure 5.2 The action research Cycle Two

5.3.1 Plan

Further to the literature reviewed in Chapter Two, *2.6.2 KM processes and biomedical research workflow*, I commenced Cycle Two of my research by identifying the processes that underpin biomedical knowledge. Two research models were adopted and from these four groupings of contemporary research processes were derived. The first model was the NHMRC biomedical knowledge creation stages (see Figure 5.3), and the second was the Kramer and Bosman (2015) research workflow model (see Figure 5.4).

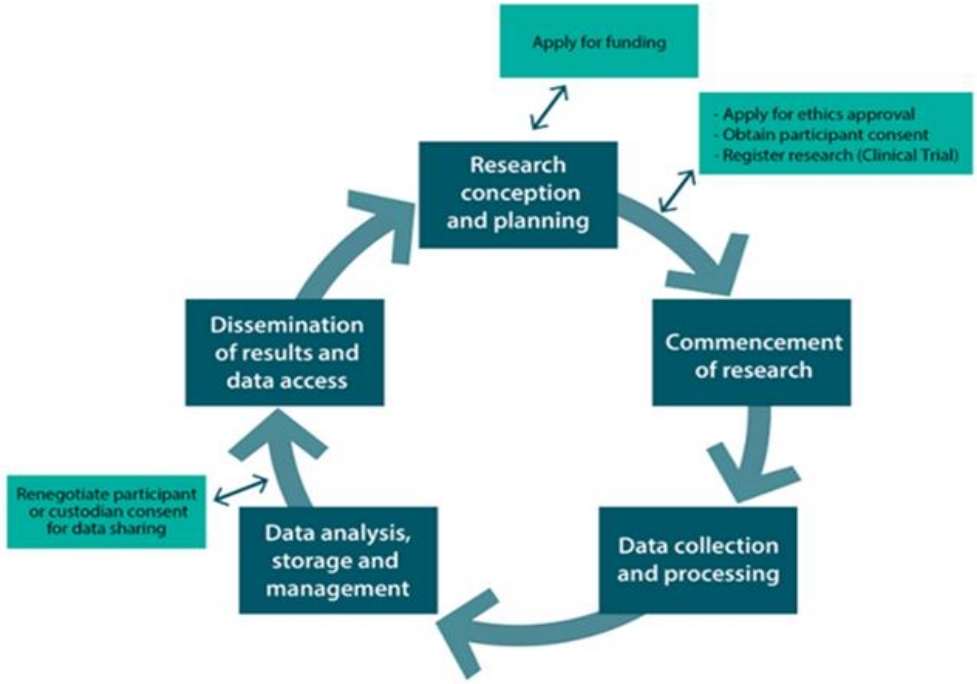


Figure 5.3 NHMRC biomedical knowledge creation stages

The National Health and Medical Research Council (NHMRC) is an Australian government authority that funds and maintains a strong integrity framework for research processes, from basic science through to clinical, public health and health services (National Health and Medical Research Council (Australia), 2019b)

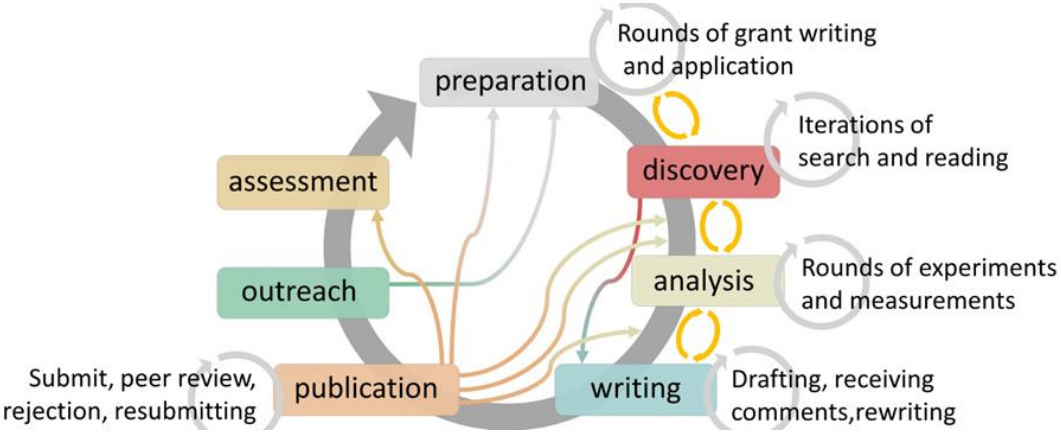


Figure 5.4 Research workflow model, Kramer & Bosman (2015)

Kramer and Bosman from Utrecht University Library in the Netherlands derived their model based on a global survey to chart the changing global landscape of scholarly communication (Kramer & Bosman, 2015). The survey undertaken from 2015 to 2016 received more than 20,000 responses. The seven most important elements in research workflow, identified by Kramer and Bosman from their data, include: *Preparation, Discovery, Analysis, Writing, Publication, Outreach and Assessment* (see Figure 5.4) (Kramer & Bosman, 2015).

It was found that KM process categories by leading KM authors overlap with the contemporary biomedical research activities in two models (Figures 5.3 and 5.4) (Alavi & Leidner, 2001; Becerra-Fernandez & Sabherwal, 2015; Kramer & Bosman, 2015; Maier, 2007; National Health and Medical Research Council (Australia), 2016). Four groupings of KM processes are in Table 5.1. Summary of KM process models that overlap with biomedical research activities. In Group 1 the KM process *discovery* overlap with the research activities, *conception, planning* and *commencement of the research* and the activities *preparation, discovery* and *analysis*. In Group 2, *storage* and *retrieval*, *capture*, and *publication*, overlap and are associated with the research activities *data collection*, *processing, analysis, storage* and *management*, and, *writing* and *publication*. In Groups 3 the KM processes of *transfer*, *sharing* and *collaboration* overlap with the research activities such as *dissemination of results* and *data access* and *outreach*. In Group 4, there is some overlap, although this

Table 5.1 Summary of KM process models that overlap with biomedical research activities

References	Knowledge Management processes			
Group	1	2	3	4
Alavi & Leidner (2001)	Creation	Storage and retrieval	Transfer	Application
Becerra-Fernandez & Sabberwal (2015)	Discovery	Capture	Sharing	Application
Maier (2007)	Discovery	Publication	Collaboration	Learning
	Research activities			
NHMRC (Australia) (2016)	Conception, planning and commencement of the research	Data collection, processing, analysis, storage and management	Dissemination of results and data access	[Translation of research]*
Kramer & Bosman (2015)	Preparation, discovery and analysis	Writing and publication	Outreach	Assessment

**Translation of research into healthcare policy and practice is one of the NHMRC's primary responsibilities*

group has some variation for example, the KM processes *application* and *learning* overlap, although assessment, as defined by Kramer & Bosman, entails metric tools, websites and platforms for measuring the uptake of digital research output. The uptake of research output does overlap with translation into practice, as the metrics may indicate the research is of relevance to certain users or contrastingly the output may just be controversial. The translation of research into healthcare policy and practice is a primary responsibility of the NHMRC but was not present on their research cycle (see Figure 5.3). Given the significance of the translation process to the role of the NHMRC (National Health and Medical Research Council (Australia), n.d.), this process was added to Table 5.1.

This was an embryonic stage for the KMS framework. Much work remained to determine and define the major biomedical KM processes and their suitable order in the research cycle. As a digital repository is a set of systems and services that ingest, store, manage, display, retrieve and allow reuse of digital objects (Pinfield, Salter, Bath, Hubbard et al., 2014), understanding elements and components of a repository in the biomedical knowledge management research chain of events was integral to the creation of a framework to achieve a sustainable OBR blueprint for the future.

The *people*, *process*, *technology* and *content* elements for each of the KM processes that are critical in the conceptual framework for an Australasia OBR were analysed and reported. As previously mentioned, the *people*, *process*, *technology* and *content* model was adapted from the Australian standard, *Knowledge Management – a guide* (Standards Australia, 2005). This standard established that the organisation of knowledge is an ecosystem that consists of a complex set of interactions between these four elements. The need for balance amongst these four elements is stressed by the Australian standard and it is argued that one element should not be developed at the expense of another (Halbwirth & Sbarcea, 2005; Standards Australia, 2005).

5.3.2 Collect data

In Cycle One, as reported in Chapter Four, endorsement was given from 45 stakeholders to proceed with research on the feasibility and opportunities for adopting an OBR (Kruesi, Burstein & Tanner, 2019). Following this, the Australasia PMC Working Group recommended that I

interview key staff members from US PMC, Europe PMC and PMC Canada (which formed PMC International) to gain an understanding about these repositories as potential models for an Australasia OBR. I organised interviews using the Zoom videoconferencing system with the overseas contacts. The interviews were framed using my KMS lens and took place with relevant staff from the US National Library of Medicine (NLM), Europe PMC and PMC Canada. The interviews took approximately one hour each. Table 5.2 provides the data collection details for Cycle Two. This is also reported in Chapter Three, in Table 3.2 Data collection for the research cycles. In-person, one-hour interviews were held with the PMC Program Manager from the US NLM and Australian academic library directors. Four library executives provided input in a focus group setting held at the NLA. Consent authorization for the interviews and focus group sessions was obtained. The interviews adopted a semi-structured format. Transcripts of the sessions were captured and analysed.

Data was also gathered from Australian sources. A focus group session was held in person with executive staff from the National Library of Australia in Canberra and I later organised a joint interview, in person, with two NSW academic library managers; these details are summarised in Chapter Three. The information garnered from the participants, in addition to details from the literature, along with my professional experience, was used to develop a conceptual KMS framework for an OBR.

Table 5.2 Data collection for Cycle Two

Organisation	**Session details**	**Cycle**	**Session Format**
Europe PMC	Two interviews and email correspondence with Mr Robert Kiley, Head of Open Research at the Wellcome Trust and Ms Lisa Kruesi. Dr Ginny Barbour, Executive Director, Open Access Australasia attended one of the interviews.	Two	Video conference interviews and email correspondence

Table 5.2 Data collection for Cycle Two - continued

Organisation	Session details	Cycle	Session Format
Canada PMC	Three interviews with Dr Eveline Landa, Manager, Reference and Library Services.	Two	Videoconference interviews
US PMC	Two interviews with Ms Katie Funk, Program Manager, PMC, National Library of Medicine.	Two	Videoconference and in person interviews
University of NSW & University of Technology Sydney	One interview with Ms Hero Macdonald, Director, Digital Library Services and Dr Belinda Tiffen, Director Library Resources Unit.	Two	Interview in-person held in Sydney
National Library of Australia (NLA), Executive Team	Focus group held with Ms Libby Cass (Director—Curatorial and Collection Research), Ms Amelia McKenzie (Assistant Director General), Ms Julia Hickie (Assistant Director of Trove Data, Discovery and Delivery) and Ms Aileen Weir, (Director, Digital Services Collaboration). This discussion followed a presentation given to the group by Ms Lisa Kruesi and Ms Heather Todd on the opportunities for an Australasia PMC.	Two	Focus Group held at the NLA in Canberra.

My first presentation on this research was at the international conference, Open Repositories (Kruesi & Macdonald, 2017). The interviews with leading staff from Europe PMC and Canada PMC were framed using the KM processes identified. The interview questions are available from Appendix A2.4.

During the period from 2017 to 2019, a range of presentations and papers were delivered to national and international audiences and these provided valuable feedback for this research (Kruesi, 2018a, 2018b; Kruesi, Burstein, Tanner & Todd, 2018; Kruesi & Macdonald, 2017; Kruesi, Tanner & Burstein, 2018).

An early version of the framework was presented at the International Federation of Library Associations and Institutions, World Library and Information Congress (Kruesi, Tanner & Burstein, 2018). At this stage, I had only identified seven processes, including *discovery, creation, representation, storage, retrieval, transfer* and *application.*

A keynote address was given at the annual national meeting for the ALIA Health Libraries Australia, titled: *To be or not to be? The prospects for an Australasia PMC (Kruesi, 2018b).* Stage One of the research was introduced to the Australian health libraries sector and a graphic illustrating the conceptual framework that was presented at this forum follows as Figure 5.5

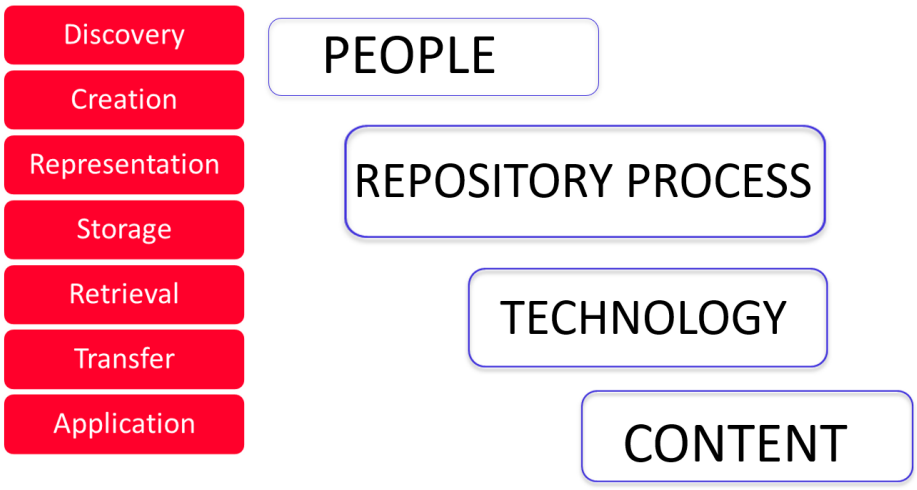


Figure 5.5 Australasia OBR conceptual framework Stage One (July 2018)

At this time in 2018, two leading Australian research universities—The University of Melbourne and The University of Queensland—were only achieving compliance with open access mandates of between 20–25%, whereas PMC was achieving 82% compliance with NIH and 75% compliance for funder requirements for open articles to be made available from Europe PMC (Van Noorden, 2014a; Wellcome, 2017).

The conceptual framework, Stage Two, was later presented at the NHMRC's annual symposium held in November 2018, in a diagram (See Figure 5.6) that illustrated the importance of achieving balance across the elements *people*, *repository process*, *technology* and *content* (Kruesi, Burstein, Tanner & Todd, 2018). The element 'repository process' would later become just 'process' based on the wide array of 'how to' elements identified as required for an OBR.

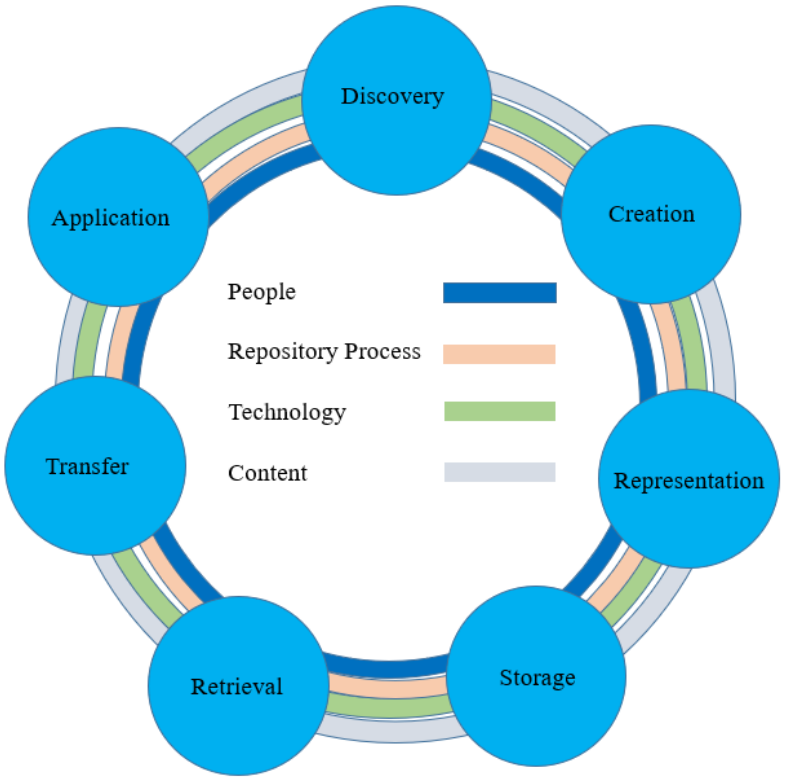


Figure 5.6 Australasia OBR conceptual framework, Stage Two (November 2018)

At a later stage of the framework's development (Stage Three) KM processes were mapped against biomedical research activities, to bring together a set of nine key knowledge processes. These included discovery, creation, representation, storage, classification, retrieval, dissemination, transfer and translation. This framework went beyond previous frameworks, such as the Institutional and Development (IAD) framework, as it is standards-based and operationalises a comprehensive system of knowledge (Hess & Ostrom, 2006) that is aligned with the elements *people, process, technology* and *content*. The *people, process, technology* and *content* aspects of each PMC repository were the focus of the interviews; the approach from the Australian KM standard was adapted with the elements being defined as *people* addressing the 'who', the *process* the 'how', the *technology* the 'tools' and the *content* the 'what' (Standards Australia, 2005). Table 5.3 provides definitions of the elements.

Table 5.3 Definitions of the elements, adapted from the Australian Standard on KM

Element	Definition
People	The 'who' such as researchers, practitioners, professional staff, support staff, publishers, editors, and consumers. Includes the culture and environmental aspects.
Process	The 'how' and includes regulations, standards, rules, guidelines, plans, priorities, checklists, codes, instructions, taxonomies, protocols, policies, procedures and other explicit knowledge sources.
Technology	The 'tools' such as software, hardware, storage, digital systems, platforms, databases, websites and expert systems.
Content	The 'what' such as research data, metadata, database records, classification schemes, articles, videos, graphs, maps, visualizations, reports, and other digital objects.

The interviews and focus group results were analysed and these details combined with findings from the published research in the field were synthesised to determine all the requirements for an OBR. The essential *people, process*, *technology* and *content* elements of an OBR are detailed for each of the nine KM processes. The framework comprises elements that exist independently from a repository platform although are required to achieve a sustainable system. As the descriptions focus on the essential components for a sustainable OBR, not all of the elements, *people, process, technology* and *content*, feature within each of the nine processes. The framework is recommended to plan for an OBR and transition towards Open Science. A diagram, which became Stage Three of the conceptual framework of the KM Processes for a sustainable OBR is illustrated in Figure 5.7.

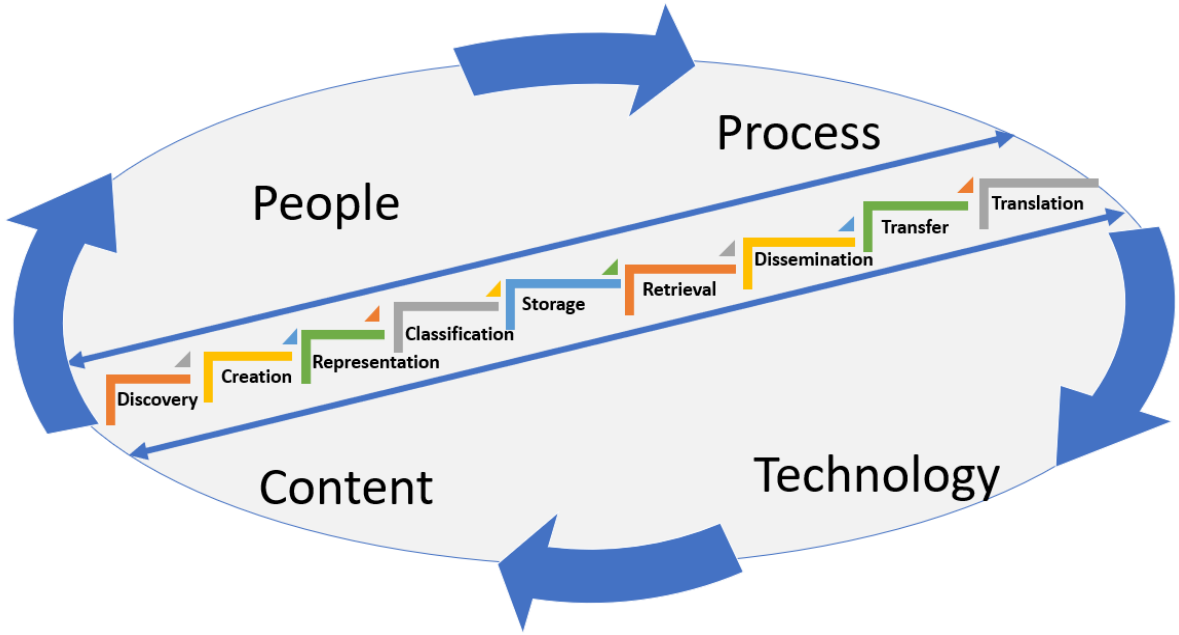


Figure 5.7 KM Processes for a Sustainable OBR, Stage Three

5.4 Documenting and thematic analysis

5.4.1 Background

This section provides an analysis of the interviews and focus group results and the published research in the field. The essential *people*, *process*, *technology* and *content* elements of an open biomedical

repository are described for each of the nine KM processes. The framework comprises elements that exist independently from a repository platform although are required to achieve a sustainable system. As the descriptions focus on the essential components for a sustainable open biomedical repository, not all of the elements, *people, process, technology* and *content*, feature within each of the nine processes.

5.4.2 Discovery

Knowledge discovery process occurs with the development of new tacit or explicit knowledge from data and information or from the synthesis of prior knowledge (Becerra-Fernandez & Sabherwal, 2015). Researchers, the *people* aspect of discovery in biomedicine, review existing knowledge by undertaking searches in biomedical databases and using search engines to identify gaps in knowledge. Knowledge (the *content*) is recorded in bibliographic databases, such as MEDLINE as well as various specialised molecular biology databases, such as the Entrez series of databases by the US NLM National Center for Biotechnology Information. These resources provide an opportunity and a need for developing advanced methods and tools for computer-supported knowledge discovery (the *technology*). For example, it is possible to search for genes that cause a particular disease or for drugs that treat that disease (Hristovski, Peterlin, Mitchell & Humphrey, 2005). Analysis of scientific texts through text-mining systems are common approaches to help with the discovery aspect of biomedical research (Jensen, Saric & Bork, 2006).

5.4.3 Creation

New knowledge is created through a combination and exchange of diverse and overlapping knowledge inputs, generated when researchers interact (Polanyi, 1966; Schumpeter, 1934). Knowledge creation involves the generation of facts, relationships, and insights that are new to the existing body of knowledge (Arrow, 1962). New knowledge is typically intangible when it is created, but it can be converted into new products, patents, publications, and other tangible forms (Nonaka & Takeuchi, 1995). Over the past three decades, open scholarship mandates and data management principles have evolved. The open universal approaches on knowledge creation are being guided by the FAIR (Findability, Accessibility, Interoperability and Reusability) principles (Wilkinson, Dumontier, Aalbersberg, Appleton et al., 2016).

The *people* element of creation relates to researchers undertaking data analysis and other investigation activities. It also includes the role of funding bodies who steer and underpin creation efforts (Europe PMC, 2020b). Others include those who create the databases and repositories, such as PMCI, and the publishers who copy-edit and provide platforms for research output.

Creation *processes* are influenced by priorities set by government and research organizations in response to public needs. Excellence in Research for Australia (ERA) is a periodic government *process* that determines research priorities and discipline strengths for Australian universities. The ERA *process* has a significant impact on creation. Higher Education Research Data Collection is undertaken by Australian universities on reporting requirements to obtain research and development income data. This *process* also influences research output creation activities in the Australian higher education sector. Funding bodies lead creation, for example, Europe PMC has 33 funders who expect that research outputs they fund will be made freely and readily available (Europe PMC, 2020b). These funders administer a *process* to drive behaviour and steer creation in the research sector.

Technology for creation involves access to a wide array of repositories to support research investigations. In particular, researchers (*people*) use *technology* such as open biomedical literature repositories like PMCI, along with *content* data repositories such as DataMed and Dryad Data Repository (Ohno-Machado et al., 2017; Roberts et al., 2017). Such repositories link to databases such as ENA, PDB, ArrayExpress, UniProt, RefSNP, OMIM, Pfam, RefSeq, Ensembl, InterPro, Bioproject, Biosample, EMDB, PXD, EGA, and TreeFam (Kim, 2015). The *content* to support creation is made available in research protocols, research data and research objects; all of these help with determining the novelty of the research and its contribution to existing knowledge.

5.4.4 Representation

Representation comprises explicit knowledge in the form of digital scholarly objects. Tuomi argues that structured knowledge becomes information when assigned a fixed representation and it is a standard interpretation as data (Tuomi, 1999). Knowledge representation may be in the form of publication, which is joint authoring, structuring, contextualizing and release of knowledge elements supported by workflows (Maier, 2007). The *people* element includes copywriters, editors

and graphic designers working for publishers, who have a major role in determining publishing styles.

In biomedical research, *process* is achieved from international protocols and *people* networks to continually develop and improve research output standards and practices. For example, the Equator Network promotes transparent and accurate reporting of health research findings to improve the impact and reliability of biomedical research articles (UK Equator Centre, 2020). The International Committee of Medical Journal Editors (ICMJE) aims to improve the quality of medical science and its reporting. The ICMJE editors make recommendations for the conduct, reporting, editing and publication of scholarly articles in medical journals (International Committee of Medical Journal Editors, 2020). The ICMJE and the Equator Network are bodies that influence the biomedical knowledge representation *process* in the form of instructions, standards, checklists and codes; examples include the Consolidated Criteria for Reporting Qualitative Research (COREQ), and the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) (UK Equator Centre, 2020). The Committee on Publication Ethics (COPE) defines best practice in the ethics of scholarly publishing and assists editors and publishers to achieve this (Committee on Publication Ethics, 2021). There are other *processes*, such as the US NLM expecting publishers to have at least a two-year history of quality scholarly publishing in the life sciences prior to their consideration of their journal for PMC; this serves to set rigorous standards for inclusion of only quality biomedical content (US National Library of Medicine, National Institutes of Health, 2021).

The *people* and t*echnology* elements of representation are achieved in an OBR, such as PMC, in the following ways:

- by publishers, some of whom make all of their content available at the time of publication (for example, PLOS, BMC and eLife);
- by publishers who make individual articles available at the time of publication in hybrid journals,
- by authors who self-archive the author manuscripts in PMCI and

- by publishers who deposit the peer-reviewed manuscripts for free on behalf of authors (for example, Nature Publishing Group does this for all articles acknowledging funding from Europe PMC Funders) (Europe PMC, n.d.).

5.4.5 Classification

Taxonomies, also called classification or categorization schemes, are considered to be knowledge organization systems that serve to group objects together based on a particular characteristic. For example, keywords to describe research output are assigned by researchers. PubMed articles are assigned descriptors by librarians from the controlled and hierarchically-organised vocabulary published by the NLM, known as Medical Subject Headings (MeSH) (US National Library of Medicine, 2020a).

Classification processes involve *people* in creating, making and revising rules for naming and describing research output. For example, rules for naming may be governed by international bodies such as the International Association for Plant Taxonomy (IAPT), which governs plants, and the International Commission of Zoological Nomenclature (ICZN), which governs the naming of animal taxon. (*Note: Agricola, an agricultural database, is available from Europe PMC*).

Technology is used to provide automated classification systems, for example PubMed uses Solr, an open-source enterprise for document indexing. Unified Medical Language System (UMLS) integrates and distributes key terminology, classification and coding standards, and associated resources to promote creation of more effective and interoperable biomedical information systems and services, including electronic health records (US National Library of Medicine, 2019).

Classification schemes and ontologies are used by repositories to allow users (the *people* element) to navigate the *content*, for example, Europe PMC researchers use GO, UniProt, EFO, ChEBI, NCBI Taxonomy and UMLS as ontologies in the biological *content* to 'achieve a common understanding of the categories of objects described in life sciences data and the labels used for those categories' (Stevens, Rector & Hull, 2010).

5.4.6 Storage

Storage comprises computer components and recording media used to retain digital data. Databases and repositories require storage for metadata and content. In the 21st Century, the speed of mass data production and deposition necessitates creative solutions for data storage and computing infrastructure (Cook, Bergman, Cochrane, Apweiler, & Birney, 2018). For repositories, storage is disk space available using a file system on top of storage hardware. Storage usually defines where the *content* resides.

Open biomedical literature repositories accommodate human data entry and publisher entry (the *people* element) of metadata and full text content. An OBR has an archival role. For example, the PMC manuscript submission system applies a standards-based approach for *content* preservation and has adopted the eXtensible Markup Language (XML) format to allow text mining. The preservation of associated data, such as clinical trials, is a priority (NLM Program Manager, 2019). Continuous improvement of the technology infrastructure takes place. A strict privacy policy is administered by PMC and no individual system user details are made publicly available. Standards-based systems are adopted to help ensure ongoing preservation of *content* and to enable text mining.

Since 2006, when funding bodies such as the NIH, NHMRC, ARC and the European Union established open access publishing mandates requiring that their funded research be stored in repositories, the transformation of scholarly publishing through these processes was set in motion. During the period that PMC Canada was active, 2009–2018, the *process* allowed manuscripts to be submitted to either an institutional repository or the PMC repository and neither *process* was mandatory. It was stated that 'when you give many options people often take the path of least resistance, which might be super-positive or might be just doing nothing' (NLM Program Manager, 2019). The failure of PMC Canada to provide clear *process* contrasts with the success of the clear, although at times cumbersome, processes of the US PMC. For example, in 2008 the US Congress mandated submission of certain funder research output to US PMC. The process was strengthened further in 2013 when every research output detailed in a government grant application had to be made openly available in PMC. This process helped to achieve 90% compliance with the open access policy. In an interview, the Manager of PMC Canada gave the definition that PMC Canada is exclusively about technology, and the repository's KM role is primarily to store what is being

discovered and it is not involved in the creation of knowledge. The lack of acknowledgement of the interrelationship of elements within a KM system and their interplay with biomedical research activities and open science may be one of the factors contributing to the closure of PMC Canada (Landa, 2018).

The 'Group of Eight' leading research universities in Australia, and other international research university networks have formed the Sorbonne Declaration on Research Data Rights. The declaration calls on governments to develop laws/policies to 'avoid a 'lock-in effect' from commercial platforms and data services to ensure the openness and the reusability for research data' ("Sorbonne declaration on research data rights," 2020). Storage *processes* are based on international standards, such as preservation and interoperability standards (Digital Preservation Coalition, 2015; International Organization for Standardisation, 2017; National Archives of Australia, 2018).

Storage *process* requires adherence to open standards, for example, PMC submissions must be in XML format that conforms with an acceptable journal article DTD (Document Type Definition). PMC stores content in XML, which represents the structure and meaning of a document in a human-readable form (US National Library of Medicine, 2020b). All PMC *content* is converted to and stored in the NISO Z39.96-2015 JATS XML format. This is the commonly used archival format for journal articles (US National Library of Medicine, 2020b).

Research data is stored in a format to meet the FAIR (Findable, Accessible, Interoperable and Retrievable) principles that have been established to share and reuse data (Wilkinson, Dumontier, Aalbersberg, Appleton et al., 2016). *Content* needs to be stored in a standard way that can be efficiently migrated to future systems. Standards such as the OAI-ORE (Open Archives Initiative, Object Reuse and Exchange) have helped to transform content management in repositories. OAI-ORE can bind knowledge objects into publications and allow the reuse of knowledge objects by storing these items in collections (Tarrant et al., 2009).

5.4.7 Retrieval

Two broad types of information retrieval are the pull model, that involves search for and retrieval of information based on specific user queries, and the push model, where information is

automatically retrieved and delivered to the potential user based on some predetermined criteria (Alavi & Leidner, 2001). Retrieval is enhanced by search support functions, such as online classification schemes, for example MeSH (Medical Subject Headings), search tips and Boolean search options (Maier, 2007). Information retrieval entails finding research references based on search algorithms that interrogate internet or database metadata or full-text articles. Researchers, funders, industry, research support staff and consumers (the *people* element) apply tacit and explicit knowledge to create search strategies to retrieve research output. PubMed provides a search and retrieval platform for biomedical and life sciences literature with the aim of improving health—both globally and personally (US National Library of Medicine, 2020c). The retrieval interface for PubMed received a major overhaul in 2020, demonstrating the importance of constant improvement processes and the technology (Collins, 2019). The new release of PubMed included improvements to advanced search features, term mapping based on an algorithm to retrieve the best match, new cite links and additional search filters. Plain language summaries for research articles are made available by publishers. The new PubMed links to secondary source sites such as ClinicalTrials.gov, GenBank, Figshare and Dryad when these sources are available from a research article.

The Open Archives Initiative Protocol for Metadata Harvesting (OAI-PMH) standard underpins the development and promotes interoperability standards that help to facilitate the efficient dissemination of content. As PMC is OAI-PMH compliant, this makes retrieval of *content* from this repository very effective in comparison to many institutional repositories which often are not OAI-PMH compliant. The fundamental technological framework and standards are a means to open up access to a range of digital objects ("Open Archives Initiative Protocol for Metadata Harvesting," 1999).

The *process* for achieving gold standard quality levels of systematic review searches is defined, for example by the Cochrane Handbook 2019, the Campbell Methods Guides 2016, the CEE Guidelines and the Standards for Environmental Evidence synthesis 2018 (Collaboration for Environmental Evidence, 2018; Kugley et al., 2017; Lefebvre, Glanville, Briscoe, Littlewood et al., 2021). It is not possible to rely upon open systems alone for search retrieval, as there is 'no [avoiding] proprietary search systems if one attempts a rigorous systematic review' (Gusenbauer & Haddaway, 2020).

OBR technology for retrieval of research output combines interoperable systems that aggregate content (publications and data) from other sources; for example, US PMC and Europe PMC have APIs for reuse of content where permitted. OpenAIRE, Unpaywall, PubMed Linkout are linking tools bringing together disparate content and have revolutionised access to the effective retrieval of research output beyond organizational boundaries (Artini et al., 2015).

International biomedical research resources exist, such as the Entrez Programming Utilities (E-utilities) at the US National Center for Biotechnology Information (NCBI) for biomedical research objects and national approaches such as the NLA's TROVE for multi-disciplinary coverage; these are two examples that offer open content for retrieval of biomedical knowledge (Sayers, 2010-). In addition, there are meta-search platforms (t*echnology* and *content* elements) for retrieval of vast biomedical research objects, e.g., Accessss, Epistemonikos and Trip (Health Sciences Library, 2020). Other directories of repositories to widen the net for sourcing biomedical research content are the Directory of Open Access Repositories (OpenDOAR), the Directory of Open Access Journals (DOAJ) and SATORI (Semantic AnnoTations and Ontological Relations Interface) (DOAJ, 2003-; Lekschas & Gehlenborg, 2018; University of Nottingham (UK), 2005-).

5.4.8 Dissemination

Dissemination ensures knowledge is available to those who need it (Kingston, 2012). The *people* element involves presentations at conferences, personal communications and systems, such as social media, that are used to disseminate research objects. Informal mechanisms, such as unscheduled meetings or seminars may be effective in promoting socialization but may preclude wide dissemination (Holtham & Courtney, 1998). Repositories may be the most effective means for disseminating knowledge that can be readily generalised to other contexts (Alavi & Leidner, 2001).

The *process* of dissemination is often detailed in policies, procedures and guidelines in relation to submissions for OBR. Organizations such as the NHMRC, ARC, NIH, universities, other research bodies and publishers specify the timing and dissemination requirements in their open access policies. The US Public Access Policy had a significant influence on depositing of research in the

US PMC by researchers (*people*) by imposing penalties for failure to comply with the requirement to publish their research openly.

One billion articles are retrieved each year from US PMC by researchers (*people* and *technology*), which demonstrates the dissemination success of this biomedical repository (NLM Program Manager, 2019). The Manager of PMC Canada reported that their site had four million article downloads and that most of these were made by users in China. In relation to dissemination and as a security measure, bulk downloads from the US PMC and Europe PMC are restricted due to copyright. Social media sites, such as ResearchGate and Academia.com foster online communities of practice and rely upon *content* from repositories such as PMC International.

Bibliographies and reference lists are effective at setting the format for the dissemination of research objects (*content*) and these are based on referencing standards, which are detailed in library guides. These guides are managed outside of repositories, although they are integral to the quality and consistency of reporting biomedical knowledge.

5.4.9 Transfer

Transfer is the conveyance of knowledge from one place, person, organization to another such entity (Major & Cordey-Hayes, 2000). The most important aspect of KM in the organizational setting is the transfer of knowledge to the location where it is needed and can be used (Major & Cordey-Hayes, 2000). The transfer of public research resources from government to universities is intended to generate common knowledge, provide instruction, and serve the public (Stevens & Bagby, 2001). Transfer involves clarification of the terms and conditions between relevant parties in relation to use of the *content*. Transfer involves transmission (sending or presenting knowledge to a potential recipient) and absorption by that person or group. 'Transmission and absorption together have no value if the new knowledge does not lead to some change in behaviour, or the development of some idea that leads to new behaviour' (Prusak & Davenport, 1998).

Executive and senior staff (*people*) in research organizations and industry refer to repository output to identify content relevant to transfer agreements. The knowledge transfer process takes place through patenting, licensing, contracts, trade secrets, joint ventures with inventors and commercial spin-offs (Stevens & Bagby, 2001).

The *Mind the Gap* report details systems (*technology*) for open knowledge databases and search platforms (Maxwell et al., 2019). Text and data mining systems are key *technologies* to aid the technology transfer process. Integration of repositories with Current Research Information Systems (CRIS) occurs in institutions as a means to optimise research knowledge (euroCris, 2020; Summers & Evans, 2020?). *Content* can be transferred and interoperable between systems based on international standards. For example, the FHIR (Fast Healthcare Interoperability Resources) is available for the transfer of healthcare information, including research articles (Health Level Seven International, 2019).

The *people* element dominates in the transfer KM process, as identified during creation of the framework for an OBR. It is evident that the interoperable characteristic of the research data (*content*) needs to seamlessly move to interdependent systems (*technology*), such as CRIS, as a key aspect of the transfer *process*.

