Successful Deployment of Cloud-hosted Services and Performance Management for Community Care

Benjamin Eze[1,3], Craig Kuziemsky[2], Jamie Stevens[3], Paul Boissonneault[3] and Liam Peyton[1]
[1]*School of Electrical Engineering and Computer Science, University of Ottawa, 800 King Edward Ave, Ottawa, Canada*
[2]*Telfer School of Management, University of Ottawa, 55 Laurier Ave E, Ottawa, Canada*
[3]*Champlain Local Health Integration Network (LHIN), 4200 Labelle St, Ottawa, Canada*

Keywords: Healthcare Interoperability, Data Aggregation, Surveillance, Performance Management, Community Care, Cloud Computing, Regional Health Authority.

Abstract: Achieving systematic performance management of care processes across a health region requires an architecture that balances interoperability and data standardization with data governance and privacy compliance. This paper presents a case study of a successful pilot of cloud-hosted performance management for community care by a Regional Health Authority mandated with coordinating home care amongst 54 Community Support Services agencies. Cloud-hosted data services enabled data integration to a common data model. Formal data sharing agreements and privacy definition documents controlled aggregation and data masking to protect privacy while enabling accurate and comprehensive performance management services for all agencies.

1 INTRODUCTION

Community healthcare is diverse with multiple settings, actors, data sources and communication channels (Eze et al., 2017a). Regional health authorities (RHA) charged with ensuring quality of care and population health would like to measure, on a continuous basis, performance management across the entire healthcare ecosystem. This is challenging because of the aforementioned distributed nature of healthcare delivery (Foldy et al., 2014).

To date, hospitals have provided much of the healthcare outcome data through data sources such as discharge summaries, referrals, emergency room visits, wait times and procedures. However, this data only tracks isolated hospital-based events and not patient outcomes at the health systems level (Veillard et al., 2010). Healthcare delivery to support complex patient care such as chronic illness takes place in the community and is an ongoing process rather than an isolated event. Monitoring system performance for community care is challenging because of the need to track and measure care delivery across settings (Durovich and Roberts, 2018; Maruthappu et al., 2015; Roughead et al., 2011).

Health system management is often coordinated at an RHA level (Molinari, 2014) that has the goal of delivering a cost-effective and high-quality collaborative environment (Sabooniha et al., 2012). Yet quality management and system accountability are challenging because of the diverse settings in which healthcare delivery is provided (Denis, 2014).

Performance management requires a systematic framework that enables continuous data integration and monitoring of care processes (Lemieux-Charles and Greengarten, 2014). Cloud computing is one potential infrastructure for developing interoperable healthcare solutions (Andry et al., 2015; Bhaskaran et al., 2013; Li and Guo, 2015). There is a need for studies that describe actual implementation of cloud computing systems and how issues such as privacy and data sharing were managed (Griebel et al., 2015).

This paper presents a case study of a successful pilot of cloud-hosted performance management for community care at by a RHA mandated coordinating home care amongst 54 Community Support Services (CSS) agencies. A cloud-hosted system owned and managed by the health authority solves interoperability and security issues when you want 54 community care organizations to share data. Cloud-hosted data services enabled data integration to a common data model. Formal data sharing agreements

Eze, B., Kuziemsky, C., Stevens, J., Boissonneault, P. and Peyton, L.
Successful Deployment of Cloud-hosted Services and Performance Management for Community Care.
DOI: 10.5220/0007365902480255
In *Proceedings of the 12th International Joint Conference on Biomedical Engineering Systems and Technologies (BIOSTEC 2019)*, pages 248-255
ISBN: 978-989-758-353-7

and privacy definition documents controlled aggregation and data masking to protect privacy while enabling accurate and comprehensive performance management services for all agencies.

2 BACKGROUND

Community healthcare is the delivery of healthcare services outside hospitals to manage chronic illness, and provide services like rehabilitation support, nursing, physiotherapy, and end of life care to patients (CIHR, 2017). Community healthcare is delivered to clients of all ages whose illness or condition necessitates long-term health care delivery at home. The purpose of healthcare performance management as it relates to community care is to measure the extent that quality of care goals are achieved through the delivery of healthcare processes (Vanhaecht et al., 2007).

Patient needs are met through service-level planning and coordinated care delivery provided by health care providers in community settings such as public health units and community services agencies, (CIHR, 2017). Continuous efforts are being made to provide good quality and cost-effective care with support from government and non-profit organizations (Boissonnealth and Lafreniere, 2014). As patient needs may need to be coordinated across different settings and providers, it is critical to build a strong collaboration platform for all aspects of community healthcare to coordinate service delivery to patients while also monitoring outcomes such as cost-effectiveness (Berler and Apostolakis, 2014).

2.1 Regional Health Authorities

Community care is typically governed by an RHA. In Ontario, Canada for example, the Regional Health Authority is the Local Health Integration Network (LHIN, 2018), with the mandate to plan, integrate and fund local healthcare in a region. Ontario has 14 Local Health Integration Networks that target each sub-region within the province.

Norway employs a similar model with 4 main RHAs, each with many subsidiaries (Ringard et al., 2013). For both Ontario and Norway, the RHA is responsible for patient treatment, medical staff, planning, research, and development, as well as support and training for patients and their caregivers. RHAs are associated with improved healthcare outcomes, healthcare equality, increased life expectancy, improved coordination and reduced cost to healthcare services (Vida et al., 2012).

2.2 Complex Patients

Patient complexity can be due to factors such as comorbid health conditions that make patient care management very challenging (Grant et al., 2011). Providing care for complex patients is putting increased strain on healthcare budgets and service delivery performance goals such as wait times (Sheikh et al., 2015). As a consequence, there is a growing need to transform the health care system and the services it delivers to more efficiently provide care for complex patients (Sabooniha et al., 2012).