5.4.10 Translation

Knowledge translation involves 'the synthesis, dissemination, exchange, and ethically sound application of knowledge to improve health, provide more effective health services and products, and strengthen the health care system' (Straus, Tetroe & Graham, 2009). The conundrum for biomedical researchers (*people*) can be in applying findings from the research literature as a result of irreproducible findings. Biomedical researchers from drug companies have reported that approximately one-quarter of high-profile papers are reproducible. The gravity of this problem is indicated by the cost of irreproducible published results, which is estimated to be US$28 billion (Freedman, Cockburn & Simcoe, 2015). Contrastingly, 'big data analytics for the medical field, is viewed as a potential panacea that will potentially save more than $300 billion per year in US health-care costs' (Luo, Wu, Gopukumar & Zhao, 2016). The future challenge for OBR is to achieve the *process* and *technological* developments necessary to make quality reproducible research content available for translation.

The translation of research is the time-lag between biomedical research and its adoption in healthcare and by the wider society. In relation to OBR, translation of research is informed through the linking process of the research grant details to their research output. For example, US PMC

and Europe PMC (*technology*) enable principal investigators (*people*) to link their articles to their grant information (*content*). *Technology* systems such as Impactstory are available for researchers to generate reports on the online impact of their research (Priem & Piwowar, 2012). Data is extracted from the repository for analytical reporting in systems such as ImpactStory that are technology systems complementary to open *content* repositories.

5.5 Reflection

The audit of the *people, process, technology* and *content* elements throughout the nine KM open biomedical processes reveals that the majority of the elements are connected, although some elements are independent from a repository platform. The foremost elements of a repository include: the *technology* in representation; the *people, technology* and *content* within storage; and the *technology* and *content* within dissemination.

The empirical data collected demonstrated that applying the KM system framework has strong support from library practitioners and researchers as a means for the Australasian biomedical and health sciences research sectors to increase their collaboration beyond the organizational silos that presently restrict their impact. Establishing an Australasia biomedical KM approach would help to avoid some of the duplication of effort that occurs in managing institutional repositories.

For biomedical researchers, the openly available PubMed, MEDLINE and PMC are the foundation, primary research repositories. As funders, such as the ARC and NHMRC, have open access policies directing researchers to make their research output openly accessible, considering an Australasian OBR for reporting on research performance is a means to achieve funding body compliance. Institutional executives and open access leaders view the PMC International system as a means to manage and review the output of biomedical research linked to grant details, to help avoid duplication of research and link related findings.

It became evident during the final stage of the Cycle Two research that *governance*, *quality* and *reproducibility* were critical overarching principles for an OBR. *Governance* is represented by controls and mechanisms of operations that include compliance, administration and ethics (Governance Institute of Australia, 2021). The six *quality* principles, as identified by the NHMRC, include

respect, rigour, transparency, accountability, innovation and efficiency (National Health and Medical Research Council (Australia), 2019a). *Reproducibility* refers to occurrences when the original researcher's data and computer codes are used to regenerate the research results (National Academies of Sciences, 2019) and is a subset of *quality*. Whilst *governance, quality* and *reproducibility* principles do not exist within each process and element of an OBR framework, they must form the wider environment in which an OBR exists. KM Processes for a Sustainable OBR with *governance, quality* and *reproducibility* as overarching principles is illustrated in Figure 5.8. This was Stage Four of the framework's development for Cycle Two (previously illustrated in Figures 5.5–5.7). The role of the overarching principles, *governance, quality* and *reproducibility* in an OBR is examined in the research for Cycle Three that is reported in Chapter Six.

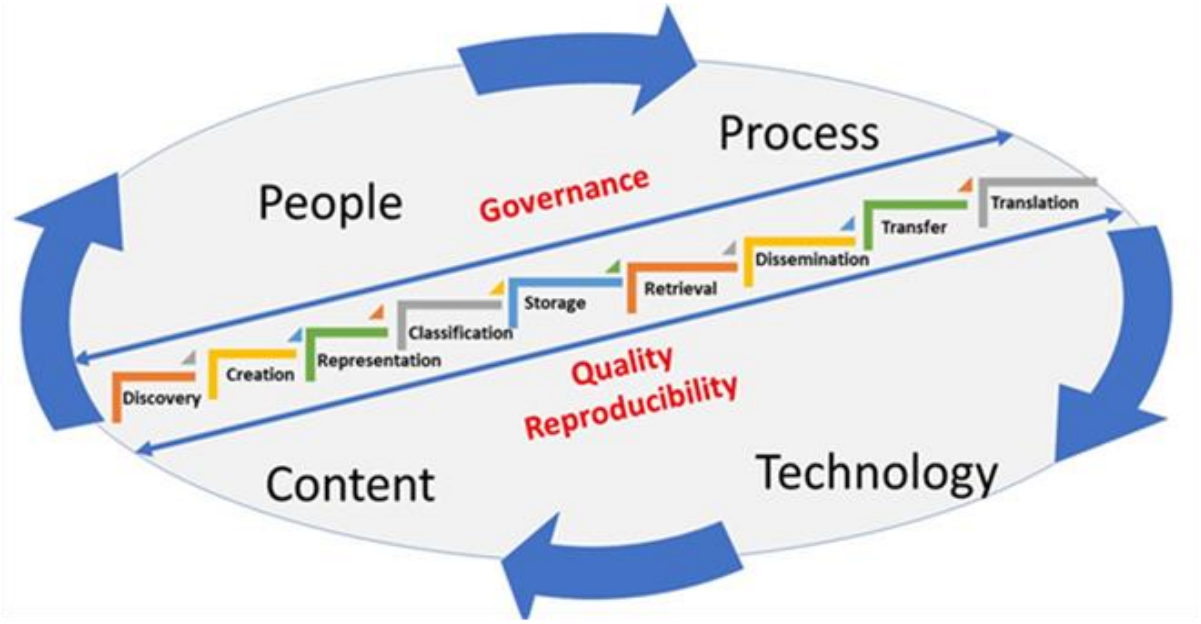


Figure 5.8 KM Processes for a Sustainable OBR with governance, quality and reproducibility as overarching principles, Stage Four for Cycle Two

A proposed Australasia OBR, as a member or regional node of PMC International has the potential to achieve a number of goals. These include: reducing the duplication of effort and the fragmented and incomplete access to health research output that presently exists with institutional repositories; preserving health research and associated data for present and future generations of users throughout the world; and producing quality metadata which is widely discoverable.

5.6 Chapter summary

Chapter Five expands upon my Cycle Two of action research. It described the planning and data collection that took place from key forums, experts and the literature. It provides an in-depth account of the conceptual KMS framework for an Australasia OBR. Nine KM processes and their *people, process, technology* and *content* elements derived from the data collected are reported. A spreadsheet of the conceptual KMS for an Australasia OBR is available from Appendix B. The empirical data collected demonstrated that applying the KM system framework has strong support from library practitioners and researchers as a means for the Australasian biomedical and health sciences research sectors to increase their collaboration beyond the organizational silos that presently restrict their impact. Establishing an Australasian biomedical KM approach would help to avoid the vast amount of duplicate effort that occurs in managing institutional repositories.

For biomedical researchers, the openly available PubMed, MEDLINE and PMC are the foundation, and primary research repositories. As funders, such as the ARC and NHMRC, have open access policies directing researchers to openly publish articles, considering an Australasia OBR for reporting on research performance is a means to achieve funding body compliance. Institutional executives and open access leaders view the PMC International system as a means to manage and review the output of biomedical research linked to grant details, to help avoid duplication of research and link related findings.

Cycle Two had successfully demonstrated that the KMS framework was an effective means to explore how to develop a sustainable open scholarship platform that could optimise existing services and resources. With the close of Cycle Two, the final research cycle puts the KMS framework to the test and the results of this investigation is reported in Chapter Six.

Chapter Six:

Uses of the KMS Framework

Cycle Three approach and findings

Figure 6.1 Leading Open Access projects at UQ,

Lisa Kruesi (left) and Heather Todd (right) 2012

Prelude: Academic Library Career & impetus for an Australasia OBR

The inspiration for an Australasia OBR emerged when I was working at The University of Queensland (UQ) Library. I commenced at UQ in November 2000, as the Senior Manager, Health Sciences Library Service. Within a decade, my substantive role at UQ Library became the Associate Director, Research Information Services, managing seven health sciences libraries and leading forty staff. Some of the key challenges of the role related to serving differing organisations. Four of the health sciences libraries were hospital libraries and jointly funded by UQ and Queensland Health (QH), and one had shared funding between UQ and the Mater Misericordiae Hospital; they were also located on non-UQ sites. Throughout my years at UQ, I worked closely with Heather Todd, Library Executive Director, who was my boss and great friend, and together we were a force in expanding UQ's role to open up access to knowledge (See Figure 6.1 for a photo of Heather and Lisa, Leading Open Access projects for The University of Queensland).

Motivation to change the system was heightened in 2007 when hospital staff without UQ academic titles were no longer entitled to access the majority of UQ library electronic resources outside of a UQ Library. A significantly reduced level of electronic resource service provided by QH for hospital clients, known as the Clinicians' Knowledge Network, was set up as an alternative service for hospital staff. Until this period, equitable services for all clients had been based on a traditional 'hard copy' collection available to walk-in researchers and patients. With the advent of digital information, a vast amount of my time in the UQ Library role was spent determining and establishing barriers and restricting access to subscription resources. It was a difficult period given that hospital staff depended upon the library service, which was used in most cases to help improve the health of sick and dying patients. The licences for the library resources were negotiated by the Council of Australian University Librarians (CAUL) and were limited to university staff and hospital staff who had an appointment with a university.

The period from 2001 and onwards marked the emergence across the globe of a movement to improve the discoverability and accessibility of resources through the establishment of repositories to disseminate open access research content. From 2011, in a new UQ role as Associate Director, Scholarly Publishing, I drafted a discussion paper, titled *Open Access for UQ Scholarly Outputs*. Recommendations made in the paper received endorsement from the UQ Vice-Chancellor's Committee, and the Open Access for UQ Research Outputs Policy, approved by the UQ Senate and Academic Board in 2014, resulted from this work. Working at UQ equipped me with experience, wisdom and the impetus to pursue improvements to the biomedical scholarly publishing system.

'But life at its best is a creative synthesis of opposites in fruitful harmony.'

Martin Luther King

6.1 Chapter outline

This chapter focuses on Cycle Three of my research that was introduced briefly in Chapters One and Three. Details on my data collection, the procedure adopted to test the KMS framework, my data analysis, my reflection and research synthesis on Cycle Three, the final cycle of my action research, are covered.

6.2 Introduction to Cycle Three

The proposition for Cycle Three was that *KMS provides an effective theoretical framework for analysing and evaluating designs for repositories and platforms* (also referred to as information systems) that support the advancement of open scholarship. Feedback on the suitability of the KMS framework for an OBR was reported in Chapter Five. Data collection for Cycle Three took place over the period 2019–2020 and during this time further development of the KMS framework took place. The focus for Cycle Three was on testing the KMS framework developed in Cycle Two. The testing of the KMS framework was undertaken from an evaluation of two repositories and two platforms, as listed in Table 6.1.

This chapter presents four case evaluations from the analysis of the systems. The first case reported is on Europe PMC and includes a detailed analysis and evaluation followed by a summary. The objective of providing one comprehensive case report for Europe PMC was to demonstrate the detail that can be extrapolated from the KMS framework for the analysis and evaluation of a system. The other three case evaluations are brief summaries of findings and each have had a comprehensive framework analysis and evaluation that is available from Appendix C. In addition, the reflection section 6.6.3 provides a case comparison. The objective was to publish a detailed case comparison in a future journal article.

At the final stage during documentation of the action research for Cycle Three, an online workshop was held with higher degree students to test and provide feedback on the application of the

conceptual KMS framework. The focus of the workshop was three of the systems that were evaluated. The chapter concludes with a reflection on the approach and findings.

6.3 Method

6.3.1 Plan

With the establishment of the conceptual framework for an OBR during Cycle Two (Kruesi, Burstein & Tanner, 2020), the need to test the framework on existing systems to complete the investigation was planned. The testing of the framework was deemed a suitable approach to determine the usefulness of the framework as an evaluation and analysis tool for information systems. The information systems that were evaluated included Europe PMC, Epistemonikos, Trove and ResearchGate. The explanation and justification for the choice of these four systems is reported in Section 6.3.2. The KMS framework shell was set up. Following collection of the data, as detailed in Chapter Three, and summarised in Section 6.4, the findings were synthesised into documents available from Appendix C: KMS framework for analysis and evaluation of systems.

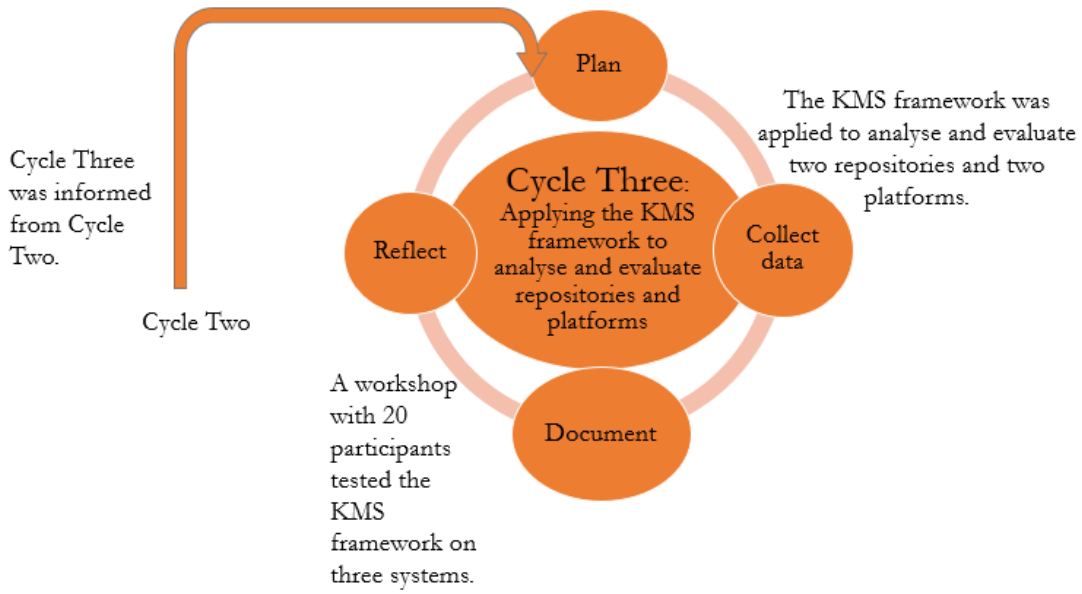


Figure 6.2 The action research Cycle Three

6.3.2 Systems evaluated

Over recent decades, thousands of repositories have been established. For example, the global indexes, Registry of Open Access Repositories (ROAR) lists 4,725 repositories and the Directory of Open Access Repositories OpenDOAR indexes 5,658 repositories ("Registry of Open Access Repositories," 1999-; University of Nottingham (UK), 2005-).

Four systems were chosen to investigate the proposition that KMS provides an effective theoretical framework for analysing and evaluating designs for repositories and platforms. The process that distinguishes a repository and an information platform is a repository usually ingests and stores digital objects (*content*) and information platforms, such as aggregator platforms do not always host digital objects. The evaluations and analyses were on a mix of systems and were not limited to open access repositories. The systems were selected on the basis of having been established for more than five years; they were open or partially open (such as ResearchGate); they include biomedical content; they each have millions of users; and each system has distinctive differences. A brief description of each system, including Europe PMC, Epistemonikos, Trove and ResearchGate follows and is provided in Table 6.1 Systems evaluated. This is followed by an overview of each system, the procedure for testing the KMS framework, then a detailed case evaluation of Europe PMC and evaluation summaries for the remaining systems.

Table 6.1 Systems evaluated

System	Description	URL
Europe PMC (repository)	Openly accessible repository, focus on biomedical research, links to research data, includes other research data sets and resources	https://europepmc.org/
Epistemonikos (platform)	Openly accessible, provides a summary of research evidence, includes biomedical research	http://www.epistemonikos.org/
Trove (platform)	Openly accessible discovery interface, Australian information resources, multi-disciplinary, national resource	https://Trove.nla.gov.au
ResearchGate (repository)	Openly accessible, based on scientific social networking services and also serves as a repository as it has a specific feature that allows members to upload full-texts of their publications. The system is not an open access repository.	https://www.researchgate.net/

6.3.3 Overview of the four systems

Europe PMC

Europe PMC is an open repository for research publications (Ferguson, Araújo, Faulk, Gou et al., 2021) and was set up in 2007 (US National Library of Medicine, National Institutes of Health, 2018). Europe PMC was introduced in Chapter Two (section 2.5). It is a member of PMC International (PMCI) (US National Library of Medicine, National Institutes of Health, 2018). PMCI is a collaborative arrangement between NIH/NLM, publishers and American funders that submit content to the PMC archive, and other funders across the globe who support open and permanent access to journal content by the researchers they fund (US National Library of Medicine, National Institutes of Health, 2018). PMCI has been able to achieve high levels of compliance, as publishers submit author content to the repository in most cases (Lariviere & Sugimoto, 2018) to enable researchers to comply with open access requirements such as the NIH access policy (US Department of Health and Human Services, 2008) and the European plan S (European Science Foundation, 2021). A key benefit of the collaboration is that national or regional repositories of grant-funded research output, can add other content to the repository that may be of interest to their users. Systems such as Europe PMC provide infrastructure to discourage authors from signing away their copyright to the publishers, who licence the content back to the organisations that have funded it in the first place.

Dr Johanna McEntyre is the principal investigator of a Wellcome Trust grant, supported by the Europe PMC's 33 funding bodies, to maintain and develop Europe PMC. Contact was made with Dr McEntyre in 2016 and she recommended information about PMC International be obtained from Katie Funk and Robert Kiley; interviews were later conducted with these experts.

Governance is an overarching principle of the KMS framework, and for Europe PMC, governance is undertaken by a Scientific Advisory Board and a Funder Committee (Europe PMC, 2021c)

Epistemonikos

Epistemonikos was started in 2009 at Pontificia Universidad Católica de Chile and is a web search platform that provides a multilingual database of human health evidence (El-Khayat, 2017; Rada et al., 2020). The platform searches ten bibliographic databases either daily or weekly to find systematic reviews related to health-decision-making (Rada, Pérez & Capurro, 2013). A combination of human and automated systems work together with the aim of providing a comprehensive platform to access systematic reviews to support clinical practice. In regard to the KMS framework's overarching quality principle, Epistemonikos' criteria for selection of systematic reviews and methods followed are in adherence with international practice, such as the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) (Page et al., 2021) and the Cochrane Handbook (Higgins et al., 2019). In 2016, Epistemonikos became a partner of The Cochrane Collaboration and the Cochrane Library now offers the option to search the Epistemonikos database from its website (Epistemonikos Foundation, n.d.). The platform aims to bring evidence closer to health decision makers through technology and innovation (Epistemonikos Foundation, n.d.).

Trove

Implemented in 2009, Trove is a collaboration of 941 organisations, communities and individuals who work with the National Library of Australia (NLA) to preserve and make Australian content accessible (Chanthadavong, 2020; National Library of Australia, n.d.). Trove is an aggregator of metadata from Australian repositories, and has its own repository of digital content (Hickie, 2017?). The NLA website describes Trove as a single point of entry to a treasure trove of over 6 billion digital items, including artefacts, curiosities and stories from Australia's cultural, community and research institutions (National Library of Australia, n.d.). Regarding any prospective collaboration with the NLA to establish an Australasia OBR, the NLA Director-General indicated that the Library is excluded from research infrastructure funding and it has never had a major role in health sciences information management (Ayres, 2017).

ResearchGate

RG is a social networking site and a repository (Jamali, 2017). According to the RG website, it has more than 80 million publications, including 19 million publications available in full text (Jamali, 2017). RG has its headquarters in Berlin, Germany and is a for-profit company. The business model is based on a range of free-of-charge services that are complemented with fee-based offerings, such as their recruitment service (ResearchGate, 2021). To become a member, RG requires an institutional email or a referral from a colleague or other evidence of research activity (ResearchGate, 2021?). There has been criticism and legal action against RG as many of the author-uploaded articles and the full-text files found by RG crawlers and added to user profiles have breached copyright laws (Van Noorden, 2014b). Nevertheless, RG has achieved agreements with a few major publishers, such as Springer Nature, Cambridge University Press and Thieme, on article uploading. Whilst RG has been controversial, it has KM processes that have attracted millions of research members and its success warrants greater understanding as it may help to advance the open scholarship system.

6.3.4 Procedure for testing the KMS framework

To undertake the testing of the KMS framework a four-step procedure was applied with each of the systems. The testing commenced firstly with Europe PMC, followed by Epistemonikos, Trove and ResearchGate. The procedure to undertake the analyses and evaluations was established during the planning stage of the Action Research Cycle, see Figure 6.2.

Step 1. Plan

A literature search for research papers on the systems was undertaken.

The Excel template developed in Cycle Two was used to tabulate the data for the evaluation. The process was revised with a grading method in Cycle Three. The template comprises a worksheet with a column for each of the nine KM processes: discovery, creation, representation, classification, storage, retrieval, dissemination, transfer and translation, listed as column headings, and aligned with the elements: *people, process, technology* and *content* that are listed in the first column as row headings. Each of the processes and the elements have been defined to achieve a consistent

approach (see Table 6.5). Definitions of each KM process are based on an associated *people, process, technology* and *content* element and form the basis of the findings synthesised in the four case evaluations. Determining the processes commenced in Cycle Two of my research (Section 5.3.1) by identifying the processes that underpin biomedical knowledge. The definitions are a constant feature in the template. An example is provided in Table 6.3 of the system ResearchGate Excel template of the descriptions (components of the system) for Representation, Classification and Storage aligned with the *content* element, with definitions in red font.

Step 2. Collect data

Step 2 comprised the following activities:

- Analysis of journal articles found in the *Step 1*. literature search and populating the Excel template;
- Reviewing the system's website and populating relevant details into the Excel template; and
- Conducting an interview with the staff responsible for the system (where possible) to discuss the draft system analysis and get feedback on the suitability of the analysis.

Specific data collection activities for the four information systems evaluated is reported in Section 6.4.

Step 3. Document

Step 3 involved the mapping of data into the Excel worksheet template. Table 6.3 on page 108 provides an example from an Excel template of processes aligned with the *content* element.

Step 4. Reflect

Step 4 involved reflection on the process of grading the data in each cell, and then evaluating and reporting on the results. A 'high' grading in green, indicates the component(s) in the element make the system an exemplar in the field; a 'medium' yellow grading indicates the components within the element either have scope for improvement and/or may rely on external influences; and a 'low' grading, shaded in red, indicates that the components in the element maybe external to the system and may detract from the system. The definitions of the colour gradings are provided in Table 6.2

Table 6.2 Definitions of the colour gradings

High	includes components that make the system an exemplar in the field
Medium	components with scope for improvement and/or may rely on external sources
Low	components maybe external to the system and detract from the system

The governance and quality processes identified during the evaluation are indicated in the cells of the framework by a code, i.e., governance=G and quality=Q.

Table 6.3 Example taken from an Excel template of processes aligned with content

System	Representation	Classification	Storage
ResearchGate = RG **Content** is the 'what' such as research data, metadata, database records, classification schemes, articles, videos, graphs, maps, visualizations, reports and other digital objects	Representation comprises explicit knowledge in the form of digital scholarly objects or the metadata for the objects. Every publication registered also has its own page giving metadata and, in some cases, a preview and a link to a full text version, if the author has uploaded one to the site and the publisher has not requested that it be removed for copyright reasons (Clarke, 2013). Users can also become actively engaged by participating in the questions discussion threads, both by posing research questions and by sharing expertise.	Classification schemes and ontologies are used by repositories to allow users to navigate content Q = RG has indexed many citations for a single website and has become a major source for academic papers, perhaps even starting to challenge Google Scholar in this regard. Combined with the apparent citation advantage of uploading to academic social network sites (Niyazov et al., 2016), RG citations can potentially be manipulated by uploading non-peer reviewed or fake documents and hence should be used cautiously for research evaluation. (Thalwall & Kousha, 2017)	Content, including metadata, needs to be stored in a standard way, that can be efficiently migrated to future systems. This is not possible using RG

6.4 Collect data

Extensive work was undertaken to collect data on each of the information systems, including Europe PMC, Epistemonikos, Trove and ResearchGate. The evaluation took place within a set time period. Table 6.4 provides a summary of the approach to data collection. The first repository that was analysed and evaluated was Europe PMC. In Cycle Two, the KMS approach was applied to develop a conceptual framework for an OBR. Consolidation of the learning gained during Cycle Two, some of which was derived from interviews with key staff at Europe PMC, a further literature review and exploration of the Europe PMC website was undertaken in Cycle Three to complete the evaluation. Certain components within the elements change regularly, for example the Europe PMC *content* element reported in the discovery process increases daily when the system is updated.

For the Epistemonikos platform, the evaluation was based on an interview with Dr Daniel Capurro, from the Epistemonikos Foundation, a literature review and examination of the Epistemonikos website. Similarly, for the Trove platform evaluation a literature review was undertaken, in addition to consolidation of the interview findings from Cycle One and the Cycle Two focus group with the NLA executive team were consolidated. The ResearchGate (RG) evaluation was based on a literature review and personal use of the information system.

The data in the spreadsheets reflect the period during 2020 when the evaluations were undertaken. The approach to evaluate the four systems is given in Section 6.3.4., which outlines the procedure for testing the KMS framework.

Table 6.4 Data collection

System	Details	Format	Evaluation
Europe PMC	Literature review and exploration of the Europe PMC website	Consolidation of Europe PMC interview data from Cycle Two	Appendix C.1.1 System One
Epistemonikos	Interview with Dr Daniel Capurro, Board Member, Epistemonikos Foundation, literature review and exploration of the Epistemonikos website	Video conference interview	Appendix C1.2 System Two
Trove	Literature review	Consolidation of NLA interview in Cycle One and the Cycle Two Focus Group	Appendix C1.3 System Three
ResearchGate (RG)	Literature review		Appendix C1.4 System Four

6.5 Documenting and thematic analysis

6.5.1 Background

Case evaluations on each of the systems using the KMS framework follow in the Sections 6.5.2 Europe PMC, 6.5.3 Epistemonikos, 6.5.4 Trove and 6.5.5. ResearchGate. The nine KM processes: discovery, creation, representation, classification, storage, retrieval, dissemination, transfer and translation are used to structure the case evaluations. Definitions of each KM process based on an associated *people, process, technology* and *content* element are provided in Table 6.5 and form the basis of the findings synthesised in the four case evaluations.

Appendix C1.1-C1.4 includes spreadsheets for the KMS framework evaluation on each of the four systems (System One Europe PMC, System Two Epistemonikos, System Three Trove and System Four ResearchGate).

Table 6.5 KM processes with associated people, process, technology and content element definitions

	People	Process	Technology	Content
Discovery	Knowledge discovery is the development of new tacit or explicit knowledge from data and information or from the synthesis of prior knowledge.	Discovery processes are the rules, regulations and guidelines established by professional bodies, organisations and research leaders.	Technology to underpin discovery for research output.	Content to underpin research discovery.
Creation	Knowledge creation assumes knowledge does not exist before the activity that catalysed the innovation. Creation entails data analysis and investigation activities undertaken by researchers.	Creation processes are influenced by priorities set by government and research organisations in response to researcher and public needs.	For creation, technology includes the access to databases and repositories for research investigations.	For creation, content is in the form of research output and can be found by searching databases and open repositories via metadata, bibliographic indexes and/or full text.
Representation	Representation comprises explicit knowledge in the form of digital scholarly objects or the metadata for the objects created and used by people.	Representation processes are found in research and publishing instructions, standards, checklists, related frameworks and codes.	Technology systems provide the format of digital research output.	Representation comprises explicit knowledge in the form of digital scholarly objects or the metadata for the objects.
Classification	Taxonomies, also called classification or categorization schemes, are considered to be knowledge organization systems that are applied by people and serve to group objects together based on a particular characteristic.	Classification processes involve rules for naming and describing research output.	Technology is used to provide automated classification systems.	Classification schemes and ontologies are used by repositories to allow users to navigate content.
Storage	People take actions for information systems (platforms, databases and repositories) to store metadata and content.	Storage processes are based on international standards, such as preservation and interoperability standards.	Technology underpins the storage of open biomedical content.	Content, including metadata, needs to be stored in a standard way, that can be efficiently migrated to future systems.
Retrieval	Information retrieval can entail people searching for and finding research references based on search algorithms that interrogate internet or database metadata or full-text articles.	Retrieval processes include search commands and filters. Open access status and standards can determine research output that is retrieved, for example, Open Archives Initiative Protocol for Metadata Harvesting (OAI-PMH) standard system is openly accessible.	Technology for retrieval of research output combines interoperable systems that aggregate content (publications and data) from other sources.	Content, including metadata, needs to be stored in a standard way, that can be efficiently migrated to future systems.
Dissemination	Dissemination of research objects and data via presentations at conferences, personal communications and use of systems. Knowledge repositories may be most effective for knowledge that can be readily generalised to other contexts. (Alavi & Leidner, 2001)	The process of dissemination may be detailed in policies, procedures and guidelines.	Technology is used for the dissemination of research objects.	Dissemination of research output (*content*) is based on standards.
Transfer	Transfer involves clarification of the terms and conditions between relevant parties in relation to the use of the content.	The knowledge transfer process takes place through patenting, licensing, contracts, trade secrets, joint ventures with inventors and commercial spin-offs.	Technology is used to transfer knowledge databases and information systems.	Content can be transferred and interoperable between systems based on international standards.
Translation	Translation involves 'the synthesis, exchange, and application of knowledge by relevant stakeholders to accelerate the benefits of global and local innovation in strengthening health systems and improving people's health' (Pablos-Mendez & Shademani, 2006).	The translation of research process is the time-lag between biomedical research and its translation to health and wider society benefits.	Technology applied to achieve the translation process.	Translation of research output is reported in systems that complement open biomedical repositories and databases.

6.5.2 Europe PMC

Process analysis and evaluation

This case example of Europe PMC reports on findings synthesised following an analysis and evaluation of this system using the KMS framework that was introduced in Chapter Five.

Discovery

Europe PMC has components that distinguish it from others in the field in regards to discovery. The *people* element of Europe PMC is expansive; Europe PMC is for researchers, practitioners and members of the public to access from anywhere in the world. For example, users can search PubMed (an aggregator database) and PMC (biomedical repository) to identify knowledge on a topic. Users examine existing knowledge to help identify gaps in understanding or as an important part of expanding, revising, or correcting misinformation.

Europe PMC has 33 research funders across Europe (Europe PMC, 2020b). The *process* requirements of the funders are made explicit by stating that the research that they fund must be made freely and readily available. Digital copies of research output that are accepted for publication in peer reviewed journals that are funded in part or whole from any of the Europe PMC Funders, must be made available from PMC and Europe PMC within six months of the journal publisher's official date of final publication. Authors and publishers are encouraged to make their research papers available to be freely copied and re-used for purposes such as text and data mining, on the basis that such uses are fully attributed (Europe PMC, 2020b).

In regard to the role of *technology,* Europe PMC is developed in collaboration with the US PMC repository. To support the discovery process, Europe PMC provides a website for searching its *content* and application programming interface (API) options for text and data mining (Ferguson, Araújo, Faulk, Gou et al., 2021). The *content* in Europe PMC is updated daily and the details are reported in a graphic on the Europe PMC website (Europe PMC, 2021a). In summary, on the 6 May 2021, Europe PMC provided access to 38.7 million abstracts, 6.9 million full text articles, 289,401 preprints, 4.2 million patents, 1,497 NHS guidelines and 784,842 Agricola records from

their website https://europepmc.org/. *Content* was expanded to make COVID-19 pre-prints, articles and related data openly available (Ferguson, Araújo, Faulk, Gou et al., 2021).

Creation

The *people* aspect of the creation process is reflected in the Europe PMC's mission, which is to 'build open, full-text scientific literature resources and support innovation by engaging users, enabling contributors, and integrating related research data' (Europe PMC, 2021b). The creation *process* is steered by the funders, who determine what research will be funded and progressed as an openly available output on Europe PMC. The *technology* works with the major data repositories to underpin the creation role of researchers.

Representation

Europe PMC users (*people*) provide testimonies of their efforts to enhance representation and scholarly publishing in the life sciences from use of the repository (Europe PMC, 2020a). External *processes* like reporting standards such as the Consolidated Criteria for Reporting Qualitative Research (COREQ) and the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) and bodies such as the Committee on Publication Ethics (COPE) and are entities external to Europe PMC, that define best practice for scholarly publishing representation.

Classification

In relation to the classification process, Europe PMC includes links to data resources such as other literature, ontologies, genes, genomes, protein sequences, molecular structures, biological systems, chemical biology and molecular archives (Cook, Bergman, Cochrane, Apweiler et al., 2018). *People* and *process* are involved in applying rules for naming and describing research output. Rules for naming may be governed by international bodies such as the International Association for Plant Taxonomy (IAPT) that governs plants and the International Commission of Zoological Nomenclature (ICZN) that governs the naming of animal taxon. Europe PMC uses a *technology* platform to consolidate text-mined annotations from different sources and makes them available to the wider research community. The annotated concepts and relations are displayed on article pages via the SciLite tool, and can be retrieved using RESTful API. Europe PMC's annotations

platform offers ~1.3 billion text-mined biological terms and concepts derived from 10 authorities and over 40 global data resources (Ferguson, Araújo, Faulk, Gou et al., 2021). Classification schemes and ontologies are used by Europe PMC to enable users to navigate *content* such as GO, UniProt, EFO, ChEBI, NCBI Taxonomy and UMLS (Stevens, Rector & Hull, 2010).

Storage

For storage, Europe PMC as an open biomedical literature repository allows human and publisher (*people*) entry of metadata and full text articles. Adherence to open standards is a required *process* for storage. Europe PMC submissions must be in XML format that conform to an acceptable journal article DTD (Document Type Definition). *Technology i*n the form of cloud computing, local and external databases are used for storage of Europe PMC content and data. Portable PMC (pPMC) is software used to operate US PMC that allows PMCI centres to import data from PMC, build a local database and display *content* of each article in PMC style. MongoDB is used by PubMed for storage and retrieval. Europe PMC, comprises databases and APIs and is a fully open-source application that uses PubSweet systems (Cook, Bergman, Cochrane, Apweiler et al., 2018). PMC stores *content* in eXtensible Markup Language (XML), which represents the structure and meaning of a document in a human-readable form. All PMC *content* is converted to and stored in the NISO Z39.96-2015 JATS XML format. This standard format is the most effective and widely used archival format for journal articles (National Center for Biotechnology Information, 2020).

Retrieval

The retrieval process is applied by *people* such as researchers, funders, industry, research support staff and consumers, who apply tacit and explicit knowledge to create search strategies to retrieve research output using Europe PMC. Various retrieval *processes* are applied in Europe PMC, including the use of external links to URLs, text mining and by ORCID and other identifiers (Kim, 2015). *Technology* protocols for retrieval of articles include FTP, OAI-PMH, SOAP-API and RESTful-API (for articles and grants). For *content* retrieval, RESTful Web Service Search enables search of the publications database, publications that have cited a paper, publications referenced in a paper, biological database records that have cited a paper, terms text-mined from full-text publications, full text in XML format for the Open Access publication subset and supplementary files where available for the full paper.

Dissemination

PMC International has more than a billion articles retrieved by users each year (NLM Program Manager, 2019). In relation to the dissemination process, Europe PMC content is permanently accessible and discoverable. *Process* is evident with each of the funders having OA publishing policies (National Center for Biotechnology Information, 2015). Making repository *content* findable is a major challenge facing libraries (Azadbakht & Schultz, 2020). Europe PMC has adopted Unpaywall (*technology*) to provide wider access to full text, preprint peer-reviewed platforms and major biomedical research data sets and experimental protocols (Ferguson, Araújo, Faulk, Gou et al., 2021). PMCI does not report on or collect usage of *content* patterns due to privacy laws.

Transfer

Europe PMC is an open science platform that enables access to a worldwide collection of life science publications and preprints from trusted sources around the globe. Executive and senior staff (*people*) in research organisations and industry rely upon the PMC repository to identify *content* relevant to the biomedical knowledge transfer process (Beagrie & Houghton, 2016).

Translation

Translation is the final process in the biomedical knowledge cycle and is key to accelerate the benefits of global and local innovation. In regard to the *people* element, Europe PMC funders have a strict criterion in allocating their research grants to help ensure quality research output by researchers and the funders proactively address the causes of research irreproducibility, which are often the result of poor research integrity (Academy of Medical Sciences, 2015). In regard to open biomedical repositories, translation of research is informed through the linking of the research grant details to their research output. For example, Europe PMC has a *process* for principal investigators to link their articles to their grant information. Europe PMC *technology* supports the linking of metadata to ImpactStory (an open-source website), which allows researchers to generate reports on the online impact of their research (Priem & Piwowar, 2012). Translation of research output (*content*) is reported in systems that complement open biomedical repositories. Analytical reports can be generated using the Web of Science platform InCites and the Scopus platform, SciVal, based on researcher publications. The InCites platform provides normalised citation

impact, institutional analysis and benchmarking details. The SciVal platform provides author field weighted citation impact, outputs in top percentiles, international collaborations, academic/corporate collaborations, institutional analysis and benchmarking. SNOWMED CT, is multilingual clinical healthcare terminology and is scientifically validated for electronic health records systems; such systems enable links between clinical records, clinical guidelines and protocols.

Summary

Research undertaken on PMC and Europe PMC during Cycle Two informed the development of the conceptual framework for an OBR. In Cycle Three, the elements and processes of Europe PMC were aligned and colour graded (see the snapshot in Figure 6.3), based on the definitions of the processes and elements covered in Section 6.5. The detailed analysis and evaluation, including the grading are available from Appendix C1.1. The findings indicated that the repository comprises of components that distinguish this system from others in the field (green shading), with only a few of the elements being dependent on external influences to exist (yellow shading) and no components that detract from the system (red shading).

Europe PMC achieves an ideal mix of KM processes and elements as identified from applying the KMS framework. The system meets the requirement of external authorities, such as adhering to legislative requirements, standards and codes determined by governments, funders and publishing bodies and has numerous elements that distinguish this system in the OBR field. Europe PMC is a set of open systems and services that ingest, store, manage, display, retrieve and allow reuse of digital objects with the balance required of the four elements, resulting in an exemplary OBR.

	Discovery	Creation	Representation	Classification	Storage	Retrieval	Dissemination	Transfer	Translation
People									
Process									
Technology									
Content									

Figure 6.3 Snapshot of the Europe PMC KMS framework colour grading

6.5.3 Epistemonikos

Brief Summary of Findings

The target audience for Epistemonikos (*people* element) is health decision makers. According to the website, the system is not intended for the general public, although it is used successfully by lay people and journalists. Epistemonikos generates output to enable explicit knowledge from the synthesis of prior knowledge. The platform has some components that make the resource an exemplar in comparison with other repositories and platforms, such as the ability to generate an evidence matrix with a pivot table that shows systematic reviews that each share one of the same studies that meet the criteria to be included in those reviews. Another exemplar feature is the wide array of sources that are searched, such as ten health sciences literature databases that are searched daily or weekly. Figure 6.4 provides a snapshot of the Epistemonikos KMS framework colour grading. The *content* is added to the platform and underpins the discovery process although there is a dependency upon clinical experts (*people*) to create the metadata and this may be an area with scope for improvement. Efforts to automate processes in classification, retrieval and translation are impressive and each of these has some human (*people*) intervention (Rada, Pérez & Capurro, 2013). Epistemonikos has a number of processes (identified in yellow in Figure 6.4) that are dependent upon external sources, such as creation, dissemination and transfer.

	Discovery	Creation	Representation	Classification	Storage	Retrieval	Dissemination	Transfer	Translation
People									
Process									
Technology									
Content									

Figure 6.4 Snapshot of the Epistemonikos KMS framework colour grading

6.5.4 Trove

Brief Summary of Findings

Trove is the outcome from the collaborative effort of organisations, communities and individuals who work with the National Library of Australia (NLA) to make Australian *content* accessible. Critiquing Trove is relevant as Australia's major medical research funding body, the NHMRC, refers to Trove as the central platform for locating its funded publications (National Health and Medical Research Council (Australia), 2021). This brief assessment of Trove has been made from the perspective of its value in the KM biomedical research cycle. In regard to the creation process, as biomedical research is an international endeavour, it is unlikely that many biomedical researchers (*people*) would typically use Trove. It is a platform for the general public (*people*) to locate a subset of Australian biomedical research output. The NLA works with 40–50 Australian university repositories to aggregate their data and this causes some *technology* challenges for the NLA when universities make a major change, such as implementing a new repository system. In addition, with the creation process, metadata for research output is discoverable from the Trove aggregator platform, although the research does not link to research protocols, research data or research objects.

An exemplary component of Trove in regard to the translation process, is the linking of Australian research grant details to their bibliographic record in Trove; these details are only accessible for Trove partners via a dashboard. An advanced search interface allows retrieval of the metadata for the general public (*people*), although the results can be unwieldy to manage, for example, the metadata links back to institutional repositories and at times it is not possible to locate associated full-text articles and any related research data. With at least a quarter of the research output unavailable from Australian institutional repositories, there is a need for the researcher to help and, according to an NLA executive, researchers are not always interested in doing so (McKenzie, Cass, Dellit & Hickie, April 2018).

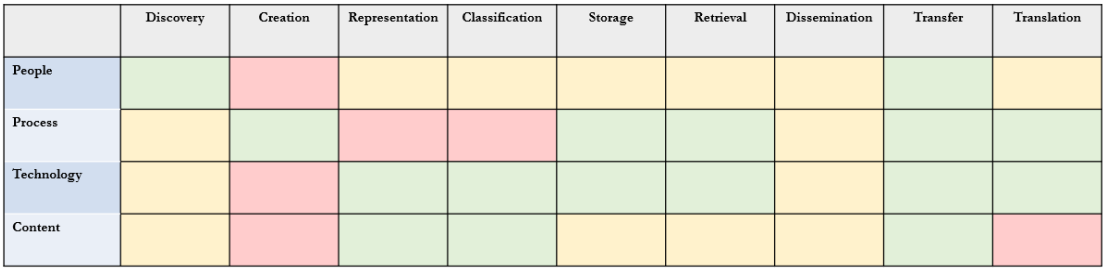


Figure 6.5 Snapshot of the Trove KMS framework colour grading.

6.5.5 ResearchGate

Brief Summary of Findings

The *people* element in regard to discovery found that ResearchGate (RG) is used by academics, who upload their articles to make them freely available (Jamali, 2017). RG is a social networking site and according to ResearchGate, it has more than 80 million publications (c*ontent)* including 19 million publications available in full text (Jamali, 2017).

There are red flag concerns with RG. Whilst RG *technology* allows the import of publications from other applications, there is no method for the transfer of the same *content* out of the RG system. There is no long-term preservation strategy (the storage process), unlike most institutional and disciplinary repositories, which was another red flag identified. The limitations identified detract from the RG system and, based on these it is not regarded as an open access repository (Fortney & Gonder, 2015).

Even so, RG does include elements that make the system exemplary when compared with other platforms. For the *people* element in the representation process, each member has a profile page that includes brief biographical information and a publication list. Every publication (*content*) registered also has its own page giving metadata and, in some cases, a preview and a link to a full text version, if the author has uploaded one to the site and the publisher has not requested that it be removed for copyright reasons (Clarke, 2013). Users (*people*) can also become actively engaged by participating in the discussion threads, both by posing research questions and by sharing expertise. The RG collaboration options, which is in the dissemination process, allows for

researcher commenting and file sharing; collaborators must be invited to see these areas. In relation to information retrieval, it is one of the top sources of full-text files found through Google Scholar (Jamali 2017). Figure 6.6 is a snapshot of the RG KMS framework colour grading.

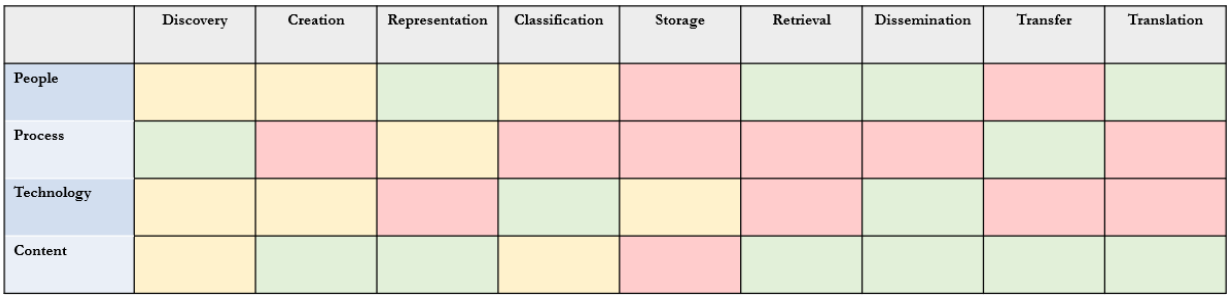


Figure 6.6 Snapshot of the RG KMS framework colour grading

6.5.6 Workshop

An online workshop on the KMS framework was presented to higher degree students, following an invitation from an Associate Professor from the Doctoral School in Communication, Information and Documentation Sciences Department, University of Bucharest, Romania. Appendix C1.5 includes the workshop program. The briefing drafted for the students on pre-session workshop preparation and arrangements for group participation is available in Appendix C1.5. Signed consent forms were received from all of the participants.

Twenty higher degree students and their Associate Professor participated at the online workshop. From the group, 19 written responses were received, including one from the Associate Professor. The students were required to apply, report and sum up their experience of using the framework. Students were provided with links to reading materials to prepare for the session and they were allocated to one of three groups to evaluate either Epistemonikos, Europe PMC, or ResearchGate. The findings were tabulated using Google forms and Google sheets. Students responded positively to all of the feedback questions. For example, all of them agreed that the KMS framework can help with designing, analyzing, and evaluating open scholarship repositories.

The verbal student summaries given at the workshop raised some contrasting findings. It was evident during the verbal feedback that the students evaluated the typical information service

processes rather than taking an expansive knowledge management approach. Students spoke of traditional areas such as retrieval and representation and did not refer to processes such as transfer and translation.

Following the workshop, the Associate Professor provided written feedback indicating that the workshop was very useful for the students, both for those who studied in the past or those who are studying KM at present and for those who didn't know about KM. For the Associate Professor, it was useful because it was an opportunity for the students to work in a different style, to learn about the KMS framework. The only negative feedback received from the group was that the workshop, which ran for 1.5 hours, was not long enough. The Associate Professor gave the feedback that the framework could be improved if it was applied and adapted to different contexts.

6.6 Reflection

6.6.1 How the KMS Framework differs from other tools

The KMS framework has been developed with a focus on open biomedical repositories. There are other frameworks and evaluation tools for repositories, although in most cases they are written for repository experts. A few of the main examples are the COAR Community Framework for Good Practices in Repositories (Confederation of Open Access Repositories, 2019), the COAR Next Generation Repositories (Confederation of Open Access Repositories, n.d.), PLOS Criteria for Recommended Data Repositories (PLOS, 2018), Plan S (European Science Foundation, 2021) and the FAIR Principles (GO FAIR, 2019).

Whilst the COAR Next Generation Repositories puts forward a vision that rests upon the resource rather than the repository being the focus of the services and infrastructure (Confederation of Open Access Repositories, 2019), the KMS framework addresses the entire biomedical knowledge life cycle. In biomedical sciences, focussing on just the 'information resource' can be limiting when the final goal of research output is to influence the route from basic research to healthcare solutions. Processes such as transfer and translation are critical to the transformation of fundamental knowledge into practice and these do not appear to be addressed in the expert evaluation tools and frameworks. The KMS framework is a means to design and evaluate the entire

spectrum of biomedical knowledge processes and it provides a systematic approach to dissect each of the elements to identify gaps and omissions. The KMS framework is a tool that can be applied by repository experts, managers, librarians and others with a need to use, understand and apply such systems.

The COAR Community Framework for Good Practices in Repositories (Confederation of Open Access Repositories, 2019) is unique because it can be used by different kinds of repositories, such as institutional, disciplinary and data repositories and it is not limited to a geographic region. In applying the KMS framework, the appropriate repository frameworks and evaluation tools would be included in the relevant elements of *people, process, technology* and *content* to achieve best practice as specified by authoritative bodies. The use of the KMS framework is a means to achieve a systematic, whole-of-system evaluation and a tool for comparing open systems with platforms that may be commercial systems or other types of platforms.

6.6.2 The Workshop

As many institutions and universities throughout Europe have been leaders in open access, in particular with steering Plan S (European Science Foundation, 2021) and given the Associate Professor contact is a medical doctor and a librarian with a PhD in KM, hosting a workshop with the University of Bucharest was a golden opportunity.

The student worksheet feedback was positive, although it was evident during the verbal feedback session that the students focused on traditional, information services processes, rather than appraising aspects such as content discoverability and interoperability, as reported in Section 6.5. Based on this experience, it would be beneficial to test the KMS framework further and explore the opportunity to assist information experts, library students and librarian practitioners to adopt a wider paradigm for the analysis of information platforms and repositories. The KMS conceptual framework has the potential for further development as a tool to critique open science platforms and repositories.

6.6.3 Testing the KMS Framework

Applying the KMS framework to analyse and evaluate Europe PMC, Epistemonikos, Trove and ResearchGate was a means to identify any gaps in the use of the framework to develop a conceptual framework for an OBR. It was demonstrated that the KMS framework can be an effective tool to analyse and evaluate designs for repositories and platforms that support open science. Europe PMC is an exemplary open science repository, as summed up in the case evaluation at section 6.4.2. Epistemonikos achieves its specific aim of synthesizing evidence for health decision makers and other systems could learn from the translation process elements it includes. Trove is an aggregator platform and achieves its aims related to collecting and preserving Australian cultural content. Trove is not a suitable platform in regard to the biomedical KM processes of creation, representation, classification and translation and nor was it designed for these purposes. RG is not an open access repository and even so millions of researchers invest their time in uploading their content to this platform and are possibly ignorant that there is no means to transfer the content out should the conditions of use suddenly change. RG does have some *people* elements in the representation, retrieval and dissemination processes that are exemplars for open systems.

6.6.4 The overarching principles

Work on identifying the *governance* and *quality* overarching principles was undertaken to varying degrees during the system evaluations and was based on the available detail for each system. Europe PMC, Epistemonikos and Trove provide explicit details in relation to their *governance,* which is openly accessible from their websites (Epistemonikos Foundation, n.d.; Europe PMC, 2021c; National Library of Australia, n.d.).

Regarding *quality*, this needs to be analysed based on a range of factors such as adherence by *people* to *process* requirements as defined by standards, codes, handbooks and statements that specify required practice and procedures. PMCI have strict vetting requirements for accepting journals and these rules are made explicit on their website (US National Library of Medicine, National Institutes of Health, 2021). Epistemonikos is an aggregator of content from other databases, although *people* have a role in flagging the *quality* of this content and assigning relevant additional

metadata to incoming system records. In addition, Epistemonikos states that it has designed its system to follow the high standards put forward by international codes and processes, for example PRISMA and the Cochrane Handbook (Higgins, Thomas, Chandler, Cumpston et al., 2019; Page, McKenzie, Bossuyt, Boutron et al., 2021). Trove is also an aggregator platform and the *quality* of the *content* within Trove depends upon the authors of the works collected by the NLA.

The *governance* of RG is not easy to determine as there is limited information about the structure of this company available in the public domain. RG has argued that the lack of *quality* with its system, due to breaches of copyright that have occurred, is because researchers have failed to adhere to copyright requirements (Jamali, 2017). Based on the KMS framework, it is possible to account for RG's lack of *content quality* because of failing processes within their system.

6.7 Chapter summary

Chapter Six reports on Cycle Three, the final action research cycle. The chapter presents an account of the data collection and procedures undertaken to analyse and evaluate two repositories and two platforms. The extensive work undertaken to document and analyse the information systems, including the definitions of each KM process based on the associated *people*, *process*, *technology* and *content* elements are provided and their application forms the basis of the findings synthesised in the four case evaluations reported. The evaluation of Europe PMC is presented as a more detailed case example and the other three systems are brief case summaries included in the chapter.

A collaboration with the Associate Professor and the workshop held with the higher degree students from the University of Bucharest provided feedback and a further insight to the use of the KMS framework as an evaluation tool for repositories and platforms that support open scholarship.

The findings from the analysis and evaluation support the proposition that the KMS framework is an effective theoretical framework for analysing and evaluating designs for repositories and platforms that support the advancement of open scholarship. The KMS framework differs from existing evaluation and assessment frameworks as it is focused on the entire biomedical knowledge

life-cycle. In particular, the transfer and translation processes are KM processes that are overlooked in the design of repositories. Whilst a repository is a set of services and systems that ingest, store, manage, display, retrieve and allow reuse of digital objects (Pinfield, Salter, Bath, Hubbard et al., 2014), a repository can potentially include elements that provide data on the transfer and translation of knowledge. It is recommended that the entire range of KM processes be included in future OBR designs.

Chapter Seven:

Summing up and beyond

Prelude: The uncertain future for health sciences librarians in Australia

In 2014, I returned to live in Melbourne and not long after I commenced at Monash University as the Manager of the Hargrave Library and Library Leader for the Faculty of Medicine, Nursing and Health Sciences. I was in the role until mid-2016 when I enrolled full-time to undertake a PhD. It was only one year later that I was tempted back to the biomedical library world and I joined the Brownless Biomedical Library at The University of Melbourne, managing a small team of liaison librarians. I undertook this role working four days a week until 2019. In 2021, neither of these library manager roles still exist. Prior to my departure from The University of Melbourne, I and other key staff recommended that my role be merged with the Sciences Library Manager, and this occurred.

Both biomedical library roles I held in Melbourne were at a HEW9 level and this was the level I was appointed at when I commenced as a biomedical library manager over twenty years ago in Queensland (UQ). My experience at The University of Melbourne (UoM) became an agonizing reminder of the work my staff performed when I was at UQ decades ago and now I was doing the tasks because of limited staffing. The academic health library environment is challenging and getting tougher to withstand as a staff member. The traditional health sciences library service of managing print collections is something of the past. Most in the health librarian profession are pleased to move on, and focus on present services related to teaching, learning and research.

The future for the health library profession in Australia is uncertain. With only a few accredited librarianship schools remaining in the country, education and training for librarians is at the cross-roads. Who will be the guardians of biomedical knowledge for Australia if the health library profession has no future? It has been argued that, given the age of fake news and misinformation, the dissemination of accurate information is vitally important to stop the spread of the infodemic (which refers to the rapid spread of accurate and inaccurate information), the pandemic and all disease epidemics (McDonald, 2020). We are embarking on a new paradigm in health sciences librarianship.

The aim ultimately is to improve the quality of health information that is essential for the better health of the nation. Improving the process pipeline from discovery to translation is the best way to achieve this. My departure from the workforce to work on a PhD was to help make a small contribution to the future with a blueprint for open scholarship from a KMS perspective.

'The fundamental principles of evidence-based medicine stand firm; it's the processes that need to evolve.'

(Fix medicine's evidence pipeline [Editorial], 2021)

7.1 Chapter outline

In this chapter the findings from the research are discussed and synthesised. How the research propositions were used to guide the inquiry throughout the three research cycles is explained. Reflections on the methodology are reported. The contribution to knowledge, with discussion of the advancement to theory and practice are summed up. The chapter concludes with discussion on the focus of this research and the opportunities for future related research.

7.2 Discussion

7.2.1 Regional, national and state challenges

There are significant challenges and hurdles that exist in Australia to achieving national coordination of open science information systems. During the COVID-19 pandemic, the power and the abilities to influence healthcare matters by government at state and territory levels have been demonstrated, although less so on a national basis, as is evident from the slow vaccine roll-out and the failed quarantine system (Ferguson, 2021). For at least two decades, it has been highlighted that there is no coordinated, national policy for purchasing and providing access to digital health information and knowledge resources and services on a level that expands jurisdictional boundaries throughout Australia (Australian Library and Information Association, 2008). Most states do have networks providing access to health knowledge resources for health professionals and other employees in the public health sector. The library services within the university sector, as reported in Chapter Two, provide subscription and other research content for their students and staff. Gaps exist in health information content provision for medical research institutes and private practitioners in Australia. Evidence of the threats, such as a lack of a national body to make a long-term commitment to establish and fund an Australasia OBR, were identified in Cycle One of this research.

A few key national challenges were summed up at the Australian eResearch Skilled Workforce Summit held in 2019 at The University of Sydney. The summit identified that a national approach to a shared model to achieve an eResearch Skilled Workforce or shared training resources will need good governance mechanisms and clear ownership and responsibility to maintain quality and continuous improvement. There is a need for research offices to work with library services and a need to rejig and continue developing librarian roles in order to teach eResearch skills at universities. Bodies, for example, the Australian Research Data Commons and Open Access Australasia, are working to address some of these challenges by pursuing national initiatives (Australian Research Data Commons; Barbour & Bradley, 2021).

The United Nations International Scientific Information System (UNISIST) model of scientific and technical communication is an example of a proposed universal international communication structure. Authors who have reviewed the UNISIST model argue that national or regional information sub-structures exist, and it is important to consider regional developments, in particular when US databases are developed based on US standards and culture (Fjordback Søndergaard et al., 2003). Development of a regional open access repository presents an opportunity to address this imbalance, such as the bias of indexing language and focus on local systems design needs.

Whilst Europe and the US have similar internal challenges with having differences in relation to open science priorities, they have been able to achieve success with international, regional and national initiatives. Country-wide approaches have been effective and are ongoing, with the European Plan S underway in 2021, after more than a decade of planning, and the US National Institutes of Health Public Access Policy successfully applied since 2008 (European Science Foundation, 2021; US Department of Health and Human Services, 2008).

Achieving Australia's National Digital Health Strategy requires networks of healthcare academics, researchers and supporting information professions to collaborate on a system that is respected by health consumers as safe, seamless and secure (Australian Digital Health Agency, 2021). The conceptual KMS conceptual framework is a powerful tool that can be used to align the components that underpin the effectiveness and sustainability of an Australasia OBR. It is a tool to assist the transition from organizational silos to an open science environment. Adoption of the

framework can ultimately assist research communities to foster world-class collaboration and corroboration through systematic and coordinated effort, informed by KM theory and practice.

7.2.2 Repository challenges

The need for archiving and making openly accessible national and regional substructures of research output is evidenced by the establishment of Europe PMC in 2007, followed by PMC Canada in 2009, as PMC International (US National Library of Medicine, National Institutes of Health, 2018). In 2018, PMC Canada ceased operation, alleging that institutional repositories could replace their role. In Australia, institutional repositories achieve low levels of compliance; they have no coordinating authority and often suffer from lack of resources (Council of Australian University Librarians, 2017).

There are no formal measures of university compliance with open access requirements of funding bodies in Australia. PMC International has been able to achieve high levels of compliance, as publishers submit author content to the repository in most cases and penalties for researchers exist if they do not comply with open publishing processes. The work of publishers to provide the accepted article *content* removes the submission burden from the researcher and is a key reason why the PMC model is effective. It is recommended that funding bodies, such as the NHMRC, ARC and the Health Research Council of New Zealand consider the opportunities made possible from investing in a permanent and sustainable OBR.

The closure of PMC Canada suggests that some of the challenges for sectors within the healthcare industry, government and universities, to work together are difficult to resolve. The success of establishing a PMC in the European region is counter to the experience in Canada. A major reason why PMC Canada went offline in 2018 was due to the growth in Canadian institutional repositories and other technology systems that superseded those of PMC Canada. Even so, institutional repositories in Australia, on average, achieve low levels of compliance with funder open access policies, whereas, due to effective processes, the US National Institutes of Health and Wellcome Trust achieve compliance rates around 90%, which is underpinned by US PMC and Europe PMC repositories respectively (Kirkman & Haddow, 2020; Lariviere & Sugimoto, 2018).

In the later period of PMC Canada's operation, there was evidence of a lack of balance with its management of KM processes—and the *technology, people,* repository and *content* dimensions of each process. The imbalance in PMC Canada's KM processes contributed towards the breakdown of this system.

Formalities exist to become a member of PMC International. An agreement with Europe PMC to establish an Australasia OBR may be the viable solution to overcome the identified threats of lack of commitment from a national or regional body. Improving biomedical knowledge management processes in the Australasian region may be possible from adopting an OBR for consolidated storage, retrieval and transfer processes of research output that is linked to its underlying data. This in turn could put regional biomedical research under a stronger spotlight and potentially lead to improvements with research quality. The amount of content available from an open consolidated repository, in particular for data and text mining, will grow if Europe PMC and an Australasia OBR could combine forces. This also would contribute to the range of bio-reports that are possible, with flow-on benefit to industry and those groups often excluded from public research due to journal subscription paywalls.

Plan S, an initiative for open access publishing, released in 2018 and supported by cOAlition S, required that from 2021, scientific publications resulting from research funded by public grants, be published in journals or platforms that are open access compliant (European Science Foundation, 2021). Europe PMC fully supports the mission of Plan S to drive universal open access for research articles (Europe PMC, 2019). Many of the cOAlition S funders use Europe PMC as their repository for deposit of their publication outputs from publicly funded biomedical projects. Europe PMC meets all the requirements outlined in the implementation plans and points out that this approach provides the best opportunity for discovery, interoperability and reuse of the full-text content of research articles, and therefore contributes effectively to open science (Europe PMC, 2019).

Recent research has found that the proportion of green open access articles could be greatly increased if New Zealand authors utilised the rights afforded to them by publishers to make versions of their work freely accessible in non-commercial repositories. Fully 3,089 (88%) of closed articles could be made available in this way, but the 2017 sample identified only 125 articles in New

Zealand's institutional repositories (White et al., 2021). Greater collaboration between Australasian health librarians in universities, hospitals, healthcare organisations and medical research bodies is recommended to overcome obstacles to implementing and advancing open science in the region.

An Australasia OBR fits with the objective of making Australia's publicly funded research outputs F.A.I.R. (Findable, Accessible, Interoperable, Reusable). It presents opportunities to enhance the clinical research cycle process and optimise Australasian biomedical research through the establishment of a permanent archive available to all.

The vast majority, if not all, Australasia repositories at present do not comply with the technical requirements of Plan S. Nevertheless, Europe PMC is one of the few repositories that does comply with Plan S, and strengthening its adoption in the Australasian region would be a means to achieve immediate open access to publications from publicly funded research.

7.2.3 Health librarianship challenges

The key barriers users experience when they try to access information in a clinical environment have been identified by recent research (Laera et al., 2021). Eight major pain-points in accessing information were identified by the study and include access, paywalls, resource platforms, resource scope, awareness, integration, financial limitations and time (Laera, Gutzman, Spencer, Beyer et al., 2021). It is not feasible for all content to be made open access, although adoption of the KMS framework for the introduction of an OBR has scope to address many of the pain-points raised. Use of the KMS framework to analyse and assess information systems is a means to determine the benefits and pitfalls that can be communicated to users. The KMS framework is a means for librarians to identify key components and lobby for them across information systems to improve the user experience.

Ongoing professional development of the health library profession to deal with the challenges of supporting the scholarly communication and research needs of users is a constant requirement (Shaffer, 2021). With the devastating financial impact from the loss of international students to Australian universities because of border closures due to the COVID-19 pandemic, Australian academic libraries in 2021 are experiencing cut-backs as a consequence (Kent, 2021). It is time to

question any further duplication of effort that occurs with library services in the academic sector. Whilst most Australian library universities have discovery systems, it is recommended that the curation of national or regional repository collections be considered to help rationalise existing duplication. With the management of print collections, the constant curating, such as updating editions, creating room for storage, removing out-of-date copies and repair of texts to maintain onsite physical collections was necessary. With digital information platforms and repositories, a radical rethink and redesign is possible and necessary.

The increasing presence of open access articles is transforming the scholarly communications landscape. With the advent of openly accessible research resources, disruption to the library's key role as the major provider of information resources, such as research databases and reference tools, from its discovery platform has occurred over the past ten years (Dahl, 2021). Movements such as the Initiative for Open Abstracts ("Initiative for open abstracts," 2020) are contributing to the effort to open up abstracts and make research output more discoverable. Traditionally only proprietary databases had a monopoly requiring a subscription to search article abstracts. It is recommended that library services gradually move on from the large package consortia 'big-deals' model that have taken place since the 1990s and investigate opportunities afforded from transformative agreements and the wider adoption of suitable information repositories for their users (Wise & Estelle, 2020).

Kennan, Kingsley and Richardson have argued for consideration of a range of formats and options for health librarians in the establishment of professional development on emerging roles in scholarly communication (Kennan, Kingsley & Richardson, 2021). At the University of Bucharest workshop, reported during Cycle Three, it was evident that library students focused on traditional, information services processes, rather than appraising aspects such as content discoverability and interoperability. It would be beneficial to test the KMS framework further and explore the opportunity to help library students and librarian practitioners adopt a wider paradigm for the analysis of information platforms and repositories.

7.3 Findings

PMC International comprised the US PMC, Europe PMC and PMC Canada, when the interviews and the focus group took place. Views on the potential for an Australasia OBR obtained from participants were not as an alternative to the existing solution—that is, institutional repositories—but as a chance to explore the Strengths Weaknesses, Opportunities and Threats of a PMC in the region.

The COVID-19 pandemic has accentuated the need for action to open up the output from research and development universally and design systems that are sustainable (Alemneh et al., 2020). Based on the investment to date in repositories such as PMC International and other world open databases, it has been possible to leverage these systems and the usage figures illustrate that reliance upon such research output is of an immense magnitude, such as:

> 'Initially, 50 publishers have made their coronavirus content available in PMC. Within the first two weeks, articles from the COVID-19 subset had been accessed 2 million times. (SPARC, 2020).' (Update: as of May 2021, 155,000 articles in PMC's coronavirus collection under this initiative have been accessed more than 160 million times).

Even so, there are reports that the research evidence pipeline is cracking. There is a need to collaborate in order to improve the quality, the speed of production and the delivery of improvements and new discoveries to improve human healthcare (Fix medicine's evidence pipeline [Editorial], 2021; Pearson, 2021). The key opportunities for a potential Australasia OBR identified by this research are: greater discoverability and accessibility of biomedical regional research output, greater sharing of repository expertise, consolidation, improved copyright compliance, data-set integration and an increased provision of mineable and reusable content. The opportunity for an Australasia OBR to overcome threats, such as the present inadequacy of existing repository and information resource access, and to address the problem of limited available funding to ensure longevity of an OBR for the Australasian region, remains to be tested.

The adoption of formalised KM processes could potentially result in significantly improved biomedical information systems (Becerra-Fernandez & Sabherwal, 2015). There is a great opportunity for a body such as the NHMRC to take a leadership role in consolidating the present fragmented approach to the management of biomedical information by linking the research output to evidence of impact and improvements for society.

The KMS framework for an OBR demonstrated the significance of the interplay of existing services and resources. A repository is not just a technology. A repository, as previously discussed, is a set of systems and services that facilitates the ingestion, storage, management, retrieval, display, and reuse of digital objects (Pinfield, 2009). A key finding is the significance of the *people, process* and quality *content* to the success of a repository and the criticality of the *technology*, although it is merely a vehicle for transporting the research *content* through its life-cycle. The inclusion of the entire biomedical KM processes in the design of an information system is potentially a way to speed up the transfer and translation of primary knowledge in the research pipeline. Use of the KMS framework is a means to identify road-blocks in getting evidence to the apex of the evidence-based healthcare pyramid. The adoption of the framework is a powerful means to identify the extent to which open scholarship processes and elements already exist and what remains to fill the gaps to achieve a sustainable open scholarship OBR system.

As a senior biomedical researcher concisely summed up, 'As we increase Open Access to make knowledge more accessible and if an Australasia PMC does this, it would be worthwhile. It is not just about clinicians accessing an Australasia PMC. The ways it would contribute are diverse; an Australasia PMC would be accessible to consumers and this is important.' (Interview participant, Head biomedical researcher, male, Queensland). A blueprint for a sustainable Australasia OBR is one way forward.

The open science movement has gained significant momentum over the past two decades. Over this time, institutional and disciplinary repositories have significant KM process roles throughout the biomedical knowledge creation stages of discovery, creation, representation, storage, retrieval, transfer and application (Kruesi et al., 2018). There are further opportunities for repositories to work together to achieve the FAIR principles.

During my research, the field of data management has grown significantly—data has become the 'new gold'. Research integrity is demonstrated by linking articles to their research data. Data driven discovery has become a major objective for organisations such as the US National Library of Medicine. Visualisation of research output and results has become increasingly important, e.g., the growth of platforms such as *impactStory*.

KM processes can inform the design for a successful regional or national PMC and this was the objective of the third cycle of this action research project. Opportunity exists to test this theory claim through the development of an Australasia OBR. According to senior staff from the National Library of Australia, KM process principles were a key reason for the success of their legal deposit online system. Senior NLM staff indicated the balance of *technology, people, process* and *content* were essential to the new legal edeposit system, NED, that has been implemented throughout the National and State libraries in Australia (National Library of Australia, 2018).

In November 2018, the Council of Australian University Librarians (CAUL) and the Australasian Open Access Strategy Group's (AOASG) submission on establishing a strategic approach to open scholarship was recognised in a report by a Standing Committee on Employment, Education and Training. According to Ginny Barbour, Director of Open Access Australasia 'we should publish research as a fully interconnected, purposefully designed, equitable, global scholarly ecosystem supported by a wide variety of open access publishing models, underpinned by sophisticated linking of well-curated, interoperable research articles and other outputs, including data and software' (Barbour, 2018). The emphasis is on removing barriers to the effective dissemination of knowledge.

Evidence exists of the success and pervasive nature of PMC International as a repository. Reports include PMC being able to satisfy funder requirements to publish open access articles within twelve months or earlier (Lariviere and Sugimoto, 2018). Other evidence of Europe PMC's effectiveness is evident from the ongoing development of system features and services that are wide-ranging, such features that allow reporting on grants and research findings, author profiles linked to ORCID, text mining, related articles and an annotations service (Europe PMC, 2018; Europe PMC, 2019).

A PMC itself is not a panacea for all regions. A PMC requires a very significant investment and strict qualifications exist to become a member of PMC International. It is the PMC model that is available to all open access biomedical repositories and is worthy of attention. Working with Europe PMC may be a suitable starting point to commence development of an open access biomedical repository for the Australasian region.

How repositories point to the essential global libraries of living systematic reviews that report concisely on issues such as vaccine roll-out to recovery and school closures, is of critical importance in particular during a global pandemic. Establishment of an Australasia OBR is a means to have a quality website of essential medical and health sciences library knowledge, that can include prominent links to the essential global libraries.

7.4 Research pathway

The following propositions set the pathway for the research:

1. There is stakeholder interest in an investigation on the opportunity for an Australasia open biomedical repository (OBR), as a potential member of PMC International.
2. A Knowledge Management System (KMS) approach provides a sound basis for developing a conceptual framework for an OBR.
3. KMS provides an effective theoretical framework for analysing and evaluating designs for repositories and platforms that support the advancement of open scholarship.

The research activities, their outcomes and the research context are summarised in Table 7.1. Research pathway.

The findings for the first proposition, that '*There is stakeholder interest in an investigation on the opportunity for an Australasia open biomedical repository, as a potential member of PMC International*' are reported in Chapter Four and published in a peer reviewed, quartile one journal (Kruesi, Burstein & Tanner, 2019). The question on the opportunity for an Australasian OBR was discussed with a wide cross-section of 45 potential stakeholders, whose details are reported in Chapter Three, Table 3.3, and Section 4.3.2 of Chapter Four. All of the stakeholders contacted during Cycle One were interested

in an investigation into the opportunity for an Australasia OBR. It is important to note that a senior executive and a head biomedical researcher both expressed interest in a multi-disciplinary open repository more so than an open biomedical repository. Two of the clinicians indicated that repositories such as PMC are just for biomedical researchers because those working in clinical practice have such huge clinical loads and are usually fulltime in the trenches (Marley, 2016). All of the other stakeholders signalled their resounding support for an investigation into the opportunity for an Australasia OBR.

The second proposition, that '*A Knowledge Management System (KMS) approach provides a sound basis for developing a conceptual framework for an OBR',* is the focus of Chapter Five. The conceptual KMS framework that was developed is a comprehensive approach based on its design as a sustainable OBR incorporating the nine KM processes (discovery, creation, representation, classification, storage, retrieval, dissemination, transfer and translation), each aligned with the elements (*people, process, technology* and *content*). A detailed version of the KMS framework for an OBR was published in *the Journal of Knowledge Management* (Kruesi, Burstein & Tanner, 2020). An earlier version of the framework was introduced at national and international outlets (Kruesi, Burstein, Tanner & Todd, 2018; Kruesi, Tanner & Burstein, 2019; Kruesi, Tanner & Burstein, 2018).

The third proposition, that '*KMS provides an effective theoretical framework for analysing and evaluating designs for repositories and platforms that support the advancement of open scholarship',* is explored in detail in Chapter Six. An analysis and evaluation of two repositories and two platforms was undertaken to test the KMS framework. The Europe PMC evaluation is presented as a more detailed case example and the other three information systems are brief case summaries included in Chapter Six. The analyses and evaluations of the four information systems using the KMS framework demonstrated the robust nature of the framework. With each of the evaluations it was possible to refine the approach by improving definitions of processes and the gradings. The addition of colour coding to the procedure was a beneficial feature. From the grading, it was possible to compile snap-shot summaries that provide at a glance a visual of the mix of positive and negative aspects of the information system. A collaboration with the Associate Professor from the University of Bucharest on the workshop held with the higher degree students provided feedback on the use of the KMS framework as an evaluation tool for repositories and platforms that support open scholarship. A lightning talk on Cycle Three was accepted for presentation at the virtual Medical

Library Association's Meeting held in May 2021 (Kruesi, 2021) and a further research publication on this work is planned.

The strands of the three action research cycles, undertaken to explore the research propositions, have been integrated in the discussion, findings, future research and final conclusions sections in this chapter.

Table 7.1 Research pathway

Chapter	Cycle number and dates	Research proposition	Cycle theme	Research activities	Research outcomes	Research context
Four	One (2016-2018)	There is stakeholder interest in an investigation on the opportunity for an Australasia open biomedical repository, as a potential member of PMC International.	A strengths, weaknesses, opportunities and threats (SWOT) analysis to assess the support for investigating membership of PMC International.	SWOT analysis of a potential Australasia PMC.	The research found sufficient interest to warrant an investigation into the feasibility of an Australasia OBR. The Australasia PMC Working Group was formed and supported my recommendations to the Australian Group of Eight (G08) University Librarians' Committee.	Canada PMC was discontinued. The Australian Liberal/National Government is re-elected. The timing was not suitable for a national open access initiative.
Five	Two (2017-2020)	A KMS approach provides a sound basis for developing a conceptual framework for an OBR.	Conceptual framework of an Australasia OBR	Development of a conceptual KMS framework for an Australasia OBR	The KMS framework was shown to be an effective means to explore how to develop a sustainable open scholarship platform that could optimise existing services and resources.	COVID-19 pandemic strikes. CAUL pursuing a national open science strategy and signalling a slow and steady approach. The Australasia PMC Working Group was discontinued.

Table 7.1 Research pathway - continued

Chapter	Cycle number and dates	Research proposition	Cycle theme	Research activities	Research outcomes	Research context
Six	Three (2019-2020)	KMS provides an effective theoretical framework for analysing and evaluating designs for repositories and platforms that support the advancement of open scholarship.	Use of the KMS framework to analyse and evaluate designs for open scholarship repositories.	The KMS framework was tested for any gaps in the conceptual design. An analysis and evaluation of two repositories and two platforms was undertaken to test the KMS framework.	Feedback indicated the suitability of the KMS framework for evaluating designs for an open scholarship system was confirmed.	COVID-19 pandemic ongoing. UNESCO Recommendation on Open Science are finalised by Member States. Plan S comes into force throughout Europe.

'If you want to go fast, go alone. If you want to go far, go together' – African Proverb.

7.5 Reflections on the methodology

The research based on action research methodology has proved to be an effective approach to producing new knowledge about scholarly communications, whilst also addressing practical problems. The problems include an inadequate system for researchers to comply with funders' open access requirements, fragmentation of institutional repository content, along with challenges of accessibility, discoverability, interoperability and permanency of biomedical research output in the Australasian region.

As discussed in Chapter Three, the study followed an action research methodology. There were three action research cycles and each concluded with a research intervention. A full account of the action research methodology is reported in Chapter Three.

For Cycle One, the Australasia PMC Working Group's role was to provide strategic leadership and advice on the conceptual design, implementation and sustainability of an Australasia PMC, to provide feedback on funding opportunities, and provide input to drafting funding applications. The group held ten meetings and the action research intervention for Cycle One was the support from the working group for my recommendations to go to the Go8 University Librarians' Committee.

For Cycle Two, the KMS framework for developing an OBR was established after many iterations. The action research methodology was a means to deeply explore the elements and processes in an OBR. The cyclical method as a theoretical construct resulted in a KMS framework.

Lastly, the action research methodology for Cycle Three resulted in improvements to the procedure for the KMS framework and was a means to test its application more broadly on four information systems that support open scholarship. A summary of the action research interventions is in Table 7.2.

Table 7.2 Action research interventions

Cycle	Intervention
Cycle One: Do we need an Australasia PMC?	Support from the Australasia PMC Working Group for my recommendations to the Go8 University Librarians' Committee
Cycle Two: KMS conceptual framework for an open biomedical repository	Development of a KMS framework for developing an OBR
Cycle Three: Applying the KMS framework to analyse and evaluate repository and platform designs	Use of the KMS framework to analyse and evaluate information systems to support open scholarship

7.6 Contributions to knowledge

This PhD study contributes new theoretical and practical knowledge to the fields of librarianship, knowledge managements and the biomedical and health sciences. This section sums up the contribution this research has made to theory and practice.

7.6.1 Contributions to theory

In Cycle One, the investigation contributed by advancing the understanding of the strengths, weaknesses, threats and opportunities (SWOT) related to the establishment of disciplinary repositories (Kruesi, Burstein & Tanner, 2019). PMC International was the focus of the strengths and weaknesses analysis and a potential Australasia PMC was the focus of the opportunities and threats identified. To date, there are no other theoretical studies that assess the case for a disciplinary repository in the Australasian region, taking into consideration the investment over

recent decades in the region of institutional repositories and the wider environment such as funders and healthcare organisations outside of the university sector.

The conceptual framework for an OBR is based on theoretical KM processes which are aligned with the elements *people, process, technology* and *content*. This is another unique contribution, as the framework demonstrates the dependencies and interplay of elements and processes to sustain an OBR. It makes a theoretical and developmental contribution to the fields of KM, biomedicine, health sciences librarianship and the wider field of open scholarship (Kruesi, Burstein & Tanner, 2020). This framework goes beyond previous frameworks, such as the Institutional and Development (IAD) framework, as it is standards-based and operationalises a comprehensive system of knowledge (Hess & Ostrom, 2006). This research contributes to greater knowledge in the field of KM, as no previous studies have reported on the intersection between open science and a KMS. In the Australasian region, biomedical research is governed at the information management level, whereas to achieve informed health-care decisions, synthesised knowledge is required to support action. The research confirms that production of biomedical knowledge transcends organizational boundaries and can benefit if conceptualised as a KMS life-cycle. The overarching principles in the KMS framework, including governance and quality, is another unique theoretical contribution to the fields of KM and biomedical sciences.

7.6.2 Contributions to practice

The investigation contributed to practice for librarians, repository managers and the wider research community, from the SWOT analysis related to the establishment of disciplinary repositories. The research can influence the development of an open science infrastructure through its systematic analysis of the potential interest in, and viability of a biomedical repository for managing openly accessible research outputs for the Australasian region.

Application of the conceptual framework informed a submission to the Australian Government's National Health Information Strategy (Australian Library and Information Association, 2020). The submission that was made in 2020 by the CEO of the Australian Library and Information Association, was sourced directly from my research. ALIA put forward the 'number one

opportunity' as the creation of an open Australian biomedical repository, as a member of PMC International.

The KMS framework for an OBR is an important design approach for planning further development of existing open repositories and any future national or regional open repositories. For example, the preliminary work on the framework was presented at an IFLA Conference in 2018 (Kruesi, Tanner & Burstein, 2018) and later published in the *IFLA Journal* in 2019 (Kruesi, Tanner & Burstein, 2019). Since this time the paper has been cited eight times by researchers from countries throughout the world, including Russia, Iraq, Serbia, India, Portugal and Brazil.

A basic version of the KMS framework was introduced in a course for library students presented in October 2019. The course on Digital Health Information Services (HLTH90020) was established by the ALIA Health Libraries Australia group and hosted online by The University of Melbourne. In 2020, the course was postponed as a result of COVID-19. A review of future options for the course are underway. It may be possible to make an ongoing contribution, incorporating the KMS framework as an evaluation tool for information systems, within the future course that is planned for health sciences library students.

The finalised KMS framework was also demonstrated as a tool for analysing and evaluating repository designs. In Cycle Three, the KMS framework was tested with librarians and information experts at the University of Bucharest. Feedback from the Associate Professor and the students indicated the framework has the potential for analysing and evaluating repository designs. A 'lightning paper' was presented at the US Medical Library Association's Annual Meeting held in 2021 (Kruesi, 2021) and a future journal article on these findings is planned. The framework approach is unique, as other frameworks are written for repository experts; the KMS framework can be used by researchers to analyse and evaluate biomedical information platforms and repositories.

7.7 Focus and future research

7.7.1 Focus

This research has focused on biomedicine, for numerous reasons as discussed in section 1.3 *Why the focus on biomedicine?* During this research the KMS perspective was successfully tested as a general approach to describe how scholarly content and data serves the purposes of systematic management of scientific knowledge and how the role of open access resources complements and addresses the challenges of the regional KM.

7.7.2 Future research

Based on the increase of full-text content added by publishers to PMC during the COVID-19 pandemic, measuring how much Australasia content is now available from the repository is recommended (SPARC, 2020). Ensuring the full-text content is available from PMC International is a means to partially address the problems of fragmentation, accessibility, discoverability, interoperability, reusability and permanency of biomedical research outputs. To help avoid duplication of effort and increase collaboration, further research is recommended to explore the relationships between, and the future of, library discovery systems, university publishing presses and repositories in the Australasian region. Greater optimisation of existing information systems such as Trove and other relevant Australasia open systems in collaboration with PMC International should be pursued.

In 2019, only 43 per cent of research publications associated with Australian authors were open access (Neylon & Montgomery, 2020). It is timely to learn from our neighbour, Indonesia, which has achieved an open access rate of more than 80 per cent (Neylon & Montgomery, 2020). In addition, this research identified that Korea has also had discussions with the US NLM in regard to establishing a PMC (NLM Program Manager, 2019). Future collaboration with other Asia-Pacific partners to advance open science would be of potential benefit to the Australasian region.

The impact of improved retrieval and automation tools is speeding up time to complete systematic reviews. It is important to investigate the potential to include these tools in the design of repositories (Clark et al., 2020; Marshall & Wallace, 2019). Evaluations of other information

platforms and repositories help to identify gaps and provide opportunities to improve existing repository design. It is recommended that the KMS framework be further developed as a tool for application across multi-disciplinary and interdisciplinary information systems.

In recognition of the importance and future potential of multi-disciplinary and inter-disciplinary research, it will be important to shift knowledge out of silos, such as the closed databases, for example the Australian Informit databases and platforms. Even open systems, such as Epistemonikos, are not necessarily well known to health researchers to enhance discovery of research output across all fields.

As raised in the discussion, it would be beneficial to test the KMS framework further and explore the opportunity to help library students and librarian practitioners adopt a wider paradigm for the analysis of information platforms and repositories. The focus over recent decades for librarians has been on electronic information resources. This research has demonstrated the wider KM processes that are integral to biomedical information systems and developing deeper librarians' understanding of the elements and processes will contribute to establishing an ongoing, sustainable open scholarship environment.

Lastly, future research is required to reflect and further test the strengths and weaknesses of the *people, process, technology* and *content* elements and the overall transferability of the KMS framework to multi-disciplinary and interdisciplinary information systems.

7.8 Conclusion

A key benefit of establishing an ongoing Australasia OBR with PMC International is the consolidation of health and medical research locally and internationally. Whilst researchers may be satisfying Australian funder requirements to publish openly, most are paying gold open access fees to make research output available from journal websites and this is resulting in fragmented knowledge that is not readily discoverable by other researchers and members of the public.

Requirements to achieve open access publishing highlighted by Plan S are rigorous and controversial. High standards for open access publishing are essential and collaborating with publishers to achieve innovation in scholarly publishing is vital.

The COVID-19 pandemic has reminded us that biomedical research is a global concern and heightened the essential need to develop future systems that ensure our health knowledge is authoritative and reliable (Alemneh, Hawamdeh, Chang, Rorissa et al., 2020). Biomedical researchers need to navigate specific content and data tailored to research needs. We need to overcome the pain-points highlighted in present biomedical information systems and create reliability and quality when we bring together future OBR KMS (Laera, Gutzman, Spencer, Beyer et al., 2021).

Since the COVID-19 pandemic, universities in Australia have suffered major revenue shortfalls, in particular with the loss of international student enrolments. It will be imperative that universities work together to manage knowledge more efficiently in the future hence—a national or regional institutional repository solution should be pursued.

'*An old tradition and a new technology have converged to make possible an unprecedented public good*.' (Budapest Open Access Initiative, 2002). There is great opportunity to accelerate the advancement of scholarly publishing through open access biomedical repositories. A KMS framework for an OBR is a means to build on the present foundation and achieve sustainable open scholarship for the Australasian region.

'*Open Science is not a finish line, but rather a means to an end. For research to be more efficiently disseminated, verified and credited, system-wide changes toward Open Access must be embraced across the scientific community*.' (PLOS, 2021)

References

Academy of Medical Sciences. (2015). Reproducibility and reliability of biomedical research: improving research practice. *Symposium report*. Retrieved from https://acmedsci.ac.uk/viewFile/56314e40aac61.pdf (accessed 8 May 2021).

Alavi, M., & Leidner, D. E. (2001). Review: knowledge management and knowledge management systems: conceptual foundations and research issues. *MIS quarterly, 25*(1), 107-136.

Alemneh, D. G., Hawamdeh, S., Chang, H. C., Rorissa, A., Assefa, S., & Helge, K. (2020). Open access in the age of a pandemic. *Proceedings of the Association for Information Science and Technology, 57*, e295. https://doi.org/10.1002/pra2.295

Alper, B. S., & Haynes, R. B. (2016). EBHC pyramid 5.0 for accessing preappraised evidence and guidance. *Evid Based Med, 21*(4), 123-125. doi:10.1136/ebmed-2016-110447

Aoki-Kinoshita, K. F., Kinjo, A. R., Morita, M., Igarashi, Y., Chen, Y. A., Shigemoto, Y., . . . Ogishima, S. (2015). Implementation of linked data in the life sciences at BioHackathon 2011. *J Biomed Semantics, 6*, 3. doi:10.1186/2041-1480-6-3

Argote, L., & Ingram, P. (2000). Knowledge transfer: A basis for competitive advantage in firms. *Organizational behavior and human decision processes, 82*(1), 150-169.

Armbruster, C., & Romary, L. (2009). Comparing repository types: challenges and barriers for subject-based repositories, research repositories, national repository systems and institutional repositories in serving scholarly communication. *SSRN*. Retrieved from http://dx.doi.org/10.2139/ssrn.1506905 (accessed 26 June 2021).

Arrow, K. (1962). Economic welfare and the location of resources for invention. In *The rate and direction of inventive activity* (pp. 155-173). Princeton, NJ: Princeton University Press.

Artini, M., Atzori, C., Bardi, A., La Bruzzo, S., Manghi, P., & Mannocci, A. (2015). The OpenAIRE literature broker service for institutional repositories. *D-Lib Magazine, 21*(11/12). doi:10.1045/november2015-artini

Australian Digital Health Agency. (2021). National Digital Health Strategy and framework for action. Retrieved from https://www.digitalhealth.gov.au/about-us/national-digital-health-strategy-and-framework-for-action (accessed 20 June 2021).

Australian F.A.I.R. Access Working Group. (2017). Framework for F.A.I.R. Access to Australia's research. Retrieved from https://aoasg.org.au/2017/02/24/framework-for-f-a-i-r-access-to-australias-research/ (accessed 22 March 2021).

Australian Institute of Health and Welfare. (2020). Health expenditure Australia 2018-19. Retrieved from https://www.aihw.gov.au/reports/health-welfare-expenditure/health-expenditure-australia-2018-19/contents/data-visualisation (accessed 18 February 2021).

Australian Library and Information Association. (2008). *ALIA-HLA submission to the National Health and Hospitals Reform Commission*. Retrieved from https://read.alia.org.au/alia-hla-submission-national-health-and-hospitals-reform-commission-july-2008

Australian Library and Information Association. (2020). *Consultation response on the National Health Information Strategy Framework [unpublished report]*.

Australian Living Evidence Consortium. (2018). Medical Research Future Fund: 2018-2020 priorities. Retrieved from https://australia.cochrane.org/sites/australia.cochrane.org/files/public/uploads/Living Evidence/aust_living_evience_consortium_mrff_priorities_2018-2020_final_for_web.pdf (accessed 26 June 2021).

Australian Research Council. (2013). ARC Open Access Policy Version 2017.1. Retrieved from https://www.arc.gov.au/policies-strategies/policy/arc-open-access-policy (accessed 22 March 2021).

Australian Research Council. (2017). *ERA 2018 submission guidelines*. Canberra: Commonwealth of Australia.

Australian Research Data Commons. National Data Assets. Retrieved from https://ardc.edu.au/collaborations/strategic-activities/national-data-assets/ (accessed 10 June 2021).

Ayres, M. L. (2017) *Cycle One interview/Interviewer: L. Kruesi.*

Azadbakht, E., & Schultz, T. (2020). At the click of a button: Assessing the user experience of open access finding tools. *Information Technology and Libraries (Online), 39*(2), 1-13. doi:https://doi.org/10.6017/ital.v39i2.12041

Barbour, V. (2017). *The role of the Australasian Open Access Strategy Group in supporting OA initiatives in the Australasian region*. Paper presented at the Open Repoistories 2017, Brisbane. Retrieved from https://www.openrepositories.org/

Barbour, V., & Borchert, M. (2020). Open science: after the COVID-19 pandemic there can be no return to closed working. *Science fo Australians*. Retrieved from https://www.science.org.au/curious/policy-features/open-science-after-covid-19-pandemic-there-can-be-no-return-closed-working (accessed 18 Feburary 2020).

Barbour, V., & Bradley, F. (2021). A renewed impetus for open research in Australia. *IAU Horizons, 26*(1), 28-29.

Beagrie, N., & Houghton, J. (2016). The value and impact of the European Bioinformatics Institute: executive summary. Retrieved from http://www.beagrie.com/EBI-impact-summary.pdf (accessed 24 March 2021).

Becerra-Fernandez, I., & Sabherwal, R. (2015). *Knowledge management: systems and processes* (2nd ed.). New York, NY: Ebooks Corporation.

Bishop, B. (2020). Research impact challenge: understanding Academia.edu and ResearchGate Retrieved from https://libguides.auburn.edu/ImpactChallenge/researchgate (accessed 20 April 2021).

Björk, B. C. (2014). Open access subject repositories: An overview. *Journal of the Association for Information Science and Technology, 65*(4), 698-706.

Bodenreider, O. (2004). The Unified Medical Language System (UMLS): integrating biomedical terminology. *Nucleic acids research, 32*(Database issue), D267-D270. doi:10.1093/nar/gkh061

Borrego, Á. (2017). Institutional repositories versus ResearchGate: The depositing habits of Spanish researchers. *Learned Publishing, 30*(3), 185-192. https://doi.org/10.1002/leap.1099

Bosman, J., Frantsvag, J. E., Kramer, B., Langlais, P.-C., & Proudman, V. (2021). *The OA diamond journals study: exploring collaborative community-driven publishing models for Open Access*. Retrieved from https://zenodo.org/record/4558704

Breeding, M. (2018). Library systems report 2018: New technologies enable an expanded vision of library services. *American Libraries, 49*(5), 22-35.

Burrows, S. (2006). A review of electronic journal acquisition, management, and use in health sciences libraries. *J Med Libr Assoc, 94*(1), 67-74.

Canadian Institute of Health Research. (2019). PubMed Central Canada taken offline in February 2018. Retrieved from https://cihr-irsc.gc.ca/e/50728.html (accessed 23 March 2021).

Canese, K. (2019). An Updated PubMed Is on Its Way. *NLM Tech Bull(427)*. Retrieved from https://www.nlm.nih.gov/pubs/techbull/ma19/ma19_pubmed_update.html

Cecez-Kecmanovic, D., & Kennan, M. A. (2013). The methodological landscape: information systems and knowledge management. In K. Williamson & G. Johanson (Eds.), *Research methods : information, systems and contexts* (pp. 113-137). Prahran, Vic.: Tilde University Press.

Centobelli, P., Cerchione, R., & Esposito, E. (2019). Efficiency and effectiveness of knowledge management systems in SMEs. *Production Planning & Control, 30*(9), 779-791. doi:10.1080/09537287.2019.1582818

Chanthadavong, A. (2020). National Library of Australia brings 10-year-old Trove research portal into the 21st century. Retrieved from https://www.zdnet.com/article/national-library-of-australia-unveils-the-next-chapter-of-the-trove-portal/#ftag=RSSbaffb68

Chen, X., Dallmeier-Tiessen, S., Dasler, R., Feger, S., Fokianos, P., Gonzalez, J. B., . . . Neubert, S. (2019). Open is not enough. *Nature Physics, 15*(2), 113-119. https://doi.org/10.1038/s41567-018-0342-2

Clark, J., Glasziou, P., Del Mar, C., Bannach-Brown, A., Stehlik, P., & Scott, A. M. (2020). A full systematic review was completed in 2 weeks using automation tools: a case study. *Journal of clinical epidemiology, 121*, 81-90. https://doi.org/10.1016/j.jclinepi.2020.01.008

Collaboration for Environmental Evidence. (2018). *Guidelines and standards for evidence synthesis in environmental management* [version 5]. A. S. Pullin, G. K. Frampton, B. Livoreil, & G. Petrokofsky (Eds.). Retrieved from http://www.environmentalevidence.org/information-for-authors

Collins, M. (2019, 18 August 2020). The new PubMed is here. *NLM Tech Bull, Nov-Dec(431)*. Retrieved from https://www.nlm.nih.gov/pubs/techbull/nd19/nd19_pubmed_new.html

Committee on Publication Ethics. (2021). Promoting integrity in scholarly research and its publication COPE. Retrieved from https://publicationethics.org/ (accessed 20 June 2021).

Confederation of Open Access Repositories. (2019). COAR Community Framework for Good Practices in Repositories. Retrieved from https://www.coar-repositories.org/coar-community-framework-for-good-practices-in-repositories/ (accessed 20 May 2021).

Confederation of Open Access Repositories. (n.d.). Next generation repositories. Retrieved from https://ngr.coar-repositories.org/ (accessed 20 May 2021).

Cook, C. E., Bergman, M. T., Cochrane, G., Apweiler, R., & Birney, E. (2018). The European Bioinformatics Institute in 2017: data coordination and integration. *Nucleic acids research, 46*(D1), D21-D29. doi:https://doi.org/10.1093/nar/gkx1154

Cornet, R., & de Keizer, N. (2008). Forty years of SNOMED: a literature review. *BMC Med Inform Decis Mak, 8 Suppl 1*, S2. doi:10.1186/1472-6947-8-s1-s2

Corvello, V., Genovese, A., & Verteramo, S. (2014). Knowledge sharing among users of scientific social networking platforms. *Frontiers in Artificial Intelligence and Applications, 261*, 369-380. doi:10.3233/978-1-61499-399-5-369

Council of Australian University Librarians. (2017). *Current State of Open Access: Briefing Paper for Universities Australia (UA) Deputy Vice-Chancellors Research Committee: Agenda item 3154a. CAUL Executive Meeting 2017/6*. 1-10.

Council of Australian University Librarians and Australasian Open Access Strategy Group. (2018, 18 January 2019). Joint statement on the importance of open scholarship. Retrieved from https://www.caul.edu.au/sites/default/files/documents/media/open-scholarship2018joint-statement.pdf (accessed 26 June 2021).

Creative Commons. (n.d.). Unit 1: What is Creative Commons. *Creative Commons certificate for educators, academic librarians and GLAM*. Retrieved from https://certificates.creativecommons.org/cccertedu/chapter/1-1-the-story-of-creative-commons/ (accessed 19 June 2021).

Creswell, J. W. (1998). *Qualitative inquiry and research design: choosing among five traditions*. Thousand Oaks, CA: Sage Publications.

Crowley, S. D., Owens, T. A., Schardt, C. M., Wardell, S. I., Peterson, J., Garrison, S., & Keitz, S. A. (2003). A Web-based Compendium of Clinical Questions and Medical Evidence to Educate Internal Medicine Residents. *Academic Medicine, 78*(3), 270-274.

Cullen, R., & Chawner, B. (2011). Institutional repositories, open access, and scholarly communication: a study of conflicting paradigms. *J Acad Libr, 37*(6), 460-470.

Dahl, M. (2021). The evolving role of library collections in the broader information ecosystem. In D. Baker & L. Ellis (Eds.), *Future directions in digital information: predictions, practice, participation* (pp. 161-174). Cambridge, MA: Elsevier.

Deloite Access Economics. (2015). *The importance of universities to Australia's prosperity: a report prepared for Universities Australia*. Retrieved from https://www2.deloitte.com/au/en/pages/economics/articles/importance-universities-australias-prosperity.html

Digital Preservation Coalition. (2015). *Digital preservation handbook*. N. Beagrie & W. Kilbridie (Eds.). (2nd ed.). Retrieved from https://www.dpconline.org/handbook

Dizikes, P. (2016). MIT task force releases preliminary "future of libraries" report. *MIT News*. Retrieved from http://news.mit.edu/2016/mit-task-force-releases-preliminary-future-libraries-report-1024 (accessed 27 June 2021).

DOAJ. (2003-). Directory of Open Access Journals. Retrieved from https://doaj.org (accessed 20 June 2021).

Dudovskiy, J. (2018). *The ultimate guide to writing a dissertation in business studies: a step-by-step assistance*. New York: Sage Publications. Retrieved from https://research-methodology.net/research-philosophy/epistomology/constructivism/

El-Khayat, Y. M. (2017). Epistemonikos. *Journal of the Medical Library Association, 105*(4), 431. https://doi.org/10.5195/jmla.2017.260

Elden, M., & Chisholm, R. F. (1993). Emerging varieties of action research: introduction to the special issue. *Human Relations, 46(2),* 121-142. Retrieved from https://search.proquest.com/docview/1474345838?accountid=12528

Elliott, J. H., Turner, T., Clavisi, O., Thomas, J., Higgins, J. P., Mavergames, C., & Gruen, R. L. (2014). Living systematic reviews: an emerging opportunity to narrow the evidence-practice gap. *PLoS Med, 11(2),* e1001603. Retrieved from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3928029/pdf/pmed.1001603.pdf

Elsevier B.V. (2017). [Disciplines of Medicine and Biochemistry]. *SciVal, RELX Group* Retrieved from https://www.scival.com/

Epistemonikos Foundation. (n.d.). Who we are. Retrieved from https://www.epistemonikos.cl/who-we-are/ (accessed 26 May 2021).

euroCris. (2020). Why does one need a CRIS [Current Research Information Systems]? Retrieved from https://www.eurocris.org/why-does-one-need-cris (accessed 26 June 2021).

Europe PMC. (2017). Retrieved from https://europepmc.org/ (accessed 26 October 2017).

Europe PMC. (2019). Europe PMC's response to the implementation guidance of Plan S. *Blog - Europe PMC*. Retrieved from http://blog.europepmc.org/2019/02/europe-pmc-plan-s-feedback.html (accessed 19 June 2021).

Europe PMC. (2020a). Five stories showing how Europe PMC is used by the life sciences community. *Blog - Europe PMC*. Retrieved from http://blog.europepmc.org/2020/03/user-stories-europe-pmc-research-article-search.html (accessed 6 May 2020).

Europe PMC. (2020b). Funders. Retrieved from https://europepmc.org/Funders/ (accessed 20 June 2021).

Europe PMC. (2021a). About Europe PMC. Retrieved from https://europepmc.org/About (accessed 6 May 2021).

Europe PMC. (2021b). Europe PMC Roadmap. Retrieved from https://europepmc.org/Roadmap (accessed 19 April 2021).

Europe PMC. (2021c). Governance. Retrieved from https://europepmc.org/Governance (accessed 26 May 2021).

Europe PMC. (2021d). [Website home page]. Retrieved from https://europepmc.org/ (accessed 19 June 2021).

Europe PMC. (n.d.). How do I make my research open access through Europe PMC? [Poster]. Retrieved from https://europepmc.org/docs/Information_poster_Europe_PMC_OA_routes.pdf (accessed 20 June 2021).

European Science Foundation. (2021). 'Plan S' principles and implementation. Retrieved from https://www.coalition-s.org/addendum-to-the-coalition-s-guidance-on-the-implementation-of-plan-s/principles-and-implementation/ (accessed 20 May 2021).

Evans, J., Faulkhead, S., Manaszewicz, R., & Thorpe, K. (2012). Bridging communities: Foundations for the interchange of ideas. *Information, Communication & Society, 15*(7), 1055-1080.

Ferguson, C., Araújo, D., Faulk, L., Gou, Y., Hamelers, A., Huang, Z., . . . McEntyre, J. (2021). Europe PMC in 2020. *Nucleic Acids Res, 49*(D1), D1507-d1514. doi:10.1093/nar/gkaa994

Ferguson, J. (2021, May 26). Covid-19: Melbourne outbreak shows flaws in hotel quarantine, vaccine rollout. *The Australian*. Retrieved from https://www.theaustralian.com.au/commentary/covid19-melbourne-outbreak-shows-flaws-in-hotel-quarantine-vaccine-rollout/news-story/09f0771fad8923fea0baf603dfa75280

Fix medicine's evidence pipeline [Editorial]. (2021, 13 May). *Nature 593,* 168. Retrieved from https://media.nature.com/original/magazine-assets/d41586-021-01255-w/d41586-021-01255-w.pdf

Fortney, K., & Gonder, J. (2015). A social networking site is not an open access repository. Retrieved from https://osc.universityofcalifornia.edu/2015/12/a-social-networking-site-is-not-an-open-access-repository/ (accessed 16 April 2021).

Four Corners ABC (Producer). (2015). Wasted [Video]. Retrieved from http://www.abc.net.au/4corners/wasted-promo/6804372

Frazier, K. (2001). The librarians' dilemma: contemplating the costs of the. *D-Lib Magazine, 7*(3). https://librarytechnology.org/document/8950

Freedman, L. P., Cockburn, I. M., & Simcoe, T. S. (2015). The economics of reproducibility in preclinical research. *PLoS Biol, 13(6),* e1002165. Retrieved from https://journals.plos.org/plosbiology/article%3Fid=10.1371%252Fjournal.pbio.1002165

Fyfe, A., McDougall-Waters, J., & Moxham, N. (2015). 350 years of scientific periodicals. *Notes and Records of the Royal Society of London, 69*(3), 227-239. doi:10.1098/rsnr.2015.0036 (Accession No. PMC4528406)

Gabbay, J., & le May, A. (2010). *Practice-based evidence for healthcare clinical mindlines*. Hoboken, NJ: Taylor & Francis.

Gadd, E., Oppenheim, C., & Probets, S. (2003). RoMEO studies 4: an analysis of journal publishers' copyright agreements. *Learned Publishing, 16*(4), 293-308. doi:10.1087/095315103322422053

Gezelter, D. (2009). What, exactly, is Open Science? Retrieved from http://openscience.org/what-exactly-is-open-science/ (accessed 19 June 2021).

Glenton, C., Santesso, N., Rosenbaum, S., Nilsen, E. S., Rader, T., Ciapponi, A., & Dilkes, H. (2010). Presenting the results of Cochrane Systematic Reviews to a consumer audience: a qualitative study. *Medical Decision Making, 30*(5), 566-577. https://doi.org/10.1177/0272989X10375853

Global Healthcare Information Network. (2017). *Healthcare information for all.* Retrieved from http://www.hifa.org/ (accessed 14 October 2020).

GO FAIR. (2019). FAIR principles. Retrieved from https://www.go-fair.org/fair-principles/ (accessed 22 February 2022).

Gorman, P. N., Ash, J., & Wykoff, L. (1994). Can primary care physicians' questions be answered using the medical journal literature? *Bulletin of the Medical Library Association, 82*(2), 140-146.

Governance Institute of Australia. (2021). What is governance? Retrieved from https://www.governanceinstitute.com.au/resources/what-is-governance/#:~:text=Governance%20encompasses%20the%20system%20by,are%20all%20elements%20of%20governance. (accessed 3 May 2021).

Greenberg, S. J., & Gallagher, P. E. (2009). The great contribution: Index Medicus, Index-Catalogue, and IndexCat. *Journal of the Medical Library Association 97*(2), 108-113. doi:10.3163/1536-5050.97.2.007

Grimes, D. A., & Schulz, K. F. (2002). An overview of clinical research: the lay of the land. *The Lancet, 359*(9300), 57-61.

Guba, E. G. (1981). Criteria for assessing the trustworthiness of naturalistic inquiries. *Educational Communication and Technology, 29*(2), 75-91.

Guba, E. G., & Lincoln, Y. S. (1994). Competing paradigms in qualitative research. In N. K. Denzin & Y. S. Lincoln (Eds.), *Handbook of qualitative research* (Vol. 2, pp. 110-111). London: Sage.

Gusenbauer, M., & Haddaway, N. R. (2020). Which academic search systems are suitable for systematic reviews or meta-analyses? Evaluating retrieval qualities of Google Scholar, PubMed and 26 other resources. *Research Synthesis Methods, 11*(2), 181-217. https://doi.org/10.1002/jrsm.1378

Halawi, L. A., Aronson, J. E., & McCarthy, R. V. (2005). Resource-based view of knowledge management for competitive advantage. *The electronic journal of knowledge management, 3(2),* 75. Retrieved from https://academic-publishing.org/index.php/ejkm/article/view/724/687

Halbwirth, S., & Sbarcea, K. (2005). *The spotlight on knowledge management, joint presentation*. Paper presented at the NSW KM Forum, Sydney

Hall, G. (2015). Should this be the last thing you read on Academia.edu? . Retrieved from https://libraries.ou.edu/content/understanding-academiaedu-and-researchgate (accessed 29 June 2021)

Hamm, S. (2009). ResearchGate and its savvy use of the web. *Business week, 7 Dec.*

Hansoti, B., Langdorf, M. I., & Murphy, L. S. (2016). Discriminating between legitimate and predatory open access journals: report from the International Federation for Emergency Medicine Research Committee. *West J Emerg Med, 17*(5), 497-507. doi:10.5811/westjem.2016.7.30328

Harnad, S. (1995). Universal FTP archives for esoteric science and scholarship: A subversive proposal. In A. Okerson & J. O'Donnell (Eds.), *Scholarly journals at the crossroads; A subversive proposal for electronic publishing*. Washington DC: Association of Research Libraries.

Harvey, H. B., & Weinstein, D. F. (2017). Predatory publishing: an emerging threat to the medical literature. *Academic Medicine, 92*(2), 150-151. https://doi:10.1097/ACM.0000000000001521

Hawkins, E., Hofmayer, S., Noyes, D., Schoenenberger, H., & Winter, S. (2020). Researchers at the centre: content discoverability, visibility, and access: an evaluation of the content syndication partnership between Springer Nature and ResearchGate [Report]. Retrieved from https://www.springernature.com/gp/librarians/landing/discoverability-visibility-access (accessed 23 June 2021).

Haynes, R. B. (2001). Of studies, syntheses, synopses, and systems: the "4S" evolution of services for finding current best evidence. *ACP journal club, 134*(2), A11-A11.

Haynes, R. B. (2006). Of studies, syntheses, synopses, summaries, and systems: the "5S" evolution of information services for evidence-based health care decisions. *ACP journal club, 145*(3), A8-A8.

Haynes, R. B., Devereaux, P. J., & Guyatt, G. H. (2002). Physicians' and patients' choices in evidence based practice: Evidence does not make decisions, people do. *BMJ 324*(7350), 1350.

He, J., & King, W. R. (2008). The role of user participation in information systems development: implications from a meta-analysis. *Journal of Management Information Systems, 25*(1), 301-331.

Health Level Seven International. (2019). Overview - FHIR v4.0.1. Retrieved from https://www.hl7.org/fhir/overview.html (accessed 20 June 2021).

Health Sciences Library, McMaster University. (2020). Resources for evidence-based practice: the 6S pyramid. Retrieved from https://hslmcmaster.libguides.com/ebm (accessed 19 June 2021).

Heriyanto. (2018). *Understanding how Australian researchers experience open access as part of their information literacy*. (PhD Thesis). QUT, Brisbane, Qld. Retrieved from https://eprints.qut.edu.au/117651/

Hess, C., & Ostrom, E. (2006). A framework for analyzing the knowledge commons. In C. Hess & E. Ostrom (Eds.), *Understanding Knowledge as a Commons: from Theory to Practice* (pp. 41-81). Cambridge, MA: MIT Press.

Hickie, J. (2017?). Trove: harvesting Australian repositories [Presentation]. Retrieved from https://help.nla.gov.au/sites/default/files/AustralianRepositories_0.pdf (accessed 26 May 2021).

Hicks, D., Wouters, P., Waltman, L., De Rijcke, S., & Rafols, I. (2015). Bibliometrics: the Leiden Manifesto for research metrics. *Nature News, 520*(7548), 429. doi:https://doi.org/10.1038/520429a

Higgins, J. P., Thomas, J., Chandler, J., Cumpston, M., Li, T., Page, M. J., & Welch, V. A. (2019). *Cochrane handbook for systematic reviews of interventions*. Hoboken, NJ: John Wiley & Sons. (2nd ed.). Retrieved from https://onlinelibrary.wiley.com/doi/book/10.1002/9781119536604

Holtham, C., & Courtney, N. (1998). *The executive learning ladder: a knowledge creation process grounded in the strategic information systems domain.* Paper presented at the Proceedings of the Fourth Americas Conference on Information Systems, Baltimore, MD

Howick, J. (2002). *Introduction to study design [Document]*. Centre for Evidence-Based Medicine, University of Oxford. Oxford, UK. Retrieved from https://www.cebm.ox.ac.uk/resources/ebm-tools/study-designs

Hristovski, D., Peterlin, B., Mitchell, J. A., & Humphrey, S. M. (2005). Using literature-based discovery to identify disease candidate genes. *International Journal of Medical Informatics, 74*(2-4), 289-298.

Huber, J. T., Swogger, Susan (eds.). (2014). *Introduction to reference sources in the health sciences* (Sixth ed.). Chicago: Neal-Schuman Publishers.

Initiative for open abstracts. (2020). Retrieved from https://i4oa.org/ (accessed 20 June 2021).

International Committee of Medical Journal Editors. (2020). About ICMJE. Retrieved from http://www.icmje.org/about-icmje/ (accessed 20 June 2021).

International Organization for Standardisation. (2017). ISO 20614:2017. Retrieved from https://www.iso.org/cms/render/live/en/sites/isoorg/contents/data/standard/06/85/68562.html (accessed 26 June 2021).

Jamali, H. R. (2017). Copyright compliance and infringement in ResearchGate full-text journal articles. *Scientometrics, 112*(1), 241-254.

Jamali, H. R., & Nabavi, M. (2015). Open access and sources of full-text articles in Google Scholar in different subject fields. *Scientometrics, 105*(3), 1635-1651. doi:10.1007/s11192-015-1642-2

Jennex, M. E., Smolnik, S., & Croasdell, D. T. (2009). Towards a consensus knowledge management success definition. *VINE, 39*(2), 174-188.

Jensen, L. J., Saric, J., & Bork, P. (2006). Literature mining for the biologist: from information retrieval to biological discovery. *Nature reviews genetics, 7*(2), 119-129.

Joo, S., Hofman, D., & Kim, Y. (2018). Investigation of challenges in academic institutional repositories: a survey of academic librarians. *Library Hi Tech.* https://doi.org/10.1108/LHT-12-2017-0266

Kelly, T. (2016). ORCID one year on: still helping you find Australian researchers Retrieved from https://www.nla.gov.au/blogs/trove/2016/05/31/orcid-one-year-on (accessed 27 April 2021).

Kennan, M. A. (2008). *Reassembling scholarly publishing: open access, institutional repositories and the process of change.* (PhD Thesis). Information Systems, Technology & Management, Australian School of Business, University of New South Wales Sydney, NSW. Retrieved from http://handle.unsw.edu.au/1959.4/43924

Kennan, M. A., Kingsley, D., & Richardson, J. (2021). Scholarly communication knowledge and skills in hospital and health services libraries: Report of a survey. *Journal of Health Information and Libraries Australasia, 2(1).* Retrieved from https://www.johila.org/index.php/Johila

Kent, P. (2021). *Our future: diversified or diluted?* Paper presented at the CAVAL CRIG / PDIG joint forum 25 May 2021. Retrieved from https://members.caval.edu.au/media/images/Documents/OurFuture/Speaker_2_Philip_Kent.pdf

Kiley, R. (2018) *Europe PMC: interview with the Development Lead, Open Research, Wellcome Trust/Interviewer: L. Kruesi.*

Kim, J. H. (2015). *Europe PubMed Central and linked data.* Paper presented at the Biohackathon EMBL-EBI, Nagasaki. Retrieved from https://www.slideshare.net/JeeHyubKim/europe-pubmed-central-and-linked-data

Kingsley, D. (2008). *The effect of scholarly communication practices on engagement with open access: An Australian study of three disciplines.* (PhD Thesis). The Australian National University, Canberra. Retrieved from http://hdl.handle.net/1885/49304

Kingston, J. (2012). Choosing a knowledge dissemination approach. *Knowledge and Process Management, 19*(3), 160-170. doi:10.1002/kpm.1391

Kirkman, N., & Haddow, G. (2020). Compliance with the first funder open access policy in Australia. *Information Research, 25(2).* Retrieved from http://informationr.net/ir/25-2/paper857.html

Kraker, P., & Lex, E. (2015). *A critical look at the ResearchGate score as a measure of scientific reputation.* Paper presented at the Proceedings of the quantifying and analysing scholarly communication on the web workshop (ASCW'15), Web Science conference. Retrieved from http://ascw.know-center.tugraz.at/wp-content/uploads/2016/02/ASCW15_kraker-lex-a-critical-look-at-the-researchgate-score_v1-1.pdf

Kramer, B., & Bosman, J. (2015). 101 Innovations in Scholarly Communication - the Changing Research Workflow. *Figshare.* Retrieved from https://figshare.com/articles/101_Innovations_in_Scholarly_Communication_the_Changing_Research_Workflow/1286826 (accessed 23 March 2021).

Kramer, B., & Bosman, J. (2017). Wheel of Open Science practices (image). Retrieved from https://figshare.com/articles/Wheel_of_Open_Science_practices_image_/4628014 (accessed 26 June 2021).

Kruesi, L. (2016). Australasia PMC Working Group [Google website] (accessible to members). Retrieved from https://sites.google.com/monash.edu/australasia-pmc/home (accessed 20 June 2021).

Kruesi, L. (2021). *A Knowledge Management System framework to critique open science platforms and repositories.* Paper presented at the MLA '21: Transforming Our Diversifying Communities Annual Meeting, Virtual. Retrieved from https://www.mlanet.org/mla21

Kruesi, L., Burstein, F., & Tanner, K. (2020). A knowledge management system framework for an open biomedical repository: communities, collaboration and corroboration. *Journal of Knowledge Management, 24*(10), 2553-2572. doi:10.1108/JKM-05-2020-0370

Kruesi, L. M. (2018a). *PubMed Central International (PMCI): Is it time for an Australasia member?* Paper presented at the Adapting, transforming, leading, Medical Library Association 118th Annual Meeting & Exhibition, Atlanta GA, USA. Retrieved from https://www.eventscribe.com/upload/planner/links/MLA18_Paper_Abstracts_as_of_May_14_20181_47.pdf

Kruesi, L. M. (2018b). *To be or not to be? The prospects for an Australasia PMC.* Paper presented at the Health Libraries Australia Professional Development Day: Keynote presentation, Royal North Shore Hospital, Sydney. Retrieved from https://www.alia.org.au/sites/default/files/documents/HLA_Kruesi_Keynote_16.9_3.pdf

Kruesi, L. M. (2019). *Australasia PMC: A strong foundation for a multidisciplinary, regional open access repository.* Presentation to the Go8 University Librarians' Group on behalf of the Australasia PMC Working Group. Melbourne.

Kruesi, L. M., Burstein, F. V., & Tanner, K. J. (2019). With open science gaining traction, do we need an Australasia PubMed Central (PMC)? A qualitative investigation. *PLOS ONE, 14*(2), e0212843. https://doi.org/10.1371/journal.pone.0212843

Kruesi, L. M., Burstein, F. V., Tanner, K. J., & Todd, H. (2018, 27-28 November). *Ensuring value of Australasia research from improving knowledge management processes [Poster].* Paper presented at the National Health and Medical Research Council, The Reward Alliance. Seventh Annual NHMRC Symposium on Research Translation: Ensuring Value in Research, held 27-28 November, Sydney, NSW. Retrieved from https://www.nhmrc.gov.au/event/2018-nhmrc-symposium-research-translation

Kruesi, L. M., & Macdonald, H. (2017). *Do we need an Australasia PMC?* Paper presented at the Open Repositories Conference, Brisbane. Retrieved from https://web.archive.org/web/20171119044524/https://or2017.net/

Kruesi, L. M., Tanner, K., & Burstein, F. (2019). Advancing scholarly publishing through open access biomedical repositories: A knowledge management perspective. *IFLA Journal, 45(3),* 233-245. Retrieved from https://www.ifla.org/files/assets/hq/publications/ifla-journal/ifla-journal-45-3_2019.pdf

Kruesi, L. M., Tanner, K. J., & Burstein, F. V. (2018). *Knowledge Management theory and the Evidence-Based Healthcare Model to guide the design for an Australasia Open Biomedical Repository*. Paper presented at the IFLA WLIC 2018, Transform Libraries, Transform Societies, 84th IFLA General Conference and Assembly Kuala Lumpur, Malaysia Retrieved from http://library.ifla.org/id/eprint/2184

Kugley, S., Wade, A., Thomas, J., Mahood, Q., Jørgensen, A.-M. K., Hammerstrøm, K., & Sathe, N. (2017). Searching for studies: a guide to information retrieval for Campbell. *Campbell Systematic Reviews, 13*(1), 1-73. https://doi.org/10.4073/cmg.2016.1

Laera, E., Gutzman, K., Spencer, A., Beyer, C., Bolore, S., Gallagher, J., . . . Rodriguez, R. (2021). Why are they not accessing it? User barriers to clinical information access. *Journal of the Medical Library Association, 109*(1), 126-132. doi:10.5195/jmla.2021.1051

Lalu, M. M., Shamseer, L., Cobey, K. D., & Moher, D. (2017). How stakeholders can respond to the rise of predatory journals. *Nat Hum Behav, 1*(12), 852-855. doi:10.1038/s41562-017-0257-4

Landa, E. (2018) *PMC Canada: interview/Interviewer: L. Kruesi.*

Lariviere, V., & Sugimoto, C. R. (2018). Do authors comply with mandates for open access? *Nature, 562*(7728), 483-486. doi:10.1038/d41586-018-07101-w

Lefebvre, C., Glanville, J., Briscoe, S., Littlewood, A., Marshall, C., Metzendorf, M. I., . . . Wieland, L. S. (2021). Chapter 4: Searching for and selecting studies. In J. P. T. Higgins, J. Thomas, J. Chandler, M. Cumpston, T. Li, M. J. Page, & V. A. Welch (Eds.), *Cochrane handbook for systematic reviews of interventions version 6.2 (updated February 2021).* https://training.cochrane.org/handbook/current/chapter-04#section-4-7

Lekschas, F., & Gehlenborg, N. (2018). SATORI: a system for ontology-guided visual exploration of biomedical data repositories. *Bioinformatics, 34*(7), 1200-1207. doi: https://doi.org/10.1093/bioinformatics/btx739

Lemon, B., Blinco, K., & Somes, B. (2020). Building NED: Open Access to Australia's Digital Documentary Heritage. *Publications, 8(2)*. Retrieved from https://www.mdpi.com/2304-6775/8/2/19

Lewin, K. (1946). Action Research and Minority Problems. *Journal of Social Issues, 2*(4), 34-46. doi:10.1111/j.1540-4560.1946.tb02295.x

Lewin, K., Lippitt, R., & White, R. K. (1939). Patterns of Aggressive Behavior in Experimentally Created "Social Climates". *The Journal of Social Psychology, 10*(2), 269-299. doi:10.1080/00224545.1939.9713366

Lu, Z. (2011). PubMed and beyond: a survey of web tools for searching biomedical literature. *Database (Oxford), 2011*, baq036. https://doi.org/10.1093/database/baq036

Luo, J., Wu, M., Gopukumar, D., & Zhao, Y. (2016). Big data application in biomedical research and health care: a literature review. *Biomedical informatics insights, 8*. https://doi.org/10.4137/BII.S31559

Maier, R. (2007). *Knowledge management systems information and communication technologies for knowledge management* (3rd ed.). Berlin: Springer.

Major, E., & Cordey-Hayes, M. (2000). Knowledge translation: a new perspective on knowledge transfer and foresight. *Foresight-The journal of future studies, strategic thinking and policy, 2*(4), 411-423.

Manca, S. (2018). ResearchGate and Academia. edu as Networked Socio-Technical Systems for Scholarly Communication: A Literature Review. *Research in Learning Technology, 26*.

Markus, M. L., & Mao, J.-Y. (2004). Participation in development and implementation-updating an old, tired concept for today's IS contexts. *Journal of the Association for Information systems, 5*(11), 14.

Marley, J. (2016) *Cycle One PMC interview/Interviewer: L. Kruesi.*

Marshall, I. J., & Wallace, B. C. (2019). Toward systematic review automation: a practical guide to using machine learning tools in research synthesis. *Systematic reviews, 8*(1), 1-10.

Mårtensson, M. (2000). A critical review of knowledge management as a management tool. *Journal of Knowledge Management, 4*(3), 204-216.

Maxwell, J. W., Hanson, E., Desai, L., Tiampo, C., O'Donnell, K., Ketheeswaran, A., . . . Michelle, E. (2019). *Mind the gap: a landscape analysis of open source publishing tools and platforms*. Cambridge, MA: The MIT Press. Retrieved from https://mindthegap.pubpub.org/

McDonald, D. (2020). Editorial. *Journal of Health Information and Libraries Australasia, 1(3),* 2-3. Retrieved from https://www.johila.org/index.php/Johila/issue/view/4

McEntyre, J., & Lipman, D. (2001). PubMed: bridging the information gap. *Canadian Medical Association Journal, 164*(9), 1317-1319.

McKenzie, A., Cass, L., Dellit, A., & Hickie, J. (April 2018) *National Library of Australia, focus group with library executives conducted by L Kruesi and H Todd.*

McLean, N., & Lynch, C. (2004). *Interoperability between information and learning environments–bridging the gaps: a joint white paper on behalf of the IMS Global Learning Consortium and the Coalition for Networked Information*. Retrieved from https://www.immagic.com/eLibrary/ARCHIVES/GENERAL/CNI_US/C040510M.pdf

Memon, A. R. (2016). ResearchGate is no longer reliable: leniency towards ghost journals may decrease its impact on the scientific community. *J Pak Med Assoc, 66*(12), 1643-1647.

Mertens, D. M. (2020). *Research and evaluation in education and psychology : integrating diversity with quantitative, qualitative, and mixed methods* (Fifth edition. ed.): Thousand Oaks, California : SAGE.

Morçöl, G. (2001). Positivist beliefs among policy professionals: An empirical investigation. *Policy Sciences, 34*(3), 381-401.

Morris, Z. S., Wooding, S., & Grant, J. (2011). The answer is 17 years, what is the question: understanding time lags in translational research. *Journal of the Royal Society of Medicine, 104*(12), 510-520.

Munn, Z., Barker, T., Stern, C., Pollock, D., Ross-White, A., Klugar, M., . . . Shamseer, L. (2021). Should I include studies from "predatory" journals in a systematic review? Interim guidance for systematic reviewers. *JBI Evidence Synthesis, 19*(8). https://journals.lww.com/jbisrir/Fulltext/2021/08000/Should_I_include_studies_from__predatory__journals.5.aspx

Murad, M. H., Asi, N., Alsawas, M., & Alahdab, F. (2016). New evidence pyramid. *Evidence Based Medicine, 21(4),* 125-127. Retrieved from https://ebm.bmj.com/content/ebmed/21/4/125.full.pdf

Nankivell, C., Wallis, P., & Mynott, G. (2001). Networked information and clinical decision making: the experience of Birmingham Heartlands and Solihull National Health Service Trust (Teaching). *Medical education, 35*(2), 167-172.

National Academies of Sciences, Engineering, and Medicine. (2019). *Reproducibility and replicability in science*. Washington DC: National Academies Press. Retrieved from https://www.ncbi.nlm.nih.gov/books/NBK547546/

National Archives of Australia. (2018). Digital Preservation Policy. Retrieved from https://www.naa.gov.au/about-us/our-organisation/accountability-and-reporting/archival-policy-and-planning/digital-preservation-policy (accessed 27 June 2021).

National Center for Biotechnology Information, U.S. National Library of Medicine,. (2015). Funders and PMC. Retrieved from https://www.ncbi.nlm.nih.gov/pmc/about/public-access/ (accessed 7 May 2021).

National Center for Biotechnology Information, US National Library of Medicine. (2020). PMC Overview. Retrieved from https://www.ncbi.nlm.nih.gov/pmc/about/intro/ (accessed 22 February 2021).

National Health and Medical Research Council (Australia). (2016). NHMRC Statement on Data Sharing. Retrieved from https://web.archive.org/web/20150910040921/https://www.nhmrc.gov.au/grants-funding/policy/nhmrc-statement-data-sharing (accessed 20 June 2021).

National Health and Medical Research Council (Australia). (2018). Open Access Policy. Retrieved from https://nhmrc.gov.au/about-us/publications/open-access-policy (accessed 22 March 2021).

National Health and Medical Research Council (Australia). (2019a). NHMRC's Research Quality Strategy. Retrieved from https://www.nhmrc.gov.au/about-us/publications/nhmrcs-research-quality-strategy (accessed 27 June 2021).

National Health and Medical Research Council (Australia). (2019b). NHMRC Corporate Plan 2019-20. Retrieved from https://www.nhmrc.gov.au/about-us/publications/nhmrc-corporate-plan-2019-20 (accessed 18 March 2021).

National Health and Medical Research Council (Australia). (2021). NHMRC analysis of Australian health and medical research publications. Retrieved from https://www.nhmrc.gov.au/funding/data-research/nhmrc-analysis-australian-health-and-medical-research-publications (accessed 17 May 2021).

National Health and Medical Research Council (Australia). (n.d.). Research Translation. Retrieved from https://www.nhmrc.gov.au/research-policy/research-translation-and-impact (accessed 17 March 2021).

National Health and Medical Research Council (Australia) Australian Research Council & Universities Australia. (2007). *Australian code for the responsible conduct of research*. Canberra, ACT: Canberra, ACT : National Health and Medical Research Council.

National Library of Australia. (2018). Legal deposit. Retrieved from https://www.nla.gov.au/legal-deposit (accessed 22 March 2021).

National Library of Australia. (n.d.). What is Trove. Retrieved from https://trove.nla.gov.au/about/what-trove (accessed 26 May 2021).

National Science Board, National Science Foundation,. (2019). Publication Output: U.S. Trends and International Comparisons. In *Science & Engineering Indicators 2020* (Vol. NSB-2020-6). https://ncses.nsf.gov/pubs/nsb20206/publication-output-by-region-country-or-economy

Neylon, C., & Montgomery, L. (2020). A win for research open access. *Campus Morning Mail.* Retrieved from https://campusmorningmail.com.au/news/a-win-for-research-open-access/ (accessed 10 June 2021).

NLM Program Manager. (2018, 21 May 2018) *Update on PMC/Interviewer: L. Kruesi.*

NLM Program Manager. (2019, 12 April 2019) *Update on PMC/Interviewer: L. Kruesi.*

Nonaka, I. (1994). A dynamic theory of organizational knowledge creation. *Organization science, 5*(1), 14-37.

Nonaka, I., & Takeuchi, H. (1995). *The knowledge-creating company: How Japanese companies create the dynamics of innovation*. Oxford, UK: Oxford University Press.

O'Brien, K. (2019). ResearchGate. *Journal of the Medical Library Association: JMLA, 107*(2), 284. doi:org/10.5195/jmla.2019.643

Ohno-Machado, L., Sansone, S.-A., Alter, G., Fore, I., Grethe, J., Xu, H., . . . Bell, E. (2017). Finding useful data across multiple biomedical data repositories using DataMed. *Nature Genetics, 49*(6), 816-819. https://doi.org/10.1038/ng.3864

Open Archives Initiative Protocol for Metadata Harvesting. (1999). Retrieved from https://www.openarchives.org/organization/ (accessed 20 June 2021).

Orduna-Malea, E., Martín-Martín, A., Thelwall, M., & López-Cózar, E. D. (2017). Do ResearchGate Scores create ghost academic reputations? *Scientometrics, 112*(1), 443-460.

Ovadia, S. (2014). ResearchGate and Academia. edu: Academic social networks. *Behavioral & social sciences librarian, 33*(3), 165-169.

Pablos-Mendez, A., & Shademani, R. (2006). Knowledge translation in global health. *Journal of Continuing Education in the Health Professions, 26*(1), 81-86. https://doi.org/10.1002/chp.54

Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., . . . Moher, D. (2021). Updating guidance for reporting systematic reviews: development of the PRISMA 2020 statement. *Journal of clinical epidemiology, 134*, 103-112. https://doi.org/10.1016/j.jclinepi.2021.02.003

Pearson, H. (2021). How COVID broke the evidence pipeline. *Nature, 593*(7858), 182-185. doi:10.1038/d41586-021-01246-x

Petrisor, B., & Bhandari, M. (2007). The hierarchy of evidence: Levels and grades of recommendation. *Indian J Orthop, 41*(1), 11-15. doi:10.4103/0019-5413.30519

Pinfield, S. (2009). Journals and repositories: an evolving relationship? *Learned Publishing, 22*(3), 165-175.

Pinfield, S., Salter, J., Bath, P. A., Hubbard, B., Millington, P., Anders, J. H. S., & Hussain, A. (2014). Open access repositories worldwide, 2005–2012: Past growth, current characteristics, and future possibilities. *Journal of the Association for Information Science and Technology, 65*(12), 2404-2421. https://doi.org/10.1002/asi.23131

Piwowar, H., Priem, J., Lariviere, V., Alperin, J. P., Matthias, L., Norlander, B., . . . Haustein, S. (2018). The state of OA: a large-scale analysis of the prevalence and impact of Open Access articles. *PeerJ*(e4375). doi:10.7717/peerj.4375

Piwowar, H., Priem, J., & Orr, R. (2019). The Future of OA: A large-scale analysis projecting Open Access publication and readership. *bioRxiv*, 795310. https://doi.org/10.1101/795310

PLOS. (2018). PLOS criteria for recommended data repositories. Retrieved from https://everyone.plos.org/2018/03/01/criteria-for-recommended-data-repositories/ (accessed 20 May 2021).

PLOS. (2021). Imagining a transformed scientific publication landscape. *PLOS Blogs*. Retrieved from https://theplosblog.plos.org/2021/01/future-landscape-of-scientific-publishing/?utm_medium=email&utm_source=internal&utm_campaign=plosone&utm_content=protocols (accessed 10 May 2021).

Polanyi, M. (1966). *The tacit dimension*. Garden City, NY: Doubleday and Company Inc.

Poynder, R. (2016). *Q&A with CNI's Clifford Lynch: Time to re-think the institutional repository*. Retrieved from http://www.richardpoynder.co.uk/Clifford_Lynch.pdf (accessed 27 June 2021).

Priem, J., & Piwowar, H. (2012). The launch of ImpactStory: using altmetrics to tell data-driven stories. *Impact of Social Sciences Blog*. Retrieved from https://blogs.lse.ac.uk/impactofsocialsciences/2012/09/25/the-launch-of-impactstor/ (accessed 27 June 2021).

Prusak, L., & Davenport, T. (1998). *Working knowledge: how organizations manage what they know*. Boston, MA: Harvard Business School Press.

Rada, G., Pérez, D., Araya-Quintanilla, F., Ávila, C., Bravo-Soto, G., Bravo-Jeria, R., . . . Contreras, V. (2020). Epistemonikos: a comprehensive database of systematic reviews for health decision-making. *BMC medical research methodology, 20*(286), 1-7. https://doi.org/10.1186/s12874-020-01157-x

Rada, G., Pérez, D., & Capurro, D. (2013). Epistemonikos: a free, relational, collaborative, multilingual database of health evidence. *MedInfo, 2013*, 486-490.

Registry of Open Access Repositories. (1999-). Retrieved from http://roar.eprints.org/ (accessed 20 June 2021).

Research Australia. (2019). *Australian H&MR Research Facts*. Retrieved from https://researchaustralia.org/category/hmr-facts/ (accessed 18 February 2021).

ResearchGate. (2021). Hire high-quality researchers on the world's leading scientific network. Retrieved from https://www.researchgate.net/scientific-recruitment (accessed 26 May 2021).

ResearchGate. (2021?). Signing up for ResearchGate. Retrieved from https://explore.researchgate.net/display/support/Signing+up+for+ResearchGate (accessed 26 May 2021).

Rivett, D. E., Ward, C. W., Belkin, L. M., Ramshaw, J. A. M., & Wilshire, J. F. K. (1996). *The Lennox legacy : the history of the CSIRO laboratory at 343 Royal Parade, Parkville*. Melbourne: CSIRO.

Roberts, K., Gururaj, A. E., Chen, X., Pournejati, S., Hersh, W. R., Demner-Fushman, D., . . . Xu, H. (2017). Information retrieval for biomedical datasets: the 2016 bioCADDIE dataset retrieval challenge. *Database, 2017*. https://doi.org/10.1093/database/bax068

Roberts, R. J. (2001). PubMed Central: The GenBank of the published literature. *Proc Natl Acad Sci U S A, 98*(2), 381-382. https://doi.org/10.1073/pnas.98.2.381

Sackett, D. L. (2000). *Evidence based medicine : how to practice and teach EBM* (2nd ed.). Edinburgh: Churchill Livingstone.

Sackett, D. L., Rosenberg, W. M., Gray, J. M., Haynes, R. B., & Richardson, W. S. (1996). Evidence based medicine: what it is and what it isn't. *BMJ, 312*. doi: https://doi.org/10.1136/bmj.312.7023.71

Saito, A., Umemoto, K., & Ikeda, M. (2007). A strategy-based ontology of knowledge management technologies. *Journal of Knowledge Management, 11*(1), 97-114. https://doi.org/10.1108/13673270710728268

Salisbury, J., Glasziou, P., & Del Mar, C. (2007). *Evidence-based practice workbook : bridging the gap between health care research and practice* (2nd ed.). Oxford: Blackwell/BMJ Books.

Sample, I. (2012). Harvard University says it can't afford journal publishers' prices. *The Guardian*. Retrieved from https://www.theguardian.com/science/2012/apr/24/harvard-university-journal-publishers-prices

Sarcina, A. (2019). Open Science: a review of definitions with a regional perspective. Retrieved from https://impakter.com/open-science-a-review-of-definitions-with-a-regional-perspective/ (accessed 24 May 2021).

Sayers, E. (2010-). *A general introduction to the E-utilities. In Entrez Programming Utilities help [Internet]*. Bethesda MD: US National Center for Biotechnology Information. Retrieved from https://www.ncbi.nlm.nih.gov/books/NBK25497/

Schumpeter, J. A. (1934). *The theory of economic development: an inquiry into profits, capital, credit, interest and the business cycle*. Cambridge, MA.: Harvard University Press.

Science Europe Working Group on Open Access. (2015). Science Europe principles on open access to research publications. Retrieved from https://www.scienceeurope.org/our-resources/principles-on-open-access-to-research-publications (accessed 19 June 2021).

Scotland, J. (2012). Exploring the philosophical underpinnings of research: Relating ontology and epistemology to the methodology and methods of the scientific, interpretive, and critical research paradigms. *English language teaching, 5*(9), 9-16.

Sequeira, E., McEntyre, J., & Lipman, D. (2001). PubMed central decentralized. *Nature, 410*(6830), 740.

Shaffer, C. (2021). The move to open: medical library leadership in scholarly communication. *Journal of the Medical Library Association, 109*(1), 1. https://doi.org/10.5195/jmla.2021.1127

Shaneyfelt, T. (2016). Pyramids are guides not rules: the evolution of the evidence pyramid. *BMJ Evidence-Based Medicine, 21*(4), 121-122. http://dx.doi.org/10.1136/ebmed-2016-110498

Shih, I. (2017). Chatter makes popular metric unreliable: study. *Nature [News Blog]*. Retrieved from https://www.natureindex.com/news-blog/chatter-makes-popular-metric-unreliable-study-says (accessed 4 September).

Sorbonne declaration on research data rights [Webpage]. (2020). Retrieved from https://go8.edu.au/wp-content/uploads/2020/01/Sorbonne-declaration.pdf (accessed 20 June 2021).

SPARC. (2020). Strong community response to free scholarly article access to fight COVID-19. Retrieved from https://sparcopen.org/news/2020/strong-community-response-to-free-scholarly-article-access-to-fight-covid-19/ (accessed 24 May 2021).

Standards Australia. (2005). *Knowledge management: a guide (AS5037)*. Sydney: Standards Australia International. Retrieved from https://www.standards.org.au

Steele, C. (2013). Open access in Australia: an odyssey of sorts? *Insights, 26*(3), 283-289. doi:.org/10.1629/2048-7754.91/

Stevens, J. M., & Bagby, J. W. (2001). Knowledge transfer from universities to business: returns for all stakeholders? *Organization, 8*(2), 259-268. http://journals.sagepub.com/doi/abs/10.1177/1350508401082012

Stevens, R., Rector, A., & Hull, D. (2010). What is an ontology? *Ontogenesis, 2020*. Retrieved from http://ontogenesis.knowledgeblog.org/66

Straus, S. E., Tetroe, J., & Graham, I. (2009). Defining knowledge translation. *CMAJ, 181*(3-4), 165-168. doi:https://doi.org/10.1503/cmaj.081229

Suber, P. (2004). Open access overview [Web page]. Retrieved from http://legacy.earlham.edu/~peters/fos/overview.htm (accessed 27 June 2021).

Summers, B., & Evans, J. (2020?). A staged path to a fully integrated CRIS & repository [Presentation]. Retrieved from https://dspacecris.eurocris.org/bitstream/11366/1009/1/Haplo%20EuroCris%20Tech%20Case%20Study.pdf (accessed 20 June 2021).

Tarrant, D., O'Steen, B., Brody, T., Hitchcock, S., Jefferies, N., & Carr, L. (2009). Using OAI-ORE to transform digital repositories into interoperable storage and services applications. *Code4Lib Journal(6)*. Retrieved from https://tinyurl.com/w2cfm38

Techopedia. (2021). Dictionary. Retrieved from https://www.techopedia.com/definition/3411/platform-computing (accessed 25 June 2021).

Tenopir, C., & King, D. W. (1998). Designing electronic journals with 30 years of lessons from print. *Journal of Electronic Publishing, 4(2)*. Retrieved from http://dx.doi.org/10.3998/3336451.0004.202

Thelwall, M., & Kousha, K. (2017A). ResearchGate articles: Age, discipline, audience size, and impact. *Journal of the Association for Information Science and Technology, 68*(2), 468-479.

Thelwall, M., & Kousha, K. (2017B). ResearchGate versus Google Scholar: Which finds more early citations? *An International Journal for all Quantitative Aspects of the Science of Science, Communication in Science and Science Policy, 112*(2), 1125-1131. doi:10.1007/s11192-017-2400-4

Tuomi, I. (1999). Data Is more than knowledge: implications of the reversed knowledge hierarchy for knowledge management and organizational memory. *Journal of Management Information Systems, 16*(3), 103-117. doi:10.1080/07421222.1999.11518258

UK Equator Centre. (2020). The EQUATOR Network: Enhancing the QUAlity and Transparency Of health Research. Retrieved from https://www.equator-network.org/ (accessed 20 June 2021).

University of Nottingham (UK). (2005-, 13 January 2019). Directory of Open Access Repositories (OpenDOAR). Retrieved from http://v2.sherpa.ac.uk/opendoar/information.html (accessed 20 June 2021).

US Department of Health and Human Services, National Institutes of Health. (2008). NIH Public Access Policy. Retrieved from https://publicaccess.nih.gov/policy.htm (accessed 27 June 2021).

US National Library of Medicine. (2004). *Collection Development Guidelines of the National Library of Medicine*. Bethesda MD: US National Library of Medicine. Retrieved from https://www.ncbi.nlm.nih.gov/books/NBK518683/

US National Library of Medicine. (2016). Changes to the NLM Data Distribution Program. *NLM Tech Bull(413),* b4. Retrieved from https://www.nlm.nih.gov/pubs/techbull/nd16/brief/nd16_data_distrib.html

US National Library of Medicine. (2018). From 1 all the way to 100 terabytes - NLM by the numbers. *NLM in focus*. Retrieved from https://infocus.nlm.nih.gov/2018/08/09/from-1-all-the-way-to-100-terabytes-nlm-by-the-numbers/ (accessed 14 January 2019).

US National Library of Medicine. (2019). Unified Medical Language System (UMLS). Retrieved from https://www.ncbi.nlm.nih.gov/pubmed/ (accessed 27 June 2021).

US National Library of Medicine. (2020a). MeSH. Retrieved from https://www.ncbi.nlm.nih.gov/mesh (accessed 20 June 2021).

US National Library of Medicine. (2020b). PMC overview. Retrieved from https://www.ncbi.nlm.nih.gov/pmc/about/intro/ (accessed 20 June 2021).

US National Library of Medicine. (2020c). PubMed overview. Retrieved from https://pubmed.ncbi.nlm.nih.gov/about/ (accessed 17 August).

US National Library of Medicine. (2021). About the NLM. Retrieved from https://www.nlm.nih.gov/about/index.html (accessed 15 May 2021).

US National Library of Medicine, National Institutes of Health. (2018). *PMC International*. National Center for Biotechnology Information. Bethesa MD. Retrieved from https://www.ncbi.nlm.nih.gov/pmc/about/pmci/ (accessed 6 May 2021).

US National Library of Medicine, National Institutes of Health. (2019). PMC and Research Funder Policies. Retrieved from https://www.ncbi.nlm.nih.gov/pmc/about/public-access/ (accessed 23 June 2021).

US National Library of Medicine, National Institutes of Health. (2021). How to include a journal in PMC. Retrieved from https://www.ncbi.nlm.nih.gov/pmc/pub/addjournal/ (accessed 27 May 2021).

Uzwyshyn, R. (2016). Research data repositories: the what when, why, and how. *Computers in Libraries, 36(3)*. Retrieved from https://link.gale.com/apps/doc/A448901368/CDB?u=monash&sid=CDB&xid=26ce8cc8

Van Noorden, R. (2014a). Funders punish open-access dodgers. *Nature, 508*, 161. https://doi.org/10.1038/508161a

Van Noorden, R. (2014b). Online collaboration: Scientists and the social network. *Nature News, 512*(7513), 126. doi:10.1038/512126a

Veletsianos, G., & Kimmons, R. (2012). Networked Participatory Scholarship: Emergent techno-cultural pressures toward open and digital scholarship in online networks. *Computers and education, 58*(2), 766-774. doi:10.1016/j.compedu.2011.10.001

Wagner, C. S. (2008). *The new invisible college science for development*. Washington, D.C.: Washington, D.C. : Brookings Institution Press.

Watson, M. (2015). When will 'open science' become simply 'science'? *Genome biology, 16*(1), 101-101. doi:https://doi.org/10.1186/s13059-015-0669-2

Wellcome. (2017). *Charity Open Access Fund spend 2015-2016*. Retrieved from https://wellcome.ac.uk/news/charity-open-access-fund-spend-2015-2016 (accessed 27 June 2021).

Wellcome Trust. (2020). Open access policy. Retrieved from http://www.wellcome.ac.uk/About-us/Policy/Policy-and-position-statements/WTD002766.htm (accessed 19 June 2021).

White, R. K. A., Angelo, A., Fitchett, D., Fraser, M., Hayes, L., Howie, J., . . . White, B. (2021). Only two out of five articles by New Zealand researchers are free-to-access: a multiple API study of access, citations, cost of Article Processing Charges (APC), and the potential to increase the proportion of open access. *PeerJ (San Francisco, CA), 9*, e11417. doi:10.7717/peerj.11417

Wilkinson, M. D., Dumontier, M., Aalbersberg, I. J., Appleton, G., Axton, M., Baak, A., . . . Bourne, P. E. (2016). The FAIR Guiding Principles for scientific data management and stewardship. *Scientific Data, 3*(160018). doi:https://doi.org/10.1038/sdata.2016.18

Wilkinson, M. D., Dumontier, M., Jan Aalbersberg, I., Appleton, G., Axton, M., Baak, A., . . . Mons, B. (2019). Addendum: The FAIR Guiding Principles for scientific data management and stewardship. *Scientific Data, 6*(1), 6. doi:10.1038/s41597-019-0009-6

Williamson, K. (2013a). Action research: theory and practice. In K. Williamson & G. Johanson (Eds.), *Research methods : information, systems and contexts* (pp. 188-202). Prahran, Vic.: Tilde University Press.

Williamson, K. (2013b). Research concepts. In K. Williamson & G. Johanson (Eds.), *Research methods : information, systems and contexts* (pp. 3-23). Prahran, Vic.: Tilde University Press.

Williamson, K. (2017). Research concepts. In K. Williamson & G. Johanson (Eds.), *Research Methods : information, systems, and contexts* (p. 16) (2nd ed.): San Diego : Elsevier Science & Technology.

Williamson, P. O., & Minter, C. I. (2019). Exploring PubMed as a reliable resource for scholarly communications services. *Journal of the Medical Library Association, 107*(1), 16-29. doi:10.5195/jmla.2019.433

Wise, A., & Estelle, L. (2020). How society publishers can accelerate their transition to open access and align with Plan S. *Learned Publishing, 33*(1), 14-27. https://doi.org/10.1002/leap.1272

Xu, Q., Boggio, A., & Ballabeni, A. (2015). Countries' biomedical publications and attraction scores. A PubMed-based assessment *F1000Research, 3*(292). doi:10.12688/f1000research.5775.2

Yan, W., & Zhang, Y. (2018). Research universities on the ResearchGate social networking site: An examination of institutional differences, research activity level, and social networks formed. *Journal of informetrics, 12*(1), 385-400. doi:10.1016/j.joi.2017.08.002

Yoo, I., & Marinov, M. (2010). *Recent research for MEDLINE/PubMed: short review.* Paper presented at the Proceedings of the ACM fourth international workshop on Data and text mining in biomedical informatics. Retrieved from https://dlnext.acm.org/doi/10.1145/1871871

Appendix A: Ethics documentation

A1.1 Monash University Human Research Ethics Committee approval

MONASH University

Monash University Human Research Ethics Committee

Approval Certificate

This is to certify that the project below was considered by the Monash University Human Research Ethics Committee. The Committee was satisfied that the proposal meets the requirements of the *National Statement on Ethical Conduct in Human Research* and has granted approval.

Project Number: 1211
Project Title: Feasibility of establishing an Australia PubMed Central: Phase One
Chief Investigator: Professor Frada Burstein
Expiry Date: 09/11/2021

Terms of approval - failure to comply with the terms below is in breach of your approval and the *Australian Code for the Responsible Conduct of Research*.

1. The Chief Investigator is responsible for ensuring that permission letters are obtained, if relevant, before any data can occur at the specified organisation.
2. Approval is only valid whilst your hold a position at Monash University.
3. It is responsibility of the Chief Investigator to ensure that all investigators are aware of the terms of approval and to ensure the project is conducted as approved by MUHREC.
4. You should notify MUHREC immediately of any serious or unexpected adverse effects on participants or unforeseen events affecting the ethical acceptability of the project.
5. The Explanatory Statement must be on Monash letterhead and the Monash University complaints clause must include your project number.
6. Amendments to approved projects including changes to personnel must not commence without written approval from MHUREC.
7. Annual Report - continued approval of this project is dependent on the submission of an Annual Report.
8. Final Report - should be provided at the conclusion of the project. MUHREC should be notified if the project is discontinued before the expected completion date.
9. Monitoring - project may be subject to an audit or any other form of monitoring by MUHREC at any time.
10. Retention and storage of data - The Chief Investigator is responsible fo the storage and retention of the original data pertaining to the project for a minimum period of five years.

Thank you for your assistance.

Professor Nip Thomson

Chair, MUHREC

A1.2 Email invitation to participants

Dear XXXXX,

If you have 40-50 minutes available at a time that suits you, I'd like to interview you on my PhD topic. As you are a world open access leader your feedback would be extremely useful and highly valued. I have a few interview questions that we could discuss. I can elaborate on the documents that are attached that provide details on the study. It does not matter if you have limited experience of PubMed/MEDLINE, most of my participants will do so.

Some background on our research:

Researchers from Monash University, Australia are investigating the feasibility of an Australia PubMed Central (PMC) to fulfil the knowledge management requirements of evidence based clinical practice.

PubMed run by the National Institute of Health (NIH), National Center for Biotechnology Information (NCBI) at the US National Library of Medicine, is an openly accessible database with over 26 million biomedical literature citations from MEDLINE, life science journals, and online books. PubMed citations may include links to full text, peer reviewed articles that are available from PubMed Central (PMC).

In 2011 the Europe PubMed Central (PMC) came into existence and following this PMC Canada was established in 2013. Each PMC provides a national health and medical site that researchers and health consumers can use to access quality health research. In addition to technical models, each PMC site has a viable financial structure.

This research fills an important gap as there is no previous research on the relationship of Open Access health sciences repositories and evidence based clinical practice as part of clinical knowledge management. The research will be based on the Haynes' 6S pyramid model of the six hierarchical levels of access to the best clinical evidence. Knowledge management principles, which include

tacit as well as explicit knowledge, will be integrated within the Haynes' model to enhance the understanding of the uptake of clinical evidence and transfer into practice.

Your involvement would take 45 minutes of your time. It will involve an interview.

Attached to this email is an Explanatory Statement, a Briefing Document and a Consent Form if you chose to participate. If you are willing to participate, please contact the Lisa Kruesi lisa.kruesi1@monash.edu or phone my mobile XXXX XXX XXX.

Thanks for your consideration of my invitation.

Best regards,

LISA KRUESI
PhD Researcher

A1.3a Consent form: researchers and clinicians

CONSENT FORM

Researcher and Clinicians

Project: Feasibility of establishing an Australia PubMed Central: Phase One

Chief Investigator
Professor Frada Burstein
Leader, Health ICT theme
Faculty of IT
Monash University
P: +61 3 9903 2011
E: frada.burstein@monash.edu

Researcher
Dr Kerry Tanner
Adjunct Senior Research Fellow
Faculty of IT
Monash University
P: 61 3 9903 2551
E: kerry.tanner@monash.edu

PhD Researcher
Ms Lisa Kruesi
Faculty of IT
Monash University
M: 0412 655 787
E: lisa.kruesi1@monash.edu

I have been asked to take part in the Monash University research project specified above. I have read and understood the Explanatory and the Briefing Statements and I hereby consent to participate in this project.

I consent to the following:	Yes	No
Take part in an interview	☐	☐
Audio recording during the interview	☐	☐
Take part in Phase Two of the study, if the Australia PMC investigation proceeds	☐	☐
Allow my identity to be revealed	☐	☐
Allow my data to be used in a de-identified form in other research which has ethics approval	☐	☐
That I can withdraw up to the end of the interview without being penalized or disadvantaged in any way	☐	☐

Name of Participant _____

Participant Signature _____ Date _____

A1.3b Consent form: library staff

CONSENT FORM

Library Staff

Project: Feasibility of establishing an Australia PubMed Central: Phase One

Chief Investigator
Professor Frada Burstein
Leader, Health ICT theme
Faculty of IT
Monash University
P: +61 3 9903 2011
E: frada.burstein@monash.edu

Researcher
Dr Kerry Tanner
Adjunct Senior Research Fellow
Faculty of IT
Monash University
P: 61 3 9903 2551
E: kerry.tanner@monash.edu

PhD Researcher
Ms Lisa Kruesi
Faculty of IT
Monash University
M: 0412 655 787
E: lisa.kruesi1@monash.edu

I have been asked to take part in the Monash University research project specified above. I have read and understood the Explanatory and the Briefing Statements and I hereby consent to participate in this project.

I consent to the following:	Yes	No
Take part in an interview	☐	☐
Audio recording during the interview	☐	☐
Take part in Phase Two of the study, if the Australia PMC investigation proceeds	☐	☐
Allow my identity to be revealed	☐	☐
Allow my data to be used in a de-identified form in other research which has ethics approval	☐	☐
That I can withdraw up to the end of the interview without being penalized or disadvantaged in any way	☐	☐

Name of Participant _____

Participant Signature _____ Date _____

A1.4 Plain language statement

Australia PubMed Central (PMC): Briefing Statement

What is the relationship between MEDLINE, U.S. PubMed and PMC?

MEDLINE is the U.S. National Library of Medicine® (NLM) major bibliographic database with over 25 million references to journal articles on biomedicine and health. PubMed is a free citation index, produced by the National Center for Biotechnology Information (NCBI) at the NLM, which contains MEDLINE plus NLM's database of citations and abstracts. PubMed Central® (PMC) is a free full-text archive of biomedical journal literature. PMC provides content deposited by participating publishers and author manuscripts submitted to comply with the NIH public access policy. Some PMC journals are also MEDLINE journals, and there are links between corresponding citations in PubMed and the full text in PMC. See Figure 1 below.

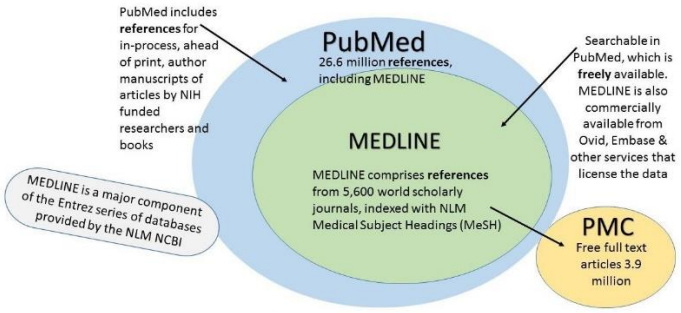


Figure 1 Source: https://www.nlm.nih.gov/pubs/factsheets/medline.html (Graphic by L. Kruesi, 2016)

What is an Australia PMC?

The Australia PMC s main purpose would be to establish a consolidated repository of openly available biomedical and health sciences articles by Australian researchers. An Australia PMC, like its counterpart, Europe PMC, can potentially include abstracts, articles and links to research data from anywhere in the world, and would not be limited by funder or geographical location. It could also include open access articles from Australian peer reviewed biomedicine and health journals not indexed by MEDLINE, making it unique. The full scope of content in the USA PubMed, MEDLINE and PMC would be available from an Australia PMC and delivered through a single search platform. An example of the content in the Europe PMC follows in Figure 2.

Why an Australia PMC?

It is an opportunity to:

- Create a comprehensive Open Access repository of papers by

Australian health and medical researchers
- Address the fragmented and incomplete access to Australian health research publication records
- Overcome the significant amount of duplicated effort underway in Australian universities to collect publications for repositories in order to meet funding bodies open access mandates
- Provide a repository system for sites without or with limited access, such as Australian medical institutes, hospitals and healthcare sites
- Leverage existing infrastructure to develop a comprehensive repository for peer-reviewed journal papers funded by the ARC/NHMRC
- Merge Australian articles with other world PMC sites
- Preserve Australian health research and associated data for present and future generations
- Become a node of the USA NLM PubMed and contribute internationally to the creation of a nationally owned, quality database of medical and health sciences content

How?

A steering committee, comprising members from Monash University, The Association of Australian Medical Research Institutes, University of Melbourne and the University of Queensland, will prepare a proposal recommending a suitable model and design of an Australia PMC prototype. The proposal will take into consideration contractual requirements of the NIH/NLM/NCBI and include funding recommendations. A prototype design and recommendations would be made available for consideration in late 2017.

Need?

This research will explore the importance of an Australia PMC repository from a knowledge management perspective. The research will be based on the Haynes 6S pyramid model of the six hierarchical levels of access to the best clinical evidence (1). Knowledge management principles, which include tacit as well as explicit knowledge, will be integrated within the Haynes' model to enhance the understanding of the uptake of clinical evidence and transfer into practice.

November 2016

A1.5 Explanatory statement

Researchers and Clinicians

Project: Feasibility of establishing an Australia PubMed Central: Phase One

Chief Investigator
Professor Frada Burstein
Leader, Health ICT theme
Faculty of IT
Monash University
P: +61 3 9903 2011
E: frada.burstein@monash.edu

Researcher
Dr Kerry Tanner
Adjunct Senior Research Fellow
Faculty of IT
Monash University
P: 61 3 9903 2551
E: kerry.tanner@monash.edu

PhD Researcher
Ms Lisa Kruesi
Faculty of IT
Monash University
M: 0412 655 787
E: lisa.kruesi1@monash.edu

As a leader in your field you are invited to take part in this study. Please read the **Explanatory Statement and Australia PubMed Central (PMC) Briefing Statement** before deciding whether or not to participate in this research. If you would like further information regarding any aspect of this project, you are encouraged to contact the researchers via the phone numbers or email addresses listed above.

We are seeking stakeholder endorsement to investigate and design an Australia PubMed Central (PMC) prototype. Like its counterpart, Europe PMC, an Australia PMC would potentially include abstracts, articles and links to research data from anywhere in the world. It could also include open access articles from Australian peer reviewed biomedicine and health journals not indexed by MEDLINE, making it unique.

What does the research involve?

A briefing statement about Australia PMC is included as an attachment, along with this statement.

If you agree to participate, Lisa Kruesi will phone your office to make an appointment to interview you. The interview can be held at a time convenient to you and will involve discussion of eight questions. It should only take 45 minutes of your time.

If you are willing to participate please sign and return the Consent Form also included as an attachment.

Why were you chosen for this research?

As a leader with significant experience you have been chosen for this research. Your contact details were obtained from your organisation s website.

Voluntary nature of participation

Participants retain the right to withdraw from this investigation at any stage of the research. If the participant has chosen to provide an anonymous questionnaire response it will not be possible to withdraw the data once they have submitted a response. If the participant is identifiable and they choose to withdraw from the study, their response can be withdrawn within one month of their submission.

Possible benefits and risks to participants?

Participation in this project will not have any immediate benefits to you. However, you will be making a major contribution to answering an important research question on the need for an Australia PMC. If an Australia PMC were to proceed in the future there would be many benefits, such as:

- Opportunity to avoid duplication of effort and time savings based on consolidation of manuscripts in one biomedical repository
- Access to an international repository system at institutes, hospitals and healthcare services that do not have such systems or expertise to develop such systems. For example, a senior library manager working at a major teaching hospital in Western

Australia commented that: *"I know the universities are pretty well served by their own repositories but it is a big issue for purely hospital or research institute based research – we don t have repositories and I know I am asked about it here. Seems mad to have lots and lots of little repositories set up (sustainability is a big issue) when it would be so much more efficient if we all plugged into a single national one."*

- Importance of open access to research and a need for a repository for peer-reviewed journal papers funded partly or in whole by the ARC/NHMRC/NIH
- Avenue for a comprehensive repository of Australian medical and health sciences research for discovery and merging of publication records with other world PMC sites
- Opportunity to use the site as an outlet to record the translation and adoption of evidence into practice
- Means to preserve Australian health research and link to associated data
- The site would be a means to help determine Australian medical research areas, identify experts and champions for collaboration and a site to obtain studies by Australian researchers
- Potential future resource for answering clinical questions and accessing journal articles
- Avenue to identify potential collaborators and experts

Possible or reasonably foreseeable risks of harm to the potential participants:

- There are no foreseeable risks of harm to potential participants from participation in the research
- The topic is not controversial
- Participants details will be kept confidential

Confidentiality

This matter is not of a highly sensitive nature. Participants can request that their responses be kept anonymous and confidential. Based on this request their correspondence will be suitably labelled and saved on a password protected network. Responses labelled confidential will not be transcribed within the final thesis or associated papers.

Storage of data

The data we collect will only be accessed by the named researchers. All data will be securely stored at the researcher's institutions and will be stored centrally at Monash University after the completion of the research. Audio recordings of interviews will be destroyed after the transcripts have been approved. With your approval, data will be deposited in the Monash University Research Repository. Otherwise the data will be securely destroyed five years after the completion of the project to comply with Monash University guidelines.

Use of data for other purposes

With your permission, we would like to use the data we collect in future research. Only aggregate de-identified data will be made available for other research and only for research where ethics approval has been granted.

Results

It is anticipated that the PhD thesis will be made openly available on the Monash University thesis website.

Complaints

Should you have any concerns or complaints about the conduct of the project, you are welcome to contact the Executive Officer, Monash University Human Research Ethics (MUHREC):

Executive Officer
Monash University Human Research Ethics Committee (MUHREC)
Room 111, Chancellery Building E,
24 Sports Walk, Clayton Campus
Research Office
Monash University VIC 3800

Tel: +61 3 9905 2052 Email: muhrec@monash.edu

Thank you,
Prof Frada Burstein

A1.6 Interview and focus group questions

INTERVIEW QUESTIONS:

The below questions are used to frame the discussion. Being a MEDLINE/PubMed searcher isn't a requirement for the interview.

1. Please describe the nature and extent of your experience with MEDLINE, PubMed and PubMedCentral (PMC)

2. What platform do you use to access MEDLINE?

a. Google scholar
b. OVID
c. EBSCO
d. SciFinder
e. Embase.com
f. PubMed (National Library of Medicine)
g. Europe PMC
h. PMC Canada
i. Other

3. How frequently do you access MEDLINE/PubMed?

a. Daily
b. Weekly
c. Monthly
d. A few times a year
e. Other

4. How important are resources such as MEDLINE/PubMed/PubMed Central to filling gaps in clinical knowledge?

5. Would an open access repository, such as Australia PMC, contribute to clinical practice?

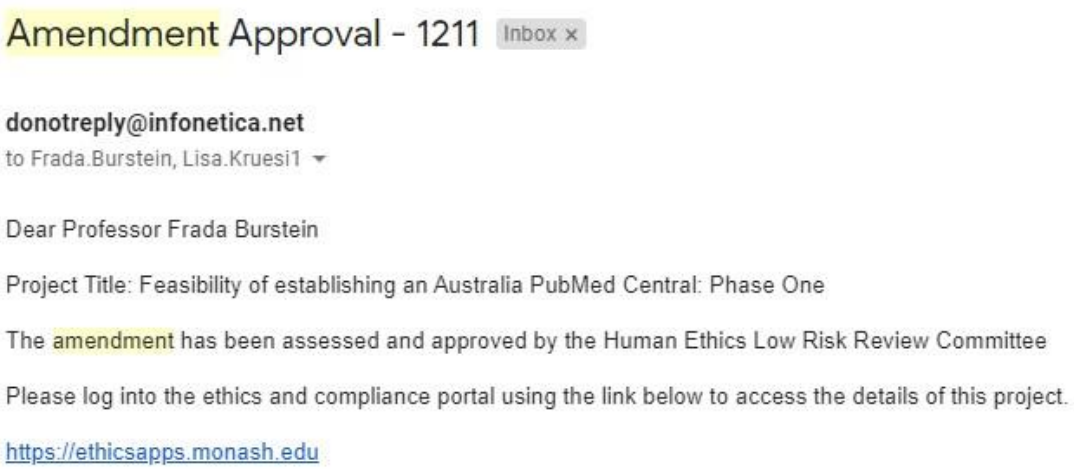
6. Based on your experience and or reading of the Australia PMC Briefing Document please explain what you perceive to be any potential value of an Australia PMC to the medical and health sciences research community?

7. Do you have any other feedback?

A2.1 Ethics amendment approval

Monash University Human Research Ethics Committee amendment approval

Amendment approved 21 April 2017



Amendment Approval - 1211 Inbox ×

donotreply@infonetica.net
to Frada.Burstein, Lisa.Kruesi1

Dear Professor Frada Burstein

Project Title: Feasibility of establishing an Australia PubMed Central: Phase One

The amendment has been assessed and approved by the Human Ethics Low Risk Review Committee

Please log into the ethics and compliance portal using the link below to access the details of this project.

https://ethicsapps.monash.edu

The amendment request: I am presenting at two conferences the results gained during Cycle One of the Australia PMC investigation. I will have the opportunity to gain feedback on my research at the conferences. I have labelled the forms phase 2 in order to distinguish these documents from the first phase of my research. In order to include the feedback that I receive from participants at the conference I have edited the following forms using track changes for distribution to conference participants:

A2.2 Plain language statement

Australia PubMed Central (PMC): briefing statement

What is the relationship between MEDLINE, U.S. PubMed and PMC?

MEDLINE is the U.S. National Library of Medicine® (NLM) major bibliographic database with over 27 million references to journal articles on biomedicine and health. PubMed is a free citation index, produced by the National Center for Biotechnology Information (NCBI) at the NLM, which contains MEDLINE plus NLM's database of citations and abstracts. PubMed Central® (PMC) is a free full-text archive of biomedical journal literature. PMC provides content deposited by participating publishers and author manuscripts submitted to comply with the NIH public access policy. Some PMC journals are also MEDLINE journals, and there are links between corresponding citations in PubMed and the full text in PMC. See Figure 1 below.

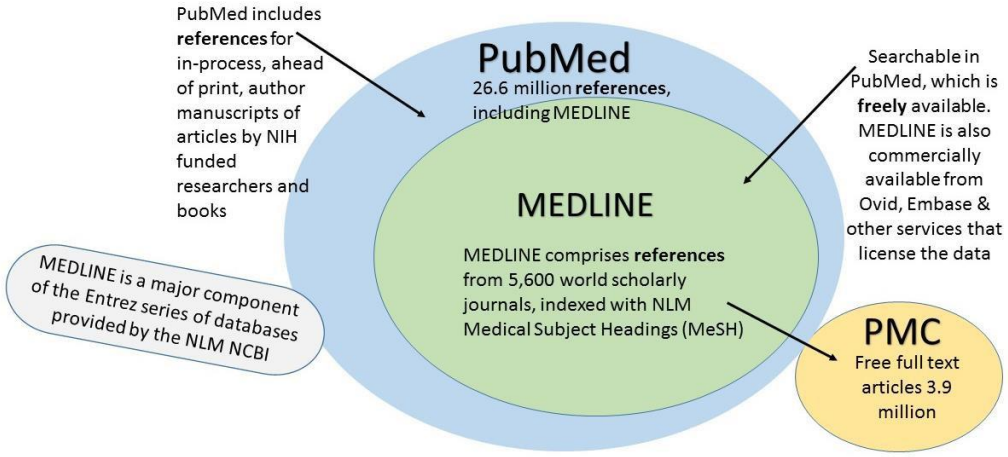


Figure 1 Source: https://www.nlm.nih.gov/pubs/factsheets/medline.html (Graphic by L. Kruesi, 2016)

What is an Australia PMC?

The Australia PMC's main purpose would be to establish a consolidated repository of openly available biomedical and health sciences articles by Australian researchers. An Australia PMC, like its counterpart, Europe PMC, can potentially include abstracts, articles and links to research data from anywhere in the world, and would not be limited by funder or geographical location. It could also include open access articles from Australian peer reviewed biomedicine and health journals not indexed by MEDLINE, making it unique. The full scope of content in the USA PubMed, MEDLINE and PMC would be available from an Australia PMC and delivered

through a single search platform. An example of the content in the Europe PMC follows in

Why an Australia PMC?

- It is an opportunity to:
- Create a comprehensive Open Access repository of papers by Australian health and medical researchers
- Address the fragmented and incomplete access to Australian health research publication records

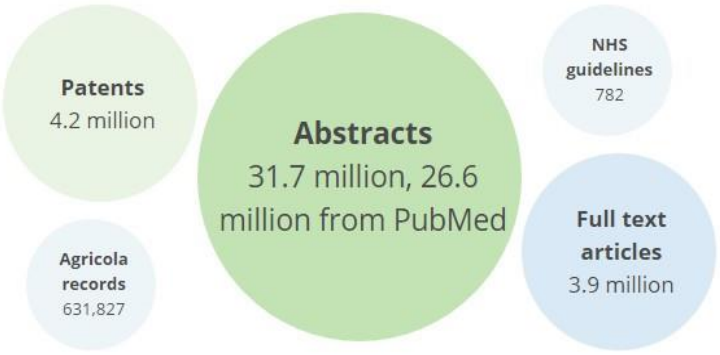


Diagram of the Europe PMC from https://europepmc.org/About

Why an Australia PMC?

- Overcome the significant amount of duplicated effort underway in
- Australian universities to collect publications for repositories in order to meet funding bodies' open access mandates
- Provide a repository system for sites without or with limited access, such as Australian medical institutes, hospitals and healthcare sites
- Leverage existing infrastructure to develop a comprehensive repository for peer-reviewed journal papers funded by the ARC/NHMRC
- Merge Australian articles with other world PMC sites
- Preserve Australian health research and associated data for present and future generations
- Become a node of the USA NLM PubMed and contribute internationally to the creation of a nationally owned, quality database of medical and health sciences content

How?

A steering committee, comprising members from Monash University, The Association of Australian Medical Research Institutes, University of Melbourne and the University of Queensland, will prepare a proposal recommending a suitable model and design of an Australia PMC prototype. The proposal will take into consideration contractual requirements of the NIH/NLM/NCBI and include funding

recommendations. A prototype design and recommendations would be made available for consideration in late 2017

Need?

This research will explore the importance of an Australia PMC repository from a knowledge management perspective. The research will be based on the Haynes' 6S pyramid model of the six hierarchical levels of access to the best clinical evidence (1). Knowledge management principles, which include tacit as well as explicit knowledge, will be integrated within the Haynes' model to enhance the understanding of the uptake of clinical evidence and transfer into practice.

April 2017

A2.3 Interview arrangements

--------- Forwarded message ----------

From: Robert Kiley

Date: 20 April 2017 at 20:10

Subject: RE: E-Introduction about PMC

Lisa: Pleased to meet you. Via this email, let me also introduce my colleague, Hannah Hope, who manages the Europe PMC repository of behalf of the 27 funders that support - and fund - the Europe PMC repository.

I wonder if it would be helpful to set up a call in which we can discuss Europe PMC and explore whether there is any appetite for Australian researchers to use this repository (rather than create a separate Australia PMC repository)? A short overview of some the services available via Europe PMC can be found at: http://europepmc.org/Joining

I understand from Ginny that the name, Europe PMC, would cause problems. Changing this name – to something that was more acceptable in different geographic locations – would be something I'd be willing to actively raise with the Europe PMC Funders Group.

Assuming a initial call might be useful, would any of the dates/times listed below be convenient?

09.00 BST/18.30 (ACST) on Friday 28th April

09.00 BST/18.30 (ACST) on Wednesday 3rd May

09.00 BST/18.30 (ACST) on Friday 5th May

I look forward to hearing from you.

Best regards

Robert Kiley

Head of Open Research

Wellcome Trust

215 Euston Road, London. NW1 2BE

ORCID: 0000-0003-4733-2558
Twitter @robertkiley

From: Virginia Barbour, Executive Director, AOASG [
Sent: 18 April 2017 02:11
To: Robert Kiley; Lisa Kruesi
Subject: E-Introduction about PMC

Dear Robert,

I wanted to make an introduction between you and Lisa Kruesi from Monash University who is part of a group looking at possible options on an Australian PMC. Her work includes an extensive set of interviews with various stakeholders here. She has previously been in contact with Jo McIntryre.

I have mentioned to Lisa the conversations you and I have recently.

I'm happy to participate in any useful way in future conversations.

Best wishes
Ginny

Dr Virginia Barbour
Executive Director, Australasian Open Access Strategy Group - AOASG
Brisbane, Australia
ORCID : 0000-0002-2358-2440

From: Lisa Kruesi [lisa.kruesi1@monash.edu]
Sent: May 18, 2017 11:16 PM
Subject: Re: FW: contact at PMC Canada

Dear Isabelle,

I am undertaking PhD research and also representing an Australasia PubMed Central Working Group. We are investigating the feasibility of an Australasia PubMed Central. Thank you for your previous help with my email queries on this topic. I'm aware of the very helpful detail about PMC Canada available from your website.

We are now developing profiles of the existing PMC international nodes. To help with this research would it be possible to meet with to gather further details on the users, technology, staffing and operations of PMC Canada? I can set-up a Zoom video conference if you are available. The interview would take approximately one hour and I can send you the questions beforehand, in addition to the briefing documentation and a consent form. A meeting time of 4 pm (Toronto time) would be ok for me (this is 6 am Melbourne time).

Thank you for your consideration of this request.

Kind regards,

Lisa

LISA KRUESI
PhD Researcher
Faculty of Information Technology

A2.4 Interview questions

A2.4.1 Questions for Europe PMC Meeting: May 12, 2017: interview one

Users

1. Please describe the Europe PMC user communities – e.g. the funders, the researchers

Technology

2. Please describe the technology architecture and standards for Europe PMC?

3. Does Europe PMC have a disaster plan?

Staffing

4. Please describe Europe PMC's staffing (including number and expertise of staff)?

Services/Operations

5. Does the income from funders cover Europe PMC's operational and development costs?

6. Would the service offered to an Australasian PMC include provision of operational and developmental aspects of the Europe PMC?

7. Please describe existing PMC partnerships? E.G. US NLM, British Lending Library or with other regions (those partnerships required for Europe PMC to function)
8. Please describe Europe PMC's relationship with universities?

9. What are the relevant compliance laws for Europe PMC?

10. What are Europe PMC's performance measures?

11. What are the benefits and drawbacks of running a PMC?

12. What aspects of Europe PMC have not been successful?

13. How do you respond to criticism raised by P Davis (in the paper cited below) that PMC reduces journal readership from journal websites and weakens the ability of journals to

build communities and reduced the perceived value of journals to institutional subscribers?

Davis, Philip M. "Public accessibility of biomedical articles from PubMed Central reduces journal readership—retrospective cohort analysis." *The FASEB Journal!* (2013) 27(7): 2536-2541 doi: 10.1096/fj.13-229922

14. Please describe the process for linking grants and publications?

Future

15. Would you consider a partnership with an Australasia PMC group? *Based on this we may not necessarily need a contract with the US NLM*

16. Do you have a plan for future PMC Europe developments? If so, are you able to share the plans with us? Would an Australasian PMC entity have the opportunity to contribute to these developments?

A2.4.2 Questions for PubMed Central Canada, May 29, 2017: interview one

Users

1. Please describe the user communities – e.g. the funders, the researchers

Technology

2. Please describe the technology architecture and standards

3. Does PMC Canada have a disaster plan?

Staffing

4. Please describe staffing (including number and expertise of staff)?

Services/Operations

5. Does your budget cover all of the operational and development costs?

6. Please describe existing PMC partnerships? E.G. US NLM, British Lending Library or with other regions (those partnerships required for Europe PMC to function)

7. Does PMC Canada have any formal relationships with Canadian universities?

8. Are there any compliance laws that PMC Canada has to meet?

9. What are PMC Canada's performance measures?

10. What are the benefits and drawbacks of running a PMC?

11. What aspects of PMC Canada have not been successful?

12. What is PMC Canada's open access compliance rate?

Future

13. Do you have a plan for future PMC developments? If so, are you able to share the plans with us?

A2.4.3 Questions for Europe PMC Meeting: January 24, 2018: interview two

Questions for the PMC Canada interview with Eveline Landa

To be held Melbourne time 9.30 am & Brisbane time 8.30 am on Wednesday 24 January.

Background

On February 23, 2018, PubMed Central Canada (PMC Canada) will be taken offline permanently. No author manuscripts will be deleted, and the approximately 2,900 manuscripts authored by Canadian Institutes of Health Research (CIHR)-funded researchers currently in the archive will be copied to the National Research Council's ;NRC Digital Repository over the coming months. These manuscripts along with all other content will also remain publicly searchable on PubMed Central (US) and Europe PubMed Central, meaning such manuscripts will continue to be compliant with the Tri-Agency Open Access Policy on Publications. Taken from: http://pubmedcentralcanada.ca/pmcc/

Knowledge Management

1. From our previous discussion, you raised some of the technical challenges and loss of staffing experienced by PMC Canada. Did human driven processes or technical issues or a combination of these factors influence the closure of PMC Canada? Please expand upon your response.

2. Please can you prioritise the four knowledge management processes: 1. Creation, 2. Storage & Retrieval, 3. Transfer and 4. Application – in order of the most important for PMC Canada? (with 1 being the most important). Please can you expand upon your response.

Governance

3. Is it possible that the closure of PMC Canada was due to lack of formal governance? e.g. definition of governance is *authority through a model that ensures delivery of anticipated or predicted benefits from a service in an authorized and regulated way*

4. If this were the case, what type of governance would have been more suitable?

5. How could PMC Canada been set up as a sustainable service? Would it have helped if KPI's had been adhered to by the NLM and PMC Canada? If so in what way?

6. What were the strategic aims for PMC Canada and where they applied?

7. During our previous interview, you explained that PMC Canada did not collaborate with Canadian university repositories (such as the Canadian Association of Research Libraries). Do you think such cooperation would have been beneficial or possible?

Regional Issues

8. Do you think being so geographically close to the USA PMC reduced the need for a Canada PMC? e.g. Based on our previous discussion, where you described the majority of Canadian authored manuscripts were already in PMC; Though according to the PMC Canada website: Approximately only 4% of author manuscripts arising from CIHR-funded research have been deposited in PMC Canada by researchers since the system was created

User Communities

9. What will happen with the regional online medical library aligned with PMC Canada and set up by the Canadian Medical Librarians?

10. What has been the wider response to the pending closure of PMC Canada i.e. from researchers, the public and industry?

Going Forward

11. Would you be willing to comment on my draft presentation for the USA Medical Library Association meeting that compares Europe PMC and PMC Canada?

12. Do you have any other feedback or comments for us?

Notes from http://pubmedcentralcanada.ca/pmcc/

In consultation between the Canadian Institutes of Health Research (CIHR) and the National Research Council (NRC), a decision has been made to permanently take PubMed Central Canada (PMC Canada) offline on February 23, 2018. This is being done for the following reasons:

- Approximately only 4% of author manuscripts arising from CIHR-funded research have been deposited in PMC Canada by researchers since the system was created; and
- To continue to operate, PMC Canada requires a number of technical upgrades to meet Government of Canada web and security standards. However, the time and resources to upgrade the system are prohibitive.

CIHR and NRC wish to assure interested parties that no author manuscripts now in PMC Canada will be deleted, and that the approximately 2,900 manuscripts authored by CIHR-funded researchers currently in the archive will be copied to the NRC's Digital Repository. These manuscripts, along with all other PMC Canada content, will also remain publicly searchable on

PubMed Central (US) and Europe PubMed Central, meaning such manuscripts will continue to be compliant with the Tri-Agency Open Access Policy on Publications.

As such, no new manuscripts will be accepted by PMC Canada after January 5, 2018. If you have recently submitted a manuscript to PMC Canada, staff will work diligently to process it before the system is taken offline. This may mean that you will have less time than usual to make any modifications to your manuscript prior to posting. We appreciate your understanding.

What are the alternatives to PubMed Central Canada?

CIHR and the NRC remain committed to open access and open science, and continue to encourage researchers to deposit their manuscripts in compliant university- and discipline-based repositories and to publish in open access journals. For a list of compliant repositories, please consult the Science.gc.ca Open Access website and the Canadian Association of Research Libraries Institutional Repository Project: Online Resource Portal.

A3.1 Ethics amendment approval

Monash University Human Research Ethics Committee amendment approval

19 July 2019

Amendment Approval - 1211 Inbox ×

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to Frada.Burstein, Kerry.Tanner, Lisa.Kruesi1

Project Title: Feasibility of establishing an Australia PubMed Central: Phase One
Project ID: 1211
Chief Investigator: Professor Frada Burstein
Expiry Date: 09/11/2021

Dear Researchers

The amendment has been assessed and approved by Human Ethics Low Risk Review Committee

Please click the following link to view the project details: https://ethicsapps.monash.edu/Project/Index/1215

Kind Regards,

Human Ethics Low Risk Review Committee

Appendix B: Conceptual KMS framework for an Australasia OBR

Appendix B: Conceptual KMS framework for an Australasia OBR

NOTE: Shading indicates the element includes a service or resource that is part of an open biomedical repository

	Discovery	Creation	Representation	Classification	Storage	Retrieval	Dissemination	Transfer	Translation
People	Knowledge discovery may be defined as the development of new tacit or explicit knowledge from data and information or from the synthesis of prior knowledge. For discovery researchers, citizens and practitioners' access and read existing knowledge e.g. search *PubMed (aggregator database) and PMC (biomedical repository)* to identify knowledge on a topic. The process of examining existing knowledge helps to identify gaps in understanding or is an important part of expanding, revising, or correcting misinformation	Knowledge creation assumes knowledge does not exist before the activity that catalysed the innovation. Creation entails **data** analysis and investigation activities undertaken by researchers. In biomedical research this usually involves teams of researchers from various organisations. Research support staff provide input to researcher creation activities.	Representation comprises explicit knowledge in the form of digital scholarly objects. Tuomi argues that structured knowledge becomes information when assigned a fixed representation and it is a standard interpretation as data. (Tuomi,1999) Copywriters, editors, graphic designers working for publishers have a major role in determining publishing styles.	Taxonomies, also called classification or categorization schemes, are considered to be knowledge organization systems that serve to group objects together based on a particular characteristic. For example, keywords to describe research output is assigned by researchers. PubMed articles are assigned descriptors by librarians from the controlled and hierarchically-organized vocabulary published by the National Library of Medicine, known as Medical Subject Headings (MeSH) (Bodenreider, 2004)	Databases and repositories require storage for metadata and content. The speed of mass data production and deposition demands creative solutions for data storage and computational infrastructure. Open biomedical literature repositories accommodate human data entry and publisher (human) entry of metadata and full-text content.	Information retrieval can entail finding research references based on search algorithms that interrogate internet or database metadata or full-text articles. Researchers, funders, industry, research support staff and consumers applying tacit and explicit knowledge to create search strategies to retrieve research output.	Dissemination of research objects and data via presentations at conferences, personal communications and use of systems. Informal mechanisms, such as unscheduled meetings, informal seminars, or coffee break conversations, may be effective in promoting socialization but may preclude wide dissemination (Holtham & Courtney,1998) knowledge repositories may be most effective for knowledge that can be readily generalized to other contexts. (Alavi & Leidner, 2001)	Transfer involves clarification of the terms and conditions between relevant parties in relation to the use of the content. It "is the transfer of knowledge to the location where it is needed and can be used" (Major & Cordey-Hayes, 2000). Executive and senior staff in research organisations and industry will refer to repository output to identify content relevant to the transfer agreement.	Translation involves "the synthesis, exchange, and application of knowledge by relevant stakeholders to accelerate the benefits of global and local innovation in strengthening health systems and improving people's health." (Pablos-Mendez & Shademani, 2006). Cost of irreproducible published results estimated to be US$28 billion (Freedman, Cockburn & Simcoe, 2015) "big data analytics for the medical field will potentially save more than $300 billion per year in US health-care costs." (Luo, Wu, Gopukumar, Zhao, 2016).

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	Discovery	Creation	Representation	Classification	Storage	Retrieval	Dissemination	Transfer	Translation
Process	Discovery processes are the rules, regulations and guidelines established by professional bodies, organisations and research leaders. Repositories and databases are accessed as part of the research discovery process. For example, to apply for funding to undertake a clinical trial and cohort study funding bodies require reporting on a systematic review or literature review as part of the grant application process. Funding bodies, universities and other organisations' strategic and operational plans guide discovery practices. Researcher access to knowledge repositories and databases in organisations is an integral part of the grant application process involved in discovery	Creation processes are influenced by priorities set by government and research organisations in response to public needs. Excellence Research Australia is a periodic government process that determines research priorities and strengths for Australian universities. This process has a significant impact on creation. Higher Education Research Data Collection is undertaken by Australian universities on reporting requirements to obtain research and development income data. This process influences research output creation activities in the higher education section. Funding bodies lead creation (e.g., Europe PMC has 33 funders). Process can drive behaviour and steer creation in the research sector.	Representation processes are found in research and publishing instructions, standards, checklists and codes. For example, the Equator Network promotes transparent and accurate reporting of health research findings to improve the impact and reliability of biomedical research articles. The International Committee of Medical Journal Editors (ICMJE) and the Equator Network are bodies that influence biomedical knowledge representation process in the form of instructions, standards, checklists and codes, examples include the Consolidated Criteria for Reporting Qualitative Research (COREQ), and the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA). The Committee on Publication Ethics (COPE) define best practice in the ethics of scholarly publishing and assist editors, publishers to achieve this. NLM expects publishers to have at least a two-year history of quality scholarly publishing in the life sciences.	Classification processes involve rules for naming and describing research output. For example, rules for naming may be governed by international bodies such as the International Association for Plant Taxonomy (IAPT) governs plants and the International Commission of Zoological Nomenclature (ICZN) governs the naming of animal taxon. *(Note: Agricola an agricultural database is available from Europe PMC)*	Storage processes are based on international standards, such as preservation and interoperability standards. Funding bodies for example, NIH, NHMRC, ARC have open access publishing mandates that require research they fund be stored in repositories that make output openly accessible. Adherence to open standards for example, PMC submissions must be in XML format that conform to an acceptable journal article DTD (Document Type Definition) FAIR principles are established to share & reuse digital objects.	Retrieval processes include search commands and filters. Open access status and standards can determine research output that is retrieved, for example, Open Archives Initiative Protocol for Metadata Harvesting (OAI-PMH) standard Quality requirements of systematic review searches: Cochrane Handbook 2019 for undertaking a systematic review; Campbell Methods Guides 2016; CEE Guidelines and Standards for Environmental Evidence synthesis 2018) Findings: "no [avoiding] proprietary search systems if one attempts a rigorous systematic review." (Gusenbauer & Haddaway, 2020)	The process of dissemination, is often detailed in policies, procedures and guidelines, related to submissions in open biomedical repositories may be determined by research bodies such as the NHMRC, the ARC, US NIH, Universities and other research bodies. Funding bodies for example, NIH, NHMRC and the ARC open access publishing mandates Dissemination of research output based on referencing standards, detailed in guides for example: https://guides.lib.monash.edu/citing-referencing	The knowledge transfer process takes place through patenting, licensing, contracts, trade secrets, joint ventures with inventors and commercial spin-offs (Stevens & Bagby, 2001) A copyright transfer agreement or copyright assignment agreement is an agreement that transfers the copyright for a work from the copyright owner to another party (https://en.wikipedia.org/wiki/Copyright_transfer_agreement) Copyright laws and Creative Commons licences https://creativecommons.org.au/learn/howto/	The translation of research process is the time lag between biomedical research and its translation to health and wider society benefits. In relation to open biomedical repositories, translation of research is informed through the linking of the research grant details to their research output. For example, PMC allows principal investigators to link their articles to their grant information.
			Open source repository submission system			"US PMC has more than a billion articles retrieved each year" content is permanently accessible and discoverable." (NLM Program Manager, 2018)			

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NOTE: Shading indicates the element includes a service or resource that is part of an open biomedical repository									
	Discovery	**Creation**	**Representation**	**Classification**	**Storage**	**Retrieval**	**Dissemination**	**Transfer**	**Translation**
Technology	Technology to underpin discovery for research output for open biomedical repositories includes for PMC, integration with NLM pub-one records and PubMed Labs. PubMed uses Solr, an open-source enterprise search system, for document indexing, and Solr provides powerful search functions. Technology (APIs) for text and data mining. PubMed uses Django Web framework on the front-end. Other examples: Visual knowledge gateways Automated current awareness services. Technology to open up full-text content is Unpaywall and PubMed Linkout	Technology for creation, includes the access to repositories for research investigations. Open biomedical literature repositories such as PMC International is used along with data repositories such as DataMed, Dryad and figshare. Such repositories link to databases such as ENA, PDB, ArrayExpress, UniProt, RefSNP, OMIM, Pfam, RefSeq, Ensembl, InterPro, Bioproject, Biosample, EMDB, PXD, EGA, TreeFam; these technologies underpin creation activities of researchers.	Technology systems provide the format of digital research output. Open source repository submission systems––such as Europe PMC plus––developed as a fully open source application built on the open source project PubSweet. The system has been developed in collaboration with the Collaborative Knowledge Foundation (Coko) and community partners including eLife and Hindawi. Portable PMC (pPMC) is software used to operate US PMC that allows PMCI centres to import data from PMC, build a local database and display content of each article in PMC style.	Technology is used to provide automated classification systems, for example PubMed uses Solr, an open-source enterprise for document indexing. Unified Medical Language System (UMLS) integrates and distributes key terminology, classification and coding standards, and associated resources to promote creation of more effective and interoperable biomedical information systems and services, including electronic health records.	Technology underpins the storage of open biomedical content. Portable PMC (pPMC) is software used to operate US PMC that allows PMCI centres to import data from PMC, build a local database and display content of each article in PMC style. MongoDB is used by PuMed for storage and retrieval. Europe PMC, for example, comprises databases and APIs and is a fully open source application that uses PubSweet systems. Analyzing data collectively puts a strain on local computing infrastructure, and is greatly facilitated by cloud-based collaboration platforms such as those being built by EMBL-EBI. Publishers provide machine entry of metadata and content into repositories.	Open biomedical repository technology for retrieval of research output combines interoperable systems that aggregate content (publications and data) from other sources, for example US PMC and Europe PMC have APIs for reuse of content where permitted OpenAIRE, Unpaywall, PubMed Linkout are linking tools bringing together disparate content Internet sources such as university repositories & subject repositories	Technology is used to disseminate research objects. The technology is based on open system protocols for searching metadata, research data and full text literature.	Technology transfer for open knowledge databases and search platforms are detailed in the report *Mind the Gap.* Text and data mining systems are key technologies to aid the technology transfer process. Integration of repositories with research management systems.	Technology systems such as Impactstory (open source website) are available for researchers to generate reports on the online impact of their research. Adoption of output in AI and expert systems (data and full-text).

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	Discovery	**Creation**	**Representation**	**Classification**	**Storage**	**Retrieval**	**Dissemination**	**Transfer**	**Translation**
Content	*The content for an Australasia open biomedical repository will be based on user requirements. Three options are proposed though further options can be tailored to user requirements.* Option 1: available data from PubMed, PMCI (US PMC, Europe PMC, PMC Canada), and other publishers and open outputs e.g. Source IP for patents – essential to the discovery process to determine novelty of research. (Potential content): Informit Health Collection covers more than 190 source titles many with an Australasia focus, including peer-reviewed journals, trade publications, conference papers and e-books. Coverage is 100% full text and includes evidence-based healthcare extending to all nursing specialties and professions. Out of 132 titles in Informit Health Collections 12 are indexed in MEDLINE and PubMed (91% not indexed) 2 indexed in PubMed only (the titles indexed by MEDLINE)	Content, in the form of research output, can be found by searching open repositories via metadata, bibliographic indexes and full text. Content to support creation is made available in research protocol(s), research data and research objects; all of these help with determining the novelty of the research and the contribution of the research to existing knowledge	Equator Network and the International Committee of Medical Journal Editors for health sciences publication standards ORCID and other researcher persistent digital identifiers to distinguish their research Example: Europe PMC – how content is added to the repository: A. By publishers who make all their content available at the time of publication (PLOS, BMC, eLife) B. By publishers who make individual articles available at the time of publication (e.g. articles in hybrid journals) C. By authors who self archive the author manuscripts in PMC/Europe PMC using the Europe PMC plus deposition service D. By publishers who deposit the peer-reviewed manuscripts for free on behalf of authors (e.g. Nature Publishing Group does this for all articles acknowledging funding from Europe PMC Funders) From: https://europepmc.org/About	Classification schemes and ontologies are used by repositories to allow users to navigate content e.g. Europe PMC researchers use GO, UniProt, EFO, ChEBI, NCBI Taxonomy and UMLS as ontologies in the biological literature to "achieve a common understanding of the categories of objects described in life sciences data and the labels used for those categories" (Stevens, 2010)	Content needs to be stored in a standard way, that can be efficiently migrated to future systems. Direct entry of metadata and objects - *These aggregations, sometimes called compound digital objects, may combine distributed resources with multiple media types including text, images, data, and video.* (Tarrant, O'Steen, Hitchcock & Carr, 2009) PMC stores content in eXtensible Markup Language (XML), which represents the structure and meaning of a document in a human-readable form. All PMC content is converted to and stored in the NISO Z39.96-2015 JATS XML format. This standard format is the most effective and widely used archival format for journal articles.	To retrieve content the following are applied --search commands, filters, open access, standards for example, Open Archives Initiative Protocol for Metadata Harvesting (OAI-PMH) standard used by PMC The National Library of Australia's Trove for biomedical institutional repository content and grey resources BASE - search engine provides 270 million documents from more than 9,000 sources https://www.base-search.net/ Meta-search platforms e.g. Accessss, Epistemonikos & Trip Directory of Open Access Repositories (OpenDOAR) Directory of Open Access Journals (DOAJ)	Dissemination of research output (content) is based on standards. Billions of articles are disseminated annually via PMCI. PMCI does not report on or collect usage patterns due to privacy laws. PMC Canada reported that Chinese users downloaded a significant number of articles from their site. Text mining is available on open access subsets of PMCI	Content can be transferred and interoperable between systems based on international standards. For example, the FHIR (Fast Healthcare Interoperability Resources) is available for the transfer of healthcare information, including research articles https://www.hl?.org/fhir/overview.html	Translation of research output is reported in systems that complement open biomedical repositories. Analytical reports can be generated using the Web of Science platform InCites and the Scopus platform SciVal based on researcher publications. The InCites platform provide normalised citation impact, institutional analysis and benchmarking details. The SciVal platform provides author field weighted citation impact, outputs in top percentiles, international collaborations, academic/corporate collaborations, institutional analysis and benchmarking. SNOWMED CT - multilingual clinical healthcare terminology; scientifically validated for electronic health records systems. Enables links between clinical records, clinical guidelines and protocols

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	Discovery	**Creation**	**Representation**	**Classification**	**Storage**	**Retrieval**	**Dissemination**	**Transfer**	**Translation**
Content	Biomedical journals indexed by proprietary databases not available in PubMed e.g. SciFinder, CINAHL, PsycINFO, EMBASE Excellence Research Australia (ERA) medical journals that are not included in PubMed or the Informit Health Collection -- of these 821 ERA titles examined 103 titles were not found in PubMed Protocols, Preprints, Clinical trials, guidelines, biomedical PhD theses and biomedical data sources (e.g. DataMed) AND/OR Option 2: more broadly, such as internet wide access to openly accessible research data and research objects OR Option 3: limited to adding PubMed/PMC approved research articles to PMC International only (Option 3 outsourced to Europe PMC or explore Australasian health libraries taking on this service)		Representation requirements are in standards for example, the *NHMRC standards for developing guidelines: Guidelines for Guidelines*		The framework for managing flexible aggregations of digital objects are provided by the Open Archives Initiative (OAI) with its work on Object Reuse and Exchange (ORE)	SATORI (Semantic AnnoTations and Ontological Relations Interface) -open source integrative search & visual interface for exploration of biomedical data repositories (Lekschas & Gehlenborg, 2018)			

Appendix C: KMS framework for analysis and evaluation of systems

C1.1 Europe PMC: System One

C1.2 Epistemonikos: System Two

C1.3 Trove: System Three

C1.4 ResearchGate: System Four

C1.5 Workshop documentation

C1.1 Europe PMC: System One

Appendix C1.1 KMS framework for analysis and evaluation of Europe PMC: System One

High	includes components that make the system an exemplar in the field
Medium	components with scope for improvement and/or may rely on external sources
Low	components maybe external to the system and /or may detract from the system

SYSTEM	Discovery	Creation	Representation	Classification	Storage	Retrieval	Dissemination	Transfer	Translation
				definitions are italicized in red font					
Europe PMC: PEOPLE	*Knowledge discovery may be defined as the development of new tacit or explicit knowledge from data and information or from the synthesis of prior knowledge.* For discovery researchers, citizens and practitioners' access and read existing knowledge e.g. search PubMed (aggregator database) and PMC (biomedical repository) to identify knowledge on a topic. The process of examining existing knowledge helps to identify gaps in understanding or is an important part of expanding, revising, or correcting misinformation	*Knowledge creation assumes knowledge does not exist before the activity that catalyzed the innovation. Creation entails data analysis and investigation activities undertaken by researchers.* In biomedical research this usually involves teams of researchers from various organisations. Research support staff provide input to researcher creation activities Europe PMC's mission: "To build open, full text scientific literature resources and support innovation by engaging users, enabling contributors, and integrating related research data." https://europepmc.org/Roadmap	*Representation comprises explicit knowledge in the form of digital scholarly objects or the metadata for the objects created and used by people.* Europe PMC is used by both experienced and early career researchers, policy makers, biocurators and innovators seeking to enhance scholarly publishing http://blog.europepmc.org/2020/03/user-stories-Europe-pmc-research-article-search.html	*Taxonomies, also called classification or categorization schemes, are considered to be knowledge organization systems that are applied by people and serve to group objects together based on a particular characteristic.* Identifiers are mentioned in the literature hosted by Europe PMC, these include links to data resources such as - ■ other literature & ontologies ■ genes, genomes & variation ■ gene, protein & metabolite ■ protein sequences, families & motifs ■ molecular structures ■ chemical biology ■ systems e.g. BioModels, BioSamples ■ Molecular archives (Cook, Bergman, Cochrane, Apweiler & Birney, 2018)	*People take actions for platforms, databases and repositories to store metadata and content.* Open biomedical literature repositories accommodate human data entry and publisher (human) entry of metadata and full-text content	*Information retrieval can entail people searching for and finding research references based on search algorithms that interrogate internet or database metadata or full-text articles.* Researchers, funders, industry, research support staff and consumers applying tacit and explicit knowledge to create search strategies to retrieve research output.	*Dissemination of research objects and data via presentations at conferences, personal communications and use of systems.* .... knowledge repositories may be most effective for knowledge that can be readily generalized to other contexts. (Alavi & Leidner, 2001) Twitter, blog, and YouTube channel. Resources are made available to promote and educate users via the Europe PMC website: https://europepmc.org/Outreach "PMC has more than a billion articles retrieved each year" content is permanently accessible and discoverable." (NLM Program Manager, 2018)	*Transfer involves clarification of the terms and conditions between relevant parties in relation to the use of the content.* Europe PMC is an open science platform that enables access to a worldwide collection of life science publications and preprints from trusted sources around the globe. Executive and senior staff in research organisations and industry refer to the PMC repository output to identify content relevant to the transfer agreement.	*Translation involves "the synthesis, exchange, and application of knowledge by relevant stakeholders to accelerate the benefits of global and local innovation in strengthening health systems and improving people's health.*" (Pablos-Mendez & Shademani 2006). Cost of irreproducible published results estimated to be US$28 billion. (Freedman, Cockburn & Simcoe, 2015) Europe PMC includes a limited set of clinical guidelines (1275 UK National Health System guidelines) these are summaries of evidence-based information about clinical problems. Otherwise, the resource does not synthesis individual studies.

Appendix C1.1 KMS framework for analysis and evaluation of Europe PMC: System One

High	includes components that make the system an exemplar in the field
Medium	components with scope for improvement and/or may rely on external sources
Low	components maybe external to the system and /or may detract from the system

SYSTEM	Discovery	Creation	Representation	Classification	Storage	Retrieval	Dissemination	Transfer	Translation
	definitions are italicized in red font								
Europe PMC: PROCESS	*Discovery processes are the rules, regulations and guidelines established by professional bodies, organisations and research leaders.* Europe PMC has 33 research funders. The Europe PMC funders expect: Research outputs arising from research that we fund to be made freely and readily available; Electronic copies of any biomedical research papers that have been accepted for publication in a peer-reviewed journal, and are supported in whole or in part by funding from any of the Europe PMC Funders, to be made available through PubMed Central (PMC) and Europe PMC, as soon as possible and in any event within six months of the journal publisher's official date of final publication; Authors and publishers, if an open access fee has been paid, to license research papers such that they may be freely copied and re-used for purposes such as text and data mining, provided that such uses are fully attributed. This is also encouraged where no fee has been paid. from: https://europepmc.org/Funders	*Creation processes are influenced by priorities set by government and research organisations in response to researcher and public needs.* Funding bodies lead creation Europe PMC has 33 funders. Process can drive behaviour and steer creation in the research sector. A submission to Europe PMC is not necessary if a manuscript has been accepted by a participating PubMed Central journal.	*Representation processes are found in research and publishing instructions, standards, checklists and codes.* For example, the Equator Network promotes transparent and accurate reporting of health research findings to improve the impact and reliability of biomedical research articles. The International Committee of Medical Journal Editors (ICMJE) and the Equator Network are bodies that influence biomedical knowledge representation process in the form of instructions, standards, checklists and codes, examples include the Consolidated Criteria for Reporting Qualitative Research (COREQ), and the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA). The Committee on Publication Ethics (COPE) define best practice in the ethics of scholarly publishing and assist editors, publishers to achieve this.	*Classification processes involve rules for naming and describing research output.* Classification processes involve rules for naming and describing research output. For example, rules for naming may be governed by international bodies such as the International Association for Plant Taxonomy (IAPT) governs plants and the International Commission of Zoological Nomenclature (ICZN) governs the naming of animal taxon. (Note: Agricola is an agricultural database and is available from Europe PMC)	*Storage processes are based on international standards, such as preservation and interoperability standards* Europe PMC funding bodies have open access publishing mandates that require research output they fund be stored in Europe PMC and be made openly accessible. Adherence to open standards for example, Europe PMC submissions must be in XML format that conform to an acceptable journal article DTD (Document Type Definition) FAIR principles are established to share & reuse digital objects - resource lists available: https://fairassist.org/#!/	*Retrieval processes include search commands and filters. Open access status and standards can determine research output that is retrieved, for example, Open Archives Initiative Protocol for Metadata Harvesting (OAI-PMH) Standard System is openly accessible.* Europe PMC provides various types of linking methods ○ By external links to any URL (e.g., database, Wikipedia, press release, etc.) ○ By text mining ○ Biological entities ○ Identifiers (e.g., accession numbers) ○ By ORCID (article claims) ○ 24 external links providers, 1 ORCID, 9 cross-reference databases, 20 data base identifiers, 6 named entity types (Kim, 2015).	*The process of dissemination may be detailed in policies, procedures and guidelines.* Each of the funders have OA publishing policies; details are available from: https://europepmc.org/Funders Journal articles are the main means of dissemination of biological findings.	*The knowledge transfer process takes place through patenting, licensing, contracts, trade secrets, joint ventures with inventors and commercial spin-offs (Stevens & Bagby 2001 page 262)* Europe PMC plus has been developed to allow submitters to easily identify grant numbers (both past and current). Copyright laws and Creative Commons licences exist to protect research output intellectual property rights.	*The translation of research process is the time lag between biomedical research and its translation to health and wider society benefits.* The translation of research process is the time lag between biomedical research and its translation to health and wider society benefits. In relation to open biomedical repositories, translation of research is informed through the linking of the research grant details to their research output. For example, PMC allows principal investigators to link their articles to their grant information.

Appendix C1.1 KMS framework for analysis and evaluation of Europe PMC: System One

High	includes components that make the system an exemplar in the field
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SYSTEM	Discovery	Creation	Representation	Classification	Storage	Retrieval	Dissemination	Transfer	Translation
	definitions are italicized in red font								
Europe PMC: TECHNOLOGY	*Technology to underpin discovery for research output* PMC, integration with NLM pub-one records and PubMed Labs. PubMed uses Solr, an open-source enterprise search system, for document indexing, and Solr provides powerful search functions. Technology (APIs) for text and data mining. PubMed uses Django Web framework on the front-end (Canese, 2019).	*Technology for creation, includes the access to databases and repositories for research investigations.* Open biomedical literature repositories such as PMC International is used along with data repositories such as DataMed, Dryad and figshare. Such repositories link to databases such as ENA, PDB, ArrayExpress, UniProt, RefSNP, OMIM, Pfam, RefSeq, Ensembl, InterPro, Bioproject, Biosample, EMDB, PXD, EGA, TreeFam; these technologies underpin creation activities of researchers.	*Technology systems provide the format of digital research output.* The Coko Foundation and its partners have built a layered and modular framework for workflows. Coko's PubSweet framework as a "component-based framework" upon which to build publishing tools. PubSweet is a simple but flexible way to adapt to different kinds of system needs (Maxwell et al., 2019) Portable PMC (pPMC) is software used to operate US PMC that allows PMCI centres to import data from PMC, build a local database and display content of each article in PMC style.	*Technology is used to provide automated classification systems* Europe PMC has established a platform that consolidates text-mined annotations from different sources and makes them available to the wider research community. The annotated concepts and relations are displayed on article pages via SciLite tool, and can be retrieved using RESTful API. There are 600 million annotations are in the system. Unified Medical Language System (UMLS) integrates and distributes key terminology, classification and coding standards, and associated resources to promote creation of more effective and interoperable biomedical information systems and services, including electronic health records (from: https://www.nlm.nih.gov/research/umls/index.html)	*Technology underpins the storage of open biomedical content.* Cloud storage, local and external databases Portable PMC (pPMC) is software used to operate US PMC that allows PMCI centres to import data from PMC, build a local database and display content of each article in PMC style. MongoDB is used by PuMed for storage and retrieval. Europe PMC, for example, comprises databases and APIs and is a fully open source application that uses PubSweet systems. Analyzing data collectively puts a strain on local compute infrastructure, and is greatly facilitated by cloud-based collaboration platforms such as those being built by EMBL-EBI. (Cook, Bergman, Cochrane, Apweiler & Birney, 2018) Publishers provide machine entry of metadata and content into repositories.	*Technology for retrieval of research output combines interoperable systems that aggregate content (publications and data) from other sources* Programmatic protocols for retrieval of articles 1. FTP 2. OAI-PMH 3. SOAP-API 4. RESTful-API (articles and grants) Retrieval processes include search commands and filters. Open access status and standards can determine research output that is retrieved, for example, Open Archives Initiative Protocol for Metadata Harvesting (OAI-PMH) standard	*Technology is used to disseminate research objects.* No central database exists that searches every possible location for OA material, which means discovery of OA content remains difficult. "Making repository content findable is a major challenge facing libraries." (Azadbakht & Schultz, 2020).	*Technology transfer for open knowledge databases and search platforms* Text and data mining systems are key technologies to aid the technology transfer process. Integration of repositories with research management systems. European Molecular Biology Laboratory (EMBL) research drives the development of new technology and methods in the life sciences. The institute works to **transfer** this knowledge for the benefit of society. European Bioinformatics Institute (EMBL-EBI) - provide the infrastructure for Europe PMC.	*Technology to achieve the translation* process* Europe PMC records link to Impactstory https://profiles.impactstory.org/ (open source website) are available for researchers to generate reports on the online impact of their research. Adoption of output in AI and expert systems (data and full-text)

Appendix C1.1 KMS framework for analysis and evaluation of Europe PMC: System One

High	includes components that make the system an exemplar in the field
Medium	components with scope for improvement and/or may rely on external sources
Low	components maybe external to the system and /or may detract from the system

SYSTEM	Discovery	Creation	Representation	Classification	Storage	Retrieval	Dissemination	Transfer	Translation
				definitions are italicized in red font					
Europe PMC: CONTENT	The content for the system includes: available on the 1/7/2020 ■ 37.2 million abstracts (31.2 million abstracts are from PubMed) and others are from Agricola and Chinese Biological Abstracts ■ 6.1 full text articles ■ 4.2 million patents ■ 155,467 preprints ■ 770,826 Agricola records ■ 1,275 UK National Health Service guidelines	*Content, in the form of research output, can be found by searching databases and open repositories via metadata, bibliographic indexes and/or full text.* Content to support creation is made available in research protocol(s), research data and research objects; all of these help with determining the novelty of the research and the contribution of the research to existing knowledge - links to clinical trials and research data is made available where possible.	*Representation comprises explicit knowledge in the form of digital scholarly objects or the metadata for the objects.* Equator Network and the International Committee of Medical Journal Editors for health sciences publication standards ORCID and other researcher persistent digital identifiers to distinguish their research Example: Europe PMC – how content is added to the repository: A. By publishers who make all their content available at the time of publication (PLOS, BMC, eLife) B. By publishers who make individual articles available at the time of publication (e.g. articles in hybrid journals) C. By authors who self-archive the author manuscripts in PMC/Europe PMC using the Europe PMC plus deposition service (e.g. articles published in Science) D. By publishers who deposit the peer-reviewed manuscripts for free on behalf of authors (e.g. Nature Publishing Group does this for all articles acknowledging funding from Europe PMC Funders) From: https://europepmc.org/About	*Classification schemes and ontologies are used by repositories to allow users to navigate content* Classification schemes and ontologies are used by repositories to allow users to navigate content e.g. Europe PMC researchers use GO, UniProt, EFO, ChEBI, NCBI Taxonomy and UMLS as ontologies in the biological literature to "achieve a common understanding of the categories of objects described in life sciences data and the labels used for those categories" (Steven, Rector & Hull, 2010).	*Content, including metadata, needs to be stored in a standard way, that can be efficiently migrated to future systems.* PMC stores content in eXtensible Markup Language (XML), which represents the structure and meaning of a document in a human-readable form. All PMC content is converted to and stored in the NISO Z39.96-2015 JATS XML format. This standard format is the most effective and widely used archival format for journal articles. (source: https://www.ncbi.nlm.nih.gov/pmc/about/intro/) The framework for managing flexible aggregations of digital objects is provided by the Open Archives Initiative (OAI) with its work on Object Reuse and Exchange (ORE)	*To retrieve content the following are applied --search commands, filters, open access, standards for example, Open Archives Initiative Protocol for Metadata Harvesting (OAI-PMH) standard used by PMC* RESTful Web Service Search enables - search of 1. the publications database 2.publications that cited a paper 3. publications referenced in a paper 4. biological database records that have cited a paper 5. terms text-mined from full-text publications 6. full text in XML format for the Open Access publication subset 7. supplementary files where available for the full paper	*Dissemination of research output (content) is based on standards* Dissemination of research output (content) is based on standards Billions of articles are disseminated annually via PMCI PMCI does not report on or collect usage patterns due to privacy laws PMC Canada reported that Chinese users downloaded a significant number of articles from their site Text mining is available on open access subsets of PMCI	*Content can be transferred and interoperable between systems based on international standards.* Content can be transferred and interoperable between systems based on international standards. For example, the FHIR (Fast Healthcare Interoperability Resources) is available for the transfer of healthcare information, including research articles https://www.hl7.org/fhir/overview.html	*Translation of research output is reported in systems that complement open biomedical repositories and databases.* Translation of research output is reported in systems that complement open biomedical repositories. Analytical reports can be generated using the Web of Science platform InCites and the Scopus platform SciVal based on researcher publications. The InCites platform provide normalised citation impact, institutional analysis and benchmarking details. The SciVal platform provides author field weighted citation impact, outputs in top percentiles, international collaborations, academic/corporate collaborations, institutional analysis and benchmarking. SNOWMED CT - multilingual clinical healthcare terminology; scientifically validated for electronic health records systems. Enables links between clinical records, clinical guidelines and protocols.

C1.2 Epistemonikos: System Two

Appendix C1.2 KMS framework for analysis and evaluation of Epistemonikos: System Two

High	includes components that make the system an exemplar in the field
Medium	components with scope for improvement and/or may rely on external sources
Low	components maybe external to the system and/or detract from the system

SYSTEM	Discovery	Creation	Representation	Classification	Storage	Retrieval	Dissemination	Transfer	Translation
				definitions are italicized in red font					
Epistemonikos: PEOPLE	*Knowledge discovery may be defined as the development of new tacit or explicit knowledge from data and information or from the synthesis of prior knowledge.* The system operates as a search engine (multilingual database of health evidence). The audience is health decision makers. According to the website, the system is not intended for the general public, though it is used 'successfully' by lay people and journalists. Epistemonikos generates output to enable explicit knowledge from the synthesis of prior knowledge.	*Knowledge creation assumes knowledge does not exist before the activity that catalysed the innovation. Creation entails data analysis and investigation activities undertaken by researchers.* Epistemonikos metadata is created by a network of clinical experts (over 250 collaborators) A spin off from Chile Catholic University, School of Medicine, Dr Gabriel Rada, the brain behind Epistemonikos, residency training for medical students - hours spent on curating data required for their training. Also includes, other collaborators around the world. Some medical students continue their contribution.	*Representation comprises explicit knowledge in the form of digital scholarly objects or the metadata for the objects created and used by people.* Staff at the Epistemonikos Foundation, who have designed the system, which is based on international publishing standards.	*Taxonomies, also called classification or categorization schemes, are considered to be knowledge organization systems that are applied by people and serve to group objects together based on a particular characteristic.* Summaries are prepared by someone other than the authors of the reports Metadata - manual process	*People take actions for platforms, databases and repositories to store metadata and content.* Epistemonikos staff have set up external storage arrangements for the metadata.	*Information retrieval can entail people searching for and finding research references based on search algorithms that interrogate internet or database metadata or full-text articles.* According to the website, the system is not intended for the general public, though it is used 'successfully' by lay people and journalists. As the basic search index can be interrogated using nine different languages, this opens up retrieval to millions of people worldwide. The advanced search only supports English language searching.	*Dissemination of research objects and data via presentations at conferences, personal communications and use of systems.* *.... knowledge repositories may be most effective for knowledge that can be readily generalized to other contexts. (Alavi & Leidner, 2001)* Takes place using: - word of mouth, exhibit at Cochrane Colloquium, social media, publish research articles and via a professional communications staff member	*Transfer involves clarification of the terms and conditions between relevant parties in relation to the use of the content.* *No licencing is necessary - all links to the full text return to proprietary source*	*Translation involves "the synthesis, exchange, and application of knowledge by relevant stakeholders to accelerate the benefits of global and local innovation in strengthening health systems and improving people's health.*" (Pablos-Mendez & Shademani 2006). Linking of primary studies and systematic reviews and by building the LOVE (Living Overview of the Evidence) on top of the database. Publications are annotated with PICO - to make it easy to navigate the content. Worked with MAGIC https://magicproject.org/magicapp/all-features/ to create interactive summaries of findings - from a synthesis of the evidence automatically generate a interactive summary of evidence. Manual input is still required to compile the summaries (synthesising and meta-analysis - human interaction still required).

Appendix C1.2 KMS framework for analysis and evaluation of Epistemonikos: System Two

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Epistemonikos: PROCESS	*Discovery processes are the rules, regulations and guidelines established by professional bodies, organisations and research leaders.* The health practitioner and researcher can discover content using PICO -- This is the way good questions are called in evidence-based health care. This question follows a PICO format, an acronym that stands for Population, Intervention, Comparison and Outcome	*Creation processes are influenced by priorities set by government and research organisations in response to researcher and public needs.* Epistemonikos Foundation (not for profit organisation) maintains the database. Eight people run Epistemonikos (website (n.d.). Mostly about curation. selection of systematic reviews by a network of collaborators	*Representation processes are found in research and publishing instructions, standards, checklists and codes.* The system includes systematic reviews, overviews of review, evidence-based policy briefs, primary studies and structured studies -- all of which need to meet the system's inclusion criteria	*Classification processes involve rules for naming and describing research output.* Structured summaries of overviews, systematic reviews and primary studies are prepared using **standard headings** and include critical appraisal and interpretation of the evidence that is summarised. Typically, these are prepared by someone other than the authors of the reports that are summarised and they contain more information than what is normally found in the abstracts written by the authors, which are also included in Epistemonikos. (from https://www.epistemonikos.org/en/about_us/glossary)	*Storage processes are based on international standards, such as preservation and interoperability standards* Metadata - meta data & machine learning process for data entry	*Retrieval processes include search commands and filters. Open access status and standards can determine research output that is retrieved, for example, Open Archives Initiative Protocol for Metadata Harvesting (OAI-PMH) standard System is openly accessible.* The author of the matrix can select the pertinent information for a specific health question (typically in Patient-Intervention-Comparator-Outcome format) in order to display the set of information for that question. Using automated methods it is possible to keep them updated with a minimum of effort. From this information, summary tables of the SoF evidence (Summary of Findings) are prepared., GRADE methodology) and key messages from them using a standardized method (Glenton et al., 2010)	*The process of dissemination may be detailed in policies, procedures and guidelines.* Can subscribe to a matrix and if new content is made available e.g. primary study -- receive an alert. You can share a matrix by creating a link to the matrix via personal profile. Chile Ministry of Health - use the system to develop their guidelines.	*The knowledge transfer process takes place through patenting, licensing, contracts, trade secrets, joint ventures with inventors and commercial spin-offs (Stevens & Bagby 2001 pg. 262)* Transfer can occur within copyright limitations of the content	*The translation of research process is the time lag between biomedical research and its translation to health and wider society benefits.* The Epistemonikos Foundation mentions that the main goal for this resource is "to bring evidence closer to those making health decisions, through technology and innovation" (EI-Khayat, 2017).

Appendix C1.2 KMS framework for analysis and evaluation of Epistemonikos: System Two

High	includes components that make the system an exemplar in the field
Medium	components with scope for improvement and/or may rely on external sources
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SYSTEM	Discovery	Creation	Representation	Classification	Storage	Retrieval	Dissemination	Transfer	Translation
	definitions are italicized in red font								
Epistemonikos: TECHNOLOGY	*Technology to underpin discovery for research output* Results will be sorted by relevance to a query (i.e. how well represented in the article are the terms you entered), which is calculated by an algorithm developed by Epistemonikos team.	*Technology for creation, includes the access to databases and repositories for research investigations.* Robots and humans select systematic reviews based on an explicit selection criterion	*Technology systems provide Technology is used to the format of digital research provides automated output. classification systems* Matrices of evidence Visualisations of evidence	*Technology is used to provide automated classification systems* Visualisations of evidence are available.	*Technology underpins the storage of open biomedical content.* Amazon Cloud service, Mongo NoSQL database program https://www.mongodb.com/	*Technology for retrieval of research output combines interoperable systems that aggregate content (publications and data) from other sources* A matrix of evidence is a table displaying all the systematic reviews answering a question, and all of the studies included in these reviews. Automated search upload is possible. The simple search is available. There is no need for Boolean logic, as the database automatically connects terms. An advanced search allows searches to be restricted to title, authors, or abstract. A search history is also available, which allows you to combine searches. The advanced search supports truncation, exact phrase searching, and Boolean operators. Only the simple search can be conducted in any of the nine languages. Search results are presented in order of relevance using a rubric based on the frequency with which the search term appears. Results are color coded to indicate whether they are systematic reviews, primary studies, structured summaries of systematic reviews, or broad syntheses. If the search topic has similar subtopics that occur in several of the articles, a "Matrix of Evidence" will appear on the top of the search results.	*Technology is used to disseminate research objects.* Can subscribe to a matrix and if new content is made available e.g. primary study -- receive an alert. You can share a matrix by creating a link to the matrix via personal profile.	*Technology transfer for open knowledge databases and search platforms* API available to query database and identify content for download. RIS output for reference software.	*Technology to achieve the translation* process* Visualisations & the LOVE platform Evidence of use is anecdotal

Appendix C1.2 KMS framework for analysis and evaluation of Epistemonikos: System Two

High	includes components that make the system an exemplar in the field
Medium	components with scope for improvement and/or may rely on external sources
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SYSTEM	Discovery	Creation	Representation	Classification	Storage	Retrieval	Dissemination	Transfer	Translation
				definitions are italicized in red font					
Epistemonikos: CONTENT	The content for the system includes metadata for systematic reviews relevant for clinical or health decision-making only. The system allows users to search for systematic reviews and related material, including but not limited to primary studies included in systematic reviews, overviews of reviews, evidence-based policy briefs and guidelines based on reviews, and structured summaries of evidence presented in reviews (El-Khayat, 2017). Researchers and practitioners can identify relevant reviews and these are assessed and included if eligible. Holds more than 115,000 unique documents, and more than 100,000 relationships between the documents are stored and indexed.	*Content, in the form of research output,can be found by searching databases and open repositories via metadata, bibliographic indexes and/or full text.* Once a unique piece is identified, it is forwarded to an Epistemonikos expert for inclusion in the database. Public and commercial databases are searched for systematic reviews, including: 1.Cochrane Database of Systematic Reviews (CDSR) 2.Pubmed 3.EMBASE 4.CINAHL (The Cumulative Index to Nursing and Allied Health Literature) 5.PsycINFO 6.LILACS (Literatura Latinoamericana y del Caribe en Ciencias de la Salud) 7.Database of Abstracts of Reviews of Effects (DARE) No new records have been added to DARE after 2015 8.The Campbell Collaboration online library 9.JBI Database of Systematic Reviews and Implementation Reports 10.EPPI-Centre Evidence Library Details available from: https://www.epistemonikos.org/en/about_us/methods	*Representation comprises explicit knowledge in the form of digital scholarly objects or the metadata for the objects.* Extraction of the studies in the systematic review Translation of content into nine languages	*Classification processes involve rules for naming and describing research output.* As described, structured summaries of overviews, systematic reviews and primary studies are prepared using standard headings and include critical appraisal and interpretation of the evidence that is summarised. Typically, these are prepared by someone other than the authors of the reports that are summarised and they contain more information than what is normally found in the abstracts written by the authors, which are also included in Epistemonikos. (from https://www.epistemonikos.org/en/about_us/glossary)	*Content, including metadata, needs to be stored in a standard way, that can be efficiently migrated to future systems.* Relationships between records are created and stored in the database	*To retrieve content* links to source of record are available e.g. PubMed in the record's summary The ability to generate evidence matrices is a unique feature of Epistemonikos. This is a pivot table showing systematic reviews that share at least one included study, and all studies included in those reviews. Search is available via nine languages. A basic and advanced search window are available from the website's search engine. The advanced search only supports English language searches.	*Dissemination of research output (content) is based on standards* As noted previously, if new content is made available e.g. primary study it is possible to receive an alert. A matrix can be shared by creating a link to the matrix via personal profile**	*Content can be transferred and interoperable between systems based on international standards.* Standards based to move bibliographic data to other reference systems	*Translation of research output is reported in systems that complement open biomedical repositories and databases.* The ability to generate an evidence matrix is a unique feature of the Epistemonikos database. This is a pivot table showing systematic reviews that share at least one included study, and all studies included in those reviews. The author of the matrix can select the pertinent information for a specific health question (typically in Patient-Intervention-Comparator-Outcome format) in order to display the set of information for that question. Using automated methods, it is possible to keep them updated with a minimum of effort. From this information, summary tables of the SoF evidence (Summary of Findings) are prepared., GRADE methodology), and key messages from them using a standardized method source. (Glenton et al.,2010).

C1.3 Trove: System Three

Appendix C1.3 KMS framework for analysis and evaluation of Trove: System Three									
Note: This critique evaluates TROVE from the perspective of a biomedical researcher I or based on TROVE's role in making Australian research discoverable									
High	includes components that make the system an exemplar in the field								
Medium	components with scope for improvement and/or may rely on external sources								
Low	components maybe external to the system and/or may detract from the system								
SYSTEM	**Discovery**	**Creation**	**Representation**	**Classification**	**Storage**	**Retrieval**	**Dissemination**	**Transfer**	**Translation**
definitions are italicized in red font									
Quality = Q Governance = G									
TROVE: PEOPLE	*Knowledge discovery may be defined as the development of new tacit or explicit knowledge from data and information or from the synthesis of prior knowledge.* Trove is a result of the collaborative effort of a host of different organisations, communities and individuals who work with the National Library to help make Australian content easier to find, share and use. We are: • librarians • cultural institutions • community organisations • researchers • educators • volunteers • book lovers • art enthusiasts • history buffs • data wizards Hundreds of organisations across Australia are working collaboratively to shape Trove's digital services and contribute to the depth and richness of content.	*Knowledge creation assumes knowledge does not exist before the activity that catalysed the innovation. Creation entails data analysis and investigation activities undertaken by researchers.* Only Australian content is available. TROVE would not typically be used by biomedical researchers. G = Never had a major role – in health sciences (Ayres, 2018) NED has a suite of policies related to its establishment and operation with partners -- for publisher management, terms & conditions etc	*Representation comprises explicit knowledge in the form of digital scholarly objects or the metadata for the objects created and used by people.* TROVE provides metadata for a vast array of information objects "i saw an estimate ..that a quarter of material that Australian academics are publishing is not in the repository" (National Library of Australia, Focus Group, 2018)	*Taxonomies, also called classification or categorization schemes, are considered to be knowledge organization systems that are applied by people and serve to group objects together based on a particular characteristic.* Metadata is aggregated from other systems - in particular Australian Research Online - derived from institutional repositories; if the records are imperfect this impacts the quality of records in TROVE. (This was discussed during my interview with senior staff from the NLA) "no one wants to create their own metadata...everyone wants to harvest it from somewhere else" (National Library of Australia, Focus Group, 2018)	*People take actions for platforms, databases and repositories to store metadata and content.* *No human meta data entry takes place aggregator system - for research metadata*	*Information retrieval can entail people searching for and finding research references based on search algorithms that interrogate internet or database metadata or full-text articles.* Researchers, funders, industry, research support staff and consumers applying tacit and explicit knowledge to create search strategies to retrieve research output.	*Dissemination of research objects and data via presentations at conferences, personal communications and use of systems.* *...knowledge repositories may be most effective for knowledge that can be readily generalized to other contexts. (Alavi & Leidner 2001)* APIs are available openly	*Transfer involves clarification of the terms and conditions between relevant parties in relation to the use of the content.* G: Deed of Agreement between NLA and publishers (confluence used to document meetings) in the establishment of NED with all nine libraries. Dispute resolution described in the Deed.	*TUaQslatioQ iQvolves "the synthesis, exchange, and application of knowledge by relevant stakeholders to accelerate the benefits of global and local innovation in strengthening health systems and improving people's health (Pablos-Mendez & Shademani 2006).* some aspects available - YouTube video on Research page. Not always instantly available - requires planning and other systems to synthesize content.

Appendix C1.3 KMS framework for analysis and evaluation of Trove: System Three

Note: This critique evaluates TROVE from the perspective of a biomedical researcher I or based on TROVE's role in making Australian research discoverable

High	includes components that make the system an exemplar in the field
Medium	components with scope for improvement and/or may rely on external sources
Low	components maybe external to the system and/or may detract from the system

SYSTEM	Discovery	Creation	Representation	Classification	Storage	Retrieval	Dissemination	Transfer	Translation
	definitions are italicized in red font								
TROVE: PROCESS	*Discovery processes are the rules, regulations and guidelines established by professional bodies, organisations and research leaders.* According to the NLA Director General: "Aggregating Australian research making it discoverable does not have a high priority in the research process." (2017) Following a four-year overhaul and digitisation project and a AU$16 million of funding from the federal government, the National Library of Australia (NLA) launched a revamped version of its online culture and research portal, Trove in 2020 in completing the transformation, the NLA has been handed an additional AU$8 million for the next (21-22) by the federal government to support the development of Trove. NLA Director General interview: "University Libraries have billions of resources in Trove though not very visible they would like to see focused view or some way focus on Australian research or research from their organisation and this the opportunity for an Australasia PMC – or a subject approach – that kind of thing would take much more development and need much bigger revenue"	*Creation processes are influenced by priorities set by government and research organisations in response to researcher and public needs.* Legal deposit legislation - law requiring publishers (all kinds) to deposit every kind publication in state or territory libraries and the national library (9 libraries). Legislation has differed in the past in each state and territory. Electronic deposit is patchy. National legislation arrived 2016 - trigger to reduce complexity for electronic deposit. The system NED was built to serve all publishers.	*Representation processes are found in research and publishing instructions, standards, checklists and codes.* For example, in regards to the biomedical content made discoverable from TROVE -- the Equator Network promotes transparent and accurate reporting of health research findings to improve the impact and reliability of biomedical research articles (ref). The international Committee of Medical Journal Editors (iCMJE) and the Equator Network are bodies that influence biomedical knowledge representation process in the form of instructions, standards, checklists and codes, examples include the Consolidated Criteria for Reporting Qualitative Research (COREQ), and the Preferred Reporting items for Systematic Reviews and Meta Analyses (PRiSMA). The Committee on Publication Ethics (COPE) define best practice in the ethics of scholarly publishing and assist editors, publishers to achieve this.	*Classification processes involve rules for naming and describing research output.* Trove provides access to aggregated metadata from multiple institutional repositories through a single platform (Ayres, 2017)	*Storage processes are based on international standards, such as preservation and interoperability standards* Digital Object Storage System Preservica	*Retrieval processes include search commands and filters. Open access status and standards can determine research output that is retrieved, for example, Open Archives Initiative Protocol for Metadata Harvesting (OAI-PMH) Standard System is openly accessible.* TROVE searches across a large aggregation of Australian content. in 2019 described as stage one of making Australian content openly accessible via publishers (Lemon, Blinco & Somes, 2020)	*The process of dissemination may be detailed in policies, procedures and guidelines.* The National Health and Medical Research Council recognises the advantages of an established network of institutional repositories, with Trove as the central platform, to provide access to Council-funded publications. The deposit of author accepted manuscripts in Australian institutional repositories while low, contributed to open access compliance under the Council's Policy. Almost one-third of Council-funded articles were not openly accessible (Kirkman & Haddow, 2020) For publications or data sets produced with the assistance of NHMRC or ARC funding, researchers/users are encouraged to add a grant number in a Dublin Core relation field; by including grant numbers in records, institutional repositories can make their research outputs easier to find and their data more useful for analysis. it becomes possible to: • Quickly find and identify all NHMRC/ARC records in Trove • Identify research created under a specific grant • Compare the number of grant-funded papers coming from each	*The knowledge transfer process takes place through patenting, licensing, contracts, trade secrets, joint ventures with inventors and commercial spin-offs (Stevens & Bagby 2001)* TROVE/NLA encourages researchers to add ARC/NHMRC grant details in metadata. Copyright laws and Creative Commons licences exist to protect research output intellectual property rights: https://creativecommons.org.au/learn/howto/	*The translation of research process is the time lag between biomedical research and its translation to health and wider society benefits.* in relation to open biomedical repositories, translation of research is informed through the linking of the research grant details to their research output -- in TROVE this is done for partners to access via a user dashboard. An advanced search interface makes retrieval possible for the consumer/general public - though there is a vast amount of data to process.

Appendix C1.3 KMS framework for analysis and evaluation of Trove: System Three

Note: This critique evaluates TROVE from the perspective of a biomedical researcher I or based on TROVE's role in making Australian research discoverable

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SYSTEM	Discovery	Creation	Representation	Classification	Storage	Retrieval	Dissemination	Transfer	Translation
	definitions are italicized in red font								
TROVE: TECHNOLOGY	*Technology to underpin discovery for research output* TROVE is a discovery platform for digital resources (though they aggregate existing resources from member organisations) - some e.g. Medical institutes 19/20 do not have a research repository or were unable to share metadata from their system. There are hospitals that also undertake research that do not have research repositories (interview NLA tape no 1) "Thought about building something that exposes Australian research. It wouldn't do what everyone wants it to do when everyone has an expectation that it looks like the meta data up here when if fact it mostly doesn't " (ibid) **G = NLA are excluded from research infrastructure funding and cannot be a lead agency.**	*Technology for creation, includes the access to databases and repositories for research investigations.* interview NLA Director General 2017: "Repository world – interesting to see what happens. World every institution having its own repository. Comment – how can this be sustained? Universities change repositories all the time. When they change something significant e.g. UWA implementing Pure – which means NLA has to start all over again." (NLA works with 40-50 repositories and aggregates their data)	*Technology systems provide the format of digital research output.* in 2020 reconfiguration of the portal's frontend and a new Drupal-based content management system (CMS). With the establishment of NED it was necessary to transfer electronic collections into the NLA system.	*Technology is used to provide automated classification systems* A way has been developed to break PDF files into automatic metadata, so instead of having a single entry in the file that might say 'letter of Winston Churchill to Sir John Monash', we can now create a record in Trove where that's the title of the item, and we do that automatically. We're able to generate thousands and thousands of records out of a single document," Dellit indicated (Chanthadavong, 2020).	*Technology underpins the storage of open biomedical content.* Preservika has been integrated to assist with managing the digital preservation of TROVE's content, as well as ArchiveSpace and DocWorks that are used for archiving materials. Standard bibliographic data from Universities - goes through extensive deduplication process -- NOT in TROVE -- clean and clear access to research outputs / all computational algorithms to deal with this	*Technology for retrieval of research output combines interoperable systems that aggregate content (publications and data) from other sources* Portal's frontend with the integration of a Drupal-based content management system so users could easily navigate, browse, search (including an advanced search interface), and access thumbnails. These systems in place allows NLA to develop a process called atomisation, which allows users to automatically search for information within archived files, something that was not previously possible because physical materials were often digitised as single files and only allowed users access to surface level information.	*Technology is used to disseminate research objects* TROVE meta-data is harvested by internet search engines With research repositories, content with special status, interview NLA Director General 2017: "how do we identify research repository content with special status and make it more visible, this is an ongoing project."	*Technology transfer for open knowledge databases and search platforms* The National Library of Australia aggregating all of the content – an Australasia PMC could get content from NLA system aggregating the descriptive metadata (notes: some level to get into the content – need to explore – deep full text – limits that you hit there) interview NLA Director General 2017.	*Technology to achieve the translation* process* New-look portal has Microsoft Power Bi built into it, which provides collecting institutions that contribute data with access to statistics and analysis.

Appendix C1.3 KMS framework for analysis and evaluation of Trove: System Three

Note: This critique evaluates TROVE from the perspective of a biomedical researcher I or based on TROVE's role in making Australian research discoverable

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SYSTEM	Discovery	Creation	Representation	Classification	Storage	Retrieval	Dissemination	Transfer	Translation
	definitions are italicized in red font								
TROVE: CONTENT	The content includes: The online library database includes archives, images, newspapers, official documents, archived websites, manuscripts and other types of data. it is one of the most well-respected research services in Australia, with over 68,000 daily users. 6 billion treasures and resources to users across Australia free access to approximately 6.5 billion digital records of content from 941 organisations, including the NLA, state and territory libraries, and other Australian cultural and research institutions. Trove " r**esources relating to Australia** and therefore the **content is Australian-focused**. Much of the material may be difficult to retrieve with other search tools, for example in cases where it is part of the deep web, including records held in collection databases, or in projects such as the PANDORA web archive, **Australian Research Online,** Australian National Bibliographic Database and others mentioned above. Emphasis on Australian cultural heritage preservation. (ANL) ¼ material is not in the repository journal articles (Focus Group NLA, 2018) 'Need the creator to put the item in the repository – need the researcher to help and they are not interested.'	*Content, in the form of research output, can be found by searching databases and open repositories via metadata, bibliographic indexes and/or full text.* Metadata for research output is discoverable from TROVE - though it does not link to research protocol(s), research data and research objects Work with many partners e.g. APO repository - captures vast number of Aust Govt reports and publications (Focus Group NLA, 2018)	*Representation comprises explicit knowledge in the form of digital scholarly objects or the metadata for the objects.* MARC (unicode) METS (Metadata Encoding and Transmission Standard) PDF, ePub and Mobi accepted formats Z39.50 for bibliographic data retrieval	*Classification schemes and ontologies are used by repositories to allow users to navigate content* Aggregated content and publisher provided content includes classification schemes and ontologies. There would be some special collections (indigenous, East Asia) that the NLA would add nomenclature / metadata in the cataloguing	*Content, including metadata, needs to be stored in a standard way, that can be efficiently migrated to future systems.* For a contribution to a potential Australasia PMC two listings of key Australian health journal publications were provided to the NLA. **T**he first was a list of Australian health and medical journals indexed by informit. **The NLA analysis of the Informit list found:** • out of 134 titles, 119 titles are published in Australia and 15 titles are published overseas and out of the scope for the Library's collection development. • 110 out of 119 Australian titles (92%) are received under legal deposit, in which 80% (88 titles) received in print and 20% (22 titles) through eDeposit (15 titles) and Pandora web archiving (7 titles).	*To retrieve content the following are applied -- search commands, filters, open access, standards for example, Open Archives Initiative Protocol for Metadata Harvesting (OAI-PMH) standard used by PMC* TROVE receives significant usage from outside Australia Research repositories – content that has a special status – how we identify that and how we might make it more visible is an ongoing project. (interview Director General NLA, 2017)	*Dissemination of research output (content) is based on standards* Access conditions vary - may be openly available, may be viewable but not downloadable, or may be viewable at a state library or viewable but not downloadable from state library. A vast amount of the content is made available only on site within one or more of the nine state & territory libraries. This is a huge limitation during periods such as COViD-19 when researchers can go on site. From 2016 the National Library Australia and Trove has been adding Australian researchers-**fro**m world renowned experts to new graduate researchers at the start of their careers-**to** its People and Organisations zone.	*Content can be transferred and interoperable between systems based on international standards.* Working towards being more open. APIs provided to enable metadata to be transferable and interoperable based on international standards	*Translation of research output is reported in systems that complement open biomedical repositories and databases.* *Not a feature of TROVE*

Appendix C1.3 KMS framework for analysis and evaluation of Trove: System Three

Note: This critique evaluates TROVE from the perspective of a biomedical researcher I or based on TROVE's role in making Australian research discoverable

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SYSTEM	Discovery	Creation	Representation	Classification	Storage	Retrieval	Dissemination	Transfer	Translation
	definitions are italicized in red font								
TROVE: CONTENT (continued)					• 43 titles have been identified as the candidates for transition to eDeposit. • 23 out of 134 titles (17%) are open access. **From the Excellence in Research Australian (ERA) journals list the NLA analysis found:** • out of 103 titles, only 23 titles are published in Australia and 80 titles are published overseas and out of the scope for the Library's collection development. • 17 out of 23 Australian titles (74%) are received under legal deposit, in which 71% (12 titles) received in print and 29% (5 titles) through eDeposit (2 titles) and Pandora web archiving (3 titles). • 9 titles have been identified as the candidates for transition to eDeposit. • 6 out of 23 titles (26%) are open access .		For ORCiD records this facet allows a user to narrow down their search to people from a particular Australian university. You can choose the University of Melbourne and only see 1,017 researchers who have nominated that they were educated or employed at the University of Melbourne (Kelly, 2016). Q = 'Raison d'etre': NLA perspectives deep commitment to OA and public access – high quality information. Focus is what is published in Australia & not beyond, in particular Australian heritage.		

C1.4 ResearchGate: System Four

Appendix C1.4 KMS framework for analysis and evaluation of ResearchGate: System Four

High	includes components that make the system an exemplar in the field
Medium	components with scope for improvement and/or may rely on external sources
Low	components maybe external to the system and/or detract from the system

SYSTEM	Discovery	Creation	Representation	Classification	Storage	Retrieval	Dissemination	Transfer	Translation
				ResearchGate = RG Quality = Q Governance = G					
ResearchGate: PEOPLE	*Knowledge discovery may be defined as the development of new tacit or explicit knowledge from data and information or from the synthesis of prior knowledge.* ResearchGate (RG) is increasingly used by scholars to upload the full-text of their articles and make them freely available for everyone. (Jamali, 2017) The faculty contribution to institutional repositories is scarce. RG have applications in research activities and past studies show that they help scholars develop and sustain networks and collaboration, and find out what others are doing (Jamali et al., 2014) Common reason using RG find out about others' research & keeping up to date, forming study group. (Jamiali, 2017) 13 million users (Shih, 2017) in 2020 17 million (*About section RG website)* Primarily social media site (Ovadia, 2014)	*Knowledge creation assumes knowledge does not exist before the activity that catalysed the innovation. Creation entails data analysis and investigation activities undertaken by researchers.* RG is a for-profit company with headquarters in Berlin. The G= **governance** component is mostly managed through the Terms and Conditions, which stipulate that the company does not store any personal data from former users, nor sell or otherwise share personal data with third parties. The business model is largely based on a wide range of free- of charge services supplemented with subscription-based services like the Job Openings section for posting job ads (Manca, 2018). RG has 300 employees, including a sales staff of 100. RG restricts its user accounts to people at recognized institutions and published researchers. Scholarly knowledge has come to be acquired, tested, validated and shared, as well as how university subcultures of 'invisible college' (Wagner 2008) Includes an area for intra-institutional collaboration on projects. G's has a question-and-answer area. As a result of the large number of members RG uses crowd-source to address problems.	*Representation comprises explicit knowledge in the form of digital scholarly objects or the metadata for the objects created and used by people.* Besides being a scientific social networking service, RG also serves as a repository as it has a specific feature that allows members to upload full-texts of their publications. (Jamali 2017) Each member has a profile page giving brief biographical information and a publication list Collaboration area allows for commenting and file sharing; collaborators must be invited to see these areas.	*Taxonomies, also called classification or categorization schemes, are considered to be knowledge organization systems that are applied by people and serve to group objects together based on a particular characteristic.* The RG publication page contains metadata about a publication, including bibliographic data, and information about how it has been used, shared, and recommended on RG. Publication branding shows that a version of the full-text of this publication has been provided by the publisher. Information about authors, including links to their RG profile pages, their lab, and project pages on RG, allows the user to read all other research by the contributing authors as well as following them (or their projects) to receive updates about future publications and their activity on RG. Members can discuss the publication using the comments tab. Users can access various versions of the full-text of this publication, which may include early author submitted drafts alongside the version of record provided by the publisher. Social statistics show information on how much activity and interest the publication has generated on	*People take actions for platforms, databases and repositories to store metadata and content.* "I think it is the University staff, librarians, who should offer to deposit all the scholars' output. Actually, it is not a problem of lack of interest, but lack of time." (Borrego, 2017) It is possible that with the large number of self-archived items infringing copyright-- publishers may start taking actions against RG. The long-term viability of RG relies on the efforts of both authors and RG to comply with publishers' copyright policies (Jamali, 2017)	*Information retrieval can entail people searching for and finding research references based on search algorithms that interrogate internet or database metadata or full-text articles.* To understand the role of RG in making full-text of papers freely available, it is enough to say that it is one of the top sources of full-text files found through Google Scholar. (Jamali, 2017**)**	*Dissemination of research objects and data via presentations at conferences, personal communications and use of systems.* RG is a social network site (ASNS) for scholarly communication. Study by Borrego in 2017 found 54.8% of the articles were available in full text on RG. When authors who had uploaded copies of their articles to RG but not to their institutional repository were asked about their reasons, most replies focused on two issues: ignorance about the existence or operation of the institutional repository and awareness of the advantages offered by RG. (Borrego, 2017) RG facilitates the exchange of information (Ovadia, 2014) RG's mission is to connect the world of science and make research open to all (RG website) "But does it mean that any open access venture hoping to meet with similar success would be well advised to adopt many of the same subjectivising features that are used by Academia.edu and other social networks to help users connect and develop their individual profiles as 'personal brands': real-name policies, personal pictures, CVs and biographies, 'credibility metrics', analytics dashboards, quantifying deep analytics and so on." (Hall, 2015)	*Transfer involves clarification of the terms and conditions between relevant parties in relation to the use of the content.* RG Terms & Conditions = G https://www.researchgate.net/terms-of-service#General-information	*Translation involves 'the synthesis, exchange, and application of knowledge by relevant stakeholders to accelerate the benefits of global and local innovation in strengthening health systems and improving people's health.'* (Pablos-Mendez & Shademani 2006). Another advantage of RG is that it suggests similar articles and there are even job and grant advertisements. (Borrego 2017) RG provides publication analytics

Appendix C1.4 KMS framework for analysis and evaluation of ResearchGate: System Four

High	includes components that make the system an exemplar in the field
Medium	components with scope for improvement and/or may rely on external sources
Low	components maybe external to the system and/or detract from the system

SYSTEM	Discovery	Creation	Representation	Classification	Storage	Retrieval	Dissemination	Transfer	Translation
ResearchGate = RG Quality = Q Governance = G									
ResearchGate: PROCESS	*Discovery processes are the rules, regulations and guidelines established by professional bodies, organisations and research leaders.* Springer Nature & RG trial 2019 found reviewing research in context so that they can see connections between publications, researchers, projects, and labs was a great benefit. (Hawkins, Hofmayer, Noyes, Schoenenberger & Winter, 2020). ResearchGate and Academia.edu don't have a lot in common with open access repositories, but they do have a lot in common with other social networking sites like Facebook, LinkedIn, and Twitter. They even encourage users to connect those and other services and contacts to their RG and Academia.edu accounts – sometimes aggressively. (Fortney & Gonder, 2015)	*Creation processes are influenced by priorities set by government and research organisations in response to researcher and public needs.* Q = concerns over quality and credibility remain a pertinent issue (Manca, 2018) ResearchGate's terms include an agreement to have the user's relationship with the company be governed by German law. And both sites have an indemnification clause, asserting that if the site faces any legal claims arising from things users upload to the site, the user will bear the cost. (Fortney & Gonder, 2015)	*Representation processes are found in research and publishing instructions, standards, checklists and codes.* The Sringer Nature version of record (VoR) refers to the final published version of a manuscript after it has been peer reviewed, typeset, and edited. When researchers use the VoR article, they can be sure that they have the most up-to-date version, and that if any errors or changes have occurred, they can be tracked by the appropriate errata. The VoR also contains live links to all underlying data sets and other information used in the research. Q= growing market of publications and improvements in the field of research, this community has been victimized by the cybercrime in the form of ghost journals, fake publishers and magical impact measures. Particularly, RG more recently, has been lenient in its policies against this dark side of academic writing. (Memon, 2016)	*Classification processes involve rules for naming and describing research output.* Q = No rules found in RG. Metadata entered by researchers.	*Storage processes are based on international standards, such as preservation and interoperability standards* Q = Copyright compliance before releasing deposited papers does not always occur. Research by Jamali 2017 found that 51% of a sample of 500 articles from RG infringed copyright & were non-compliant with publishers' policy. Majority (97.5%) non-compliant cases occurred when authors self-archived publisher PDF files (final published version). Raises - authors lack understanding copyright and related policies. RG does provide info on copyright. Onus on scholar to comply with publisher policies. (Jamali, 2017) RG does not appear to have long term preservation plans	*Retrieval processes include search commands and filters. Open access status and standards can determine research output that is retrieved, for example, Open Archives Initiative Protocol for Metadata Harvesting (OAI-PMH) Standard System is openly accessible.* RG is working towards becoming COUNTER compliant to jointly find a way to share usage generated on RG which is compliant with industry standards. Transparent communication about data exchange is also fundamental so that librarians trust the off-platform usage of their subscriptions. Collects information about who is reading what. Academia.edu, in particular, then offers to share that information with you if you subscribe to their "premium service." And while their analytics dashboard doesn't reveal readers' names, it may provide enough information for you to know exactly who read your work. (Bishop, 2020)	*The process of dissemination may be detailed in policies, procedures and guidelines.* The pilot phases of the Springer Nature (SN) & RG partnership showed that the Springer Nature publications syndicated to RG had increased exposure and visibility to members of the research community. For SN & RG users they can download and read the Version of Record (VoR), while non-entitled users will have access to a preview version of the article Researchers are the product that these services seek to monetize and/or "offer up" to advertisers. ResearchGate are an extension of those who monetize what many scholars believe should be freely shared (Bishop, 2020). RG and Academia.edu do not permit their users to take their own data and reuse it elsewhere, nor do their terms of service permit the libraries to extract that data on the authors' behalf. (Fortney & Gonder, 2015) The result is that those rich and powerful international companies who are able to capture, analyse and exploit extremely large amounts of data are coming to act as the gatekeepers of our media and communications networks; and this includes our scholarly communications networks (Hall, 2015).	*The knowledge transfer process takes place through patenting, licensing, contracts, trade secrets, joint ventures with inventors and commercial spin-offs (Stevens & Bagby, 2001 pg. 262)* ACS Publications and Elsevier, formed an organization called the Coalition for Responsible Sharing to pressure RG to take measures against distributing copyright-protected material on its platform. The coalition advocated for adherence to the International Association of Scientific, Technical and Medical (STM) Publishers' (O'Brien, 2019)	*The translation of research process is the time lag between biomedical research and its translation to health and wider society benefits.* Lack of transparency in its indicators is a disadvantage of RG (Orduna-Malea, Martin-Martin, Thelwall, & Lopez-Cozar, 2017) RG's failure to reveal its algorithm is contrary to the Leiden Manifesto, which states that evaluators of metric-based assessments should "keep data collection and analytical processes open, transparent and simple".

Appendix C1.4 KMS framework for analysis and evaluation of ResearchGate: System Four

High	includes components that make the system an exemplar in the field
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SYSTEM	Discovery	Creation	Representation	Classification	Storage	Retrieval	Dissemination	Transfer	Translation
ResearchGate = RG Quality = Q Governance = G									
ResearchGate: TECHNOLOGY	*Technology to underpin discovery for research output* 'the emergent practice of scholars' use of participatory technologies and online social networks to share, reflect upon, critique, improve, validate and further their scholarship' (Veletsianos & Kimmons 2012).	*Technology for creation, includes the access to databases and repositories for research investigations.* Working with SpringerNature, Thieme & Cambridge Uni Press to provide syndicated content	*Technology systems provide the format of digital research output.* Authentication through RG is a multi-layered process. Nature has reported that "Some of the apparent profiles on the site are not owned by real people, but are created automatically – and incompletely – by scraping details of people's affiliations, publication records and PDFs, if available, from around the web. That annoys researchers who do not want to be on the site, and who feel that the pages misrepresent them – especially when they discover that RG will not take down the pages when asked." (Van Noorden, 2014b) RG uses a crawler to find PDF versions of articles on the homepages of authors and publishers. RG demands access to a user's email address book. RG sends lots of emails to users.	*Technology is used to provide automated classification systems* Endorsing researchers for their skills and expertise and suggestions on new researchers to follow	*Technology underpins the storage of open biomedical content.* RG allows authors to upload preprints, accepted manuscripts, and VoRs, and display them on a single publication page. One important benefit of the partnership is that VoRs are added automatically to an author's RG publication page as they become available. This not only saves authors the effort of doing this themselves, it also means that they do not need to worry or find out whether they have the permission to upload the article. As an alternative the value provided by the institutional repository, however — particularly the long-term preservation and commitment to open access, should not be overlooked. Until some public commitment has been made, it should **not** be assumed that the other services provide this, and they will not be considered "open access repositories" (Fortney &	*Technology for retrieval of research output combines interoperable systems that aggregate content (publications and data) from other sources* full-text PDFs are discoverable in web searches Does not support exporting or harvesting of articles	*Technology is used to disseminate research objects* Uploading Springer Nature, Thieme & Cambridge Uni Press content to RG reduces this leakage [which is content which cannot be captured and measured; for example, peer-to-peer exchange by email or when a researcher accesses content through unauthorised routes] because usage on RG can be easily captured and measured using industry standards like COUNTER About half (51%) of the 78% user-uploaded articles (n = 500) that are not open access violate publisher copyright agreements (Jamali, 2017). This uploading may occur because authors believe that it will attract a greater audience for their work. More generally, some researchers use academic social network sites as the primary mechanism for document sharing. RG has allowed authors to upload their articles to the site since 2009 (Thelwall & Kousha, 2017B)	*Technology transfer for open knowledge databases and search platforms* *up to here* RG permits you to import publications from other applications, but provides no method for getting that same data out of the RG ecosystem (Fortney & Gonder, 2015).	*Technology to achieve the translation* process* RG Score "measures scientific reputation based on how all of your research is received by your peers" From the RG website: http://www.researchgate.net/publicprofile.RGScoreFAQ.html The score calculations are not transparent, however, and depend on journal impact factors and so are inappropriate for the assessment of individual academics (Jordan, 2015; Kraker & Lex, 2015). RG Score, RG Reach and h-index. RG Score has been criticised for having questionable reliability and an opaque calculation methodology that makes it hard to compare with other popular standard scores (Kraker & Lex, 2015).

Appendix C1.4 KMS framework for analysis and evaluation of ResearchGate: System Four

High	includes components that make the system an exemplar in the field
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SYSTEM	Discovery	Creation	Representation	Classification	Storage	Retrieval	Dissemination	Transfer	Translation
ResearchGate = RG Quality = Q Governance = G									
ResearchGate: CONTENT	The content includes: 80 million publications of which 19 million available in full text Subject wise, physical sciences were dominant both among authors and among journals and social sciences accounted for the smallest number of authors and journals. Thelwall and Kousha (2017A) also found that humanities (part of the broader social sciences category) were poorly represented in RG. (Jamali, 2017) RG is commonly being used to archive older research as well as current research (Thelwall & Kousha 2017A) Although RG is considered as a tool to communicate research results and knowledge, the level of knowledge utilization as obtained from RG is still low (Corvello, Genovese, & Verteramo, 2014). The results of surveys revealed that the main reasons for using RG are obtaining and sharing articles, forming study groups, keeping up-to-date, and catching upwith others' research fields. The main activities on RG are simply maintaining a profile, sending/reading messages, and participating in discussions (Van Noorden, 2014b). RG seems to have a wide coverage of articles from different disciplines and years, although its coverage of recent years is more substantial than its coverage of older years and some disciplines, such as the arts and humanities and some areas of the social sciences, are poorly covered. (Yan & Zhang, 2018)	*Content, in the form of research output,can be found by searching databases and open repositories via metadata, bibliographic indexes and/or full text.* RG found statistically significantly fewer citations than did Google Scholar, but more than both Scopus and Web of Science (Thelwall & Kousha, 2017B)	*Representation comprises explicit knowledge in the form of digital scholarly objects or the metadata for the objects.* Every publication registered also has its own page with metadata and, at times a preview and a link to a full text version, if the author has uploaded one to the site and the publisher has not requested that it be removed for copyright reasons. Users can also become actively engaged by participating in the questions and discussion threads, both by raising research questions and by sharing expertise and knowledge.	*Classification schemes and ontologies are used by repositories to allow users to navigate content* Q = RG has indexed many citations for a single website and has become a major source for academic papers, perhaps even starting to challenge Google Scholar in this regard. Combined with the apparent citation advantage of uploading to academic social network sites (Niyazov et al. 2016), scholars should take RG seriously as a venue for disseminating their research. RG citations can potentially be manipulated by uploading non-peer reviewed or fake documents and hence should be used cautiously for research evaluation. (Thelwall & Kousha, 2017B)	*Content, including metadata, needs to be stored in a standard way, that can be efficiently migrated to future systems.* This is NOT possible from RG	*To retrieve content the following are applied -- search commands, filters, open access, standards for example, Open Archives Initiative Protocol for Metadata Harvesting (OAI-PMH) standard used by PMC* Some of the full-text files available on RG are found by RG crawlers on other sites such as arxiv.org and are added to the profile of users and many are uploaded by authors themselves (Jamali, 2017) Recommend and Follow buttons are available to foster further interaction with peers and to highlight projects and publications Follow feature, which gives users access to new and updated information, together with opportunities to locate relevant expertise.	*Dissemination of research output (content) is based on standards* "RG is accessible from countries where Internet access is difficult, such as China; many downloads of my articles are made from this country. [RG] gives visibility to my articles, since my profile is visited by researchers from all over the world. I use it because it does not demand much effort and provides clear benefits." (Borrego, 2017) It was found that 10% of URLs to full text files presented in Google Scholar search results were to files hosted on RG (Jamali & Nabavi, 2015). RG appeared to be the second top single source of full-text files after **nih.org** in Google Scholar search results (as primary version) (Jamali, 2017) Members see RG mainly as a means to disseminate their research (Thelwall & Kousha, 2017B)	*Content can be transferred and interoperable between systems based on international standards.* The knowledge sharing component chiefly regards the adding or uploading of research output such as publications, drafts and teaching materials. It also covers contribution to Sessions pages, where users can leave general comments on papers or line-specific annotations. (Manca, 2018)	*Translation of research output is reported in systems that complement open biomedical repositories and databases.* The site also sends automatic email alerts to people about activities related to their profile and publications. Within the social part of the site, offline reputation seems to be important because answers from more authoritative figures tend to be more highly regarded (Li, He, Jeng, Goodwin, & Zhang, 2015). According to an article in Business Week --RG had been involved in notable cross-country collaborations between scientists that has led to substantive developments (Hamm, 2009)

C1.5 Workshop documentation

C1.5.1 Workshop proposal

C1.5.2 Workshop briefing document

C1.5.3 Workshop program

C1.5.1 Workshop proposal

Proposal for the workshop submitted to Associate Professor Madge, University of Bucharest

My details

Lisa Kruesi is a PhD candidate and a researcher from the Faculty of Information Technology, Monash University, Melbourne, Australia. She has held senior library manager roles at The University of Melbourne, Monash University, The University of Queensland (UQ) and CSIRO. She was the Associate Director, Scholarly Communications during 2011-2014 at UQ. Lisa has worked as an information specialist in the software industry and the intellectual property field. She has published journal articles and book chapters in areas of knowledge management, open scholarship, information management and health sciences librarianship.

Why participate?

This session will provide health sciences library and information staff with an insight into recent research findings on a Knowledge Management System (KMS) framework for designing and evaluating online information platforms and repositories. The session will provide participants with first-hand experience of applying the framework and a forum to discuss the latest developments in open scholarly publishing. Your participation will contribute to my final stage of my doctoral research.

Background to the session

The session will include a presentation on the KMS framework. As reported in a recent paper[1], the KMS framework aligns the requirements for an open biomedical repository with the *people, process, technology* and *content* elements of an Australian KM standard. The framework identifies and defines nine processes underpinning biomedical knowledge; these include: discovery, creation, representation, classification, storage, retrieval, dissemination, transfer and translation.

[1] * Kruesi, L., Burstein, F., & Tanner, K. A knowledge management system framework for an open biomedical repository: communities, collaboration and corroboration, *Journal of Knowledge Management,* 2020; To access the Author Accepted Version, go to https://doi.org/10.26180/5f7a5c30dd71c

The presentation will explain these processes and provide examples of the *people, process, technology* and *content* elements of each process. This presentation will take 15 minutes and will report on using the framework for developing, analysing and evaluating alternative designs for an open biomedical repository.

Arrangements

If suitable, we could set up a Zoom session and following my presentation, host 2-3 small groups, each with approximately 4-5 participants, who are allocated into Zoom breakout rooms to work together. I will give each of the groups an evaluation that I have done applying the framework; these include evaluations on ResearchGate, Europe PMC and Epistemonikos. The evaluations demonstrate how the framework can be used to critique information platforms and repositories to help identify suitable components within each of the elements (*people, process, technology and content*) of the nine processes.

If we have the names from those who register, I could pre-organise the groups and check these with you?

I will also provide each group with a link to a Google form for participants to provide feedback to a few key questions regarding the evaluation of alternative technologies that can be used for open biomedical repository implementation.

The small group will each review one of the evaluations based on the framework and give feedback on whether they agree or not with my preliminary assessment of the alternative designs. An evaluation form for participants will also be prepared.

C1.5.2 Workshop briefing document

A Knowledge Management System (KMS) framework to analyze and evaluate online information platforms and repositories - Workgroup leader version –

Pre-Session Reading

This paper describes the Knowledge Management System framework in detail. The paper is essential reading prior to the workshop:

Kruesi, L., Burstein, F., & Tanner, K. (2020). A knowledge management system framework for an open biomedical repository: communities, collaboration and corroboration. Journal of Knowledge Management, ahead-of-print. **https://doi.org/10.1108/JKM-05-2020-0370**

To access the Author Accepted Version, go to **https://doi.org/10.26180/5f7a5c30dd71c**

At the Session

You will be introduced to the KMS framework and its use will be demonstrated during the workshop presentation. There will be time during the session to ask questions.

Group Allocation

One week prior to the workshop (Wednesday 2 December) you will receive a **Zoom calendar invitation** to the session. You will also receive an email with a **link to a Google spreadsheet** that will include an evaluation of one of the information platforms noted in **Table 1.** The spreadsheet will be numbered (either 1, 2 or 3) and this will also be your group number. As the Workgroup Leader you will have Editor access to the spreadsheet. **Please check that you can open up the spreadsheet prior to the workshop.**

Next, please complete the online **consent form.** A link to the consent form will be accessible from the Zoom calendar invite.

You are encouraged to do some extra reading on the information platform you are assigned. A few papers on each platform are noted in the **Reference** section that follows.

Group Activity

At the workshop, following the presentation, you will be placed in a breakout room with other members of your group. The group members will have approximatelythirty minutes to provide you (as Workgroup Leader) with comments on the information platform spreadsheet that you have been assigned. Comments need only be given if there are details missing or objection to any of the details in the cells within the spreadsheet. Please add any comments in the cell below the 'Processes' in the white area. *For example, a comment on the **People** aspect of **Discovery**, should be directly below this cell.*

Following the group discussion, please direct group members to complete the **worksheet** available from **https://forms.gle/DWZ5WUa7mxHmrGeK9** to provide feedback on the information resource KMS framework. Please can you also complete a **worksheet**.

If there is insufficient time during the group activity to complete adding the details to the spreadsheet – please email the details to Lisa: **xxxxxxx@monash.edu**

Further instructions will be provided at the workshop.

Information platforms	Reasons selected	URL
Group 1. Epistemonikos	Openly accessible, provides a summary of research evidence, includes biomedical research	https://www.epistemonikos.org/
Group 2. ResearchGate	Openly accessible, alternative design based on scientific social networking services and also serves as a repository as it has a specific feature that allows members to upload full-texts of their publications.	https://www.researchgate.net/
Group 3. Europe PMC	Openly accessible repository, focus on biomedical research, links to research data, includes other research data sets and resources	https://europepmc.org/

Table 1. Information platforms

References

Group One Epistemonikos

Couban, R. (2018). Epistemonikos. *Journal of the Canadian Health Libraries Association/Journal de l'Association des biblioth~ques de la sant~ du Canada, 39*(3), 155-157.

El-Khayat, Y. M. (2017). Epistemonikos. *Journal of the Medical Library Association: JMLA, 105*(4),

431. Rada, G., Perez, D., & Capurro, D. (2013). Epistemonikos: a free, relational, collaborative,

multilingual
database of health evidence. *MedInfo, 2013*, 486-490.

Group Two ResearchGate

Borrego, A. (2017). Institutional repositories versus ResearchGate: The depositing habits of Spanish researchers. *Learned Publishing, 30*(3), 185-192. https://doi.org/10.1002/leap.1099

Jamali, H. R. (2017). Copyright compliance and infringement in ResearchGate full-text journal articles. *Scientometrics, 112*(1), 241-254.

Orduna-Malea, E., Martin-Martin, A., Thelwall, M., & L6pez-C6zar, E. D. (2017). Do ResearchGate Scores create ghost academic reputations? *Scientometrics, 112*(1), 443-460.

Yan, W., & Zhang, Y. (2018). Research universities on the ResearchGate social networking site: An examination of institutional differences, research activity level, and social networks formed. *Journal of informetrics, 12*(1), 385-400. doi:10.1016/j.joi.2017.08.002

Group Three – Europe PMC

Europe PMC. (2020). About Europe PMC. Retrieved from https://europepmc.org/About

Kruesi, L. M., Burstein, F. V., & Tanner, K. J. (2019). With open science gaining traction, do we need an Australasia PubMed Central (PMC)? A qualitative investigation. *PLOS ONE, 14*(2), e0212843. https://doi.org/10.1371/journal.pone.0212843

Levchenko, M., Gou, Y., Graef, F., Hamelers, A., Huang, Z., Ide-Smith, M., . . . McEntyre, J. (2018). Europe PMC in 2017. *Nucleic Acids Res, 46*(D1), D1254-d1260. d

A Knowledge Management System (KMS) framework to analyze and evaluate online information platforms and repositories

Online

International Workshop

Bucharest, Romania & Melbourne, Australia

Wednesday, 9 December 2020

WORKSHOP PROGRAMME

(Melb)	(Romania)	
8:00 -8.05	11.00-11.05	**Opening of the workshop** **Octavia-Luciana MADGE,** PhD, Associate Professor, University of Bucharest, Romania
8.05-8.20	11.05-11.20	**Presentation on KMS Framework towards open science & briefing for workgroups** **Lisa KRUESI**, PhD Researcher, Monash University, Melbourne, Australia
8.20-8.30	11.20-11.30	**Questions & Discussion (All)** **Lisa KRUESI & Octavia-Luciana MADGE**
8.30-9.10	11.30-12.10	**Workgroup activity (All)** -- ***(30 mins to discuss & 10 mins Workgroup Leader to add details)*** **(under the supervision of Lisa Kruesi)** LK will check in with each workgroup to respond to any queries during this time) Provide feedback on the information resource spreadsheet to your workgroup leader and complete an online worksheet. Refer to the briefing document for instructions. (one worksheet for each participant)
9.10-9.25	12.10-12.25	**Large Group Session: 5 minutes summary of findings given by each Workgroup Leader** **Moderator: Lisa KRUESI**
9.25-9.30	12.25-12.30	**Close of the workshop** **Octavia-Luciana MADGE**