Government and healthcare organizations want better accountability for money spent on healthcare delivery (Bohmer, 2016), which requires performance management of care processes across all stakeholders in the healthcare ecosystem (Berwick et al., 2008). Achieving this requires coordination and integration of data across disparate healthcare information systems (Sabooniha et al., 2012).

Complex patient management is challenging and expensive as it requires care and service delivery from a variety of providers (Mcgregor et al., 2016). Further, complex patients may be managed using multiple clinical practice guidelines which may have conflicting recommendations about medications or treatments (Wilk et al., 2017).

2.3 Performance Management

Performance management provides a mechanism for translating strategic objectives and business goal to operational processes (Kemper et al., 2013). Performance management involves planning, setting expectations, continuous monitoring of performance, developing the capacity to perform, as well as rating and rewarding of performance (OPM.GOV, 2017).

Continuous monitoring of KPIs is key to effective monitoring and management of strategic goals (Sanchez and Robert, 2010). However, each strategic goal also needs to be linked to these KPIs to measure the extent that the performance of the organization is achieving goals (Kuziemsky et al., 2010).

Heterogeneous data silos and inconsistent patient identity approaches, coupled with patient privacy regulations, limit our ability to correlate data for complex patients as part of performance management (Eze et al., 2016). This results in the inability of stakeholders to coordinate care delivery across multiple healthcare domains (Adler-Milstein and Jha, 2012). Attempts to address these factors often lead to unintended consequences (e.g., social, legal and workflow consequences) that arise from technology-mediated connectivity (Kuziemsky et al., 2016).

2.4 Cloud Computing

Cloud computing is a distributed, configurable approach for generating ubiquitous access to a pool of convenient, on-demand computing resources (compute, storage, platform, application and services) through a web interface. Cloud computing has been shown to provide for regional, national and international data aggregation using a broad range of topologies that could integrate various devices, data sources and services very quickly in a scalable and cost-effective manner (Andry et al., 2015). In addition, Cloud infrastructure provides an infinitely scalable storage for very data-intensive applications (Bhaskaran et al., 2013; Ochian et al., 2014).

Cloud deployment models are differentiated by the location of the infrastructure, the user of the infrastructure and the entity that manages the infrastructure (Furht and Escalante, 2010). There are three deployment models of cloud computing – Private, Public, and Hybrid Clouds. A private cloud is operated by a single organization, which has full control over the infrastructure, data, security, and quality of service (QoS). The public cloud is operated by a 3rd party and can be used by with applications mixed together on cloud servers, storage systems, and networks (Eze et al., 2016). Finally, a hybrid cloud is a mix of public and private clouds. In the hybrid cloud, data and applications are distributed across both public and private clouds using secure data bridges (Ma et al., 2014).

A private cloud provides the owners full control over everything – compute, storage, networking, as well as the quality of service. While having full control increases the complexity associated with the development and deployment of a cloud application and services, it provides better security and confidentiality with user data. Unfortunately, compared to other cloud deployment models, a private cloud is more expensive (Ma et al., 2014).

The public cloud provides the lowest Total Cost of Ownership (TCO) of the cloud types but also provides the least control. Also, data security cannot be guaranteed since cloud resources are shared by many organizations. Public clouds are also prone to resource contention issues, SLA breaches, and service disruptions. For healthcare organizations with high volumes of highly sensitive data, this would not be acceptable since it violates data privacy laws in many countries (Furht and Escalante, 2010; Gazzarata et al., 2015).

3 PILOT PROJECT

The Champlain Local Health Integration Network (LHIN) provides at-home care services for patients in a metropolitan area with a population of over 1.2 million. About 60,000 annual active patients are receiving over two dozen community care services from the LHIN and its 54 Community Support Services (CSS) agencies.

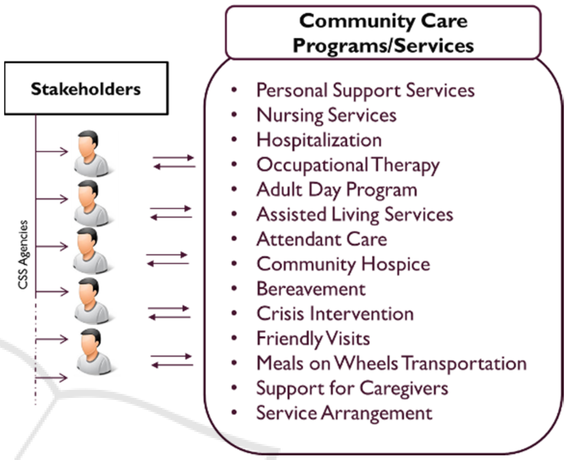

Figure 1: CSS Agencies and Spectrum of Services.

Fig. 1 shows examples of some of these services. Services provided by these CSS agencies are intended to improve the quality of life of patients with complex and chronic health conditions.

3.1 Lack of Performance Management

The lack of performance management of community care in the Champlain LHIN before the pilot project is depicted in fig. 2. CSS agencies target specific populations with niche community services. Usually, these agencies are small organizations with limited budgets and their own small ad-hoc IT systems.

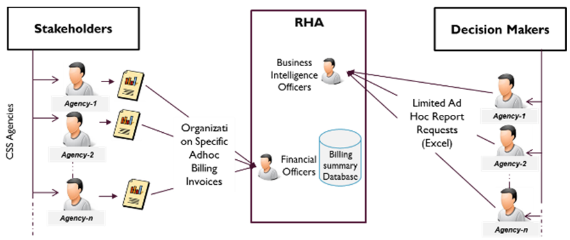

Figure 2: Lack of Performance Management.

As a result, there is minimal interoperability and limited performance management. Data collection is limited to ad-hoc invoices (typically in MS Excel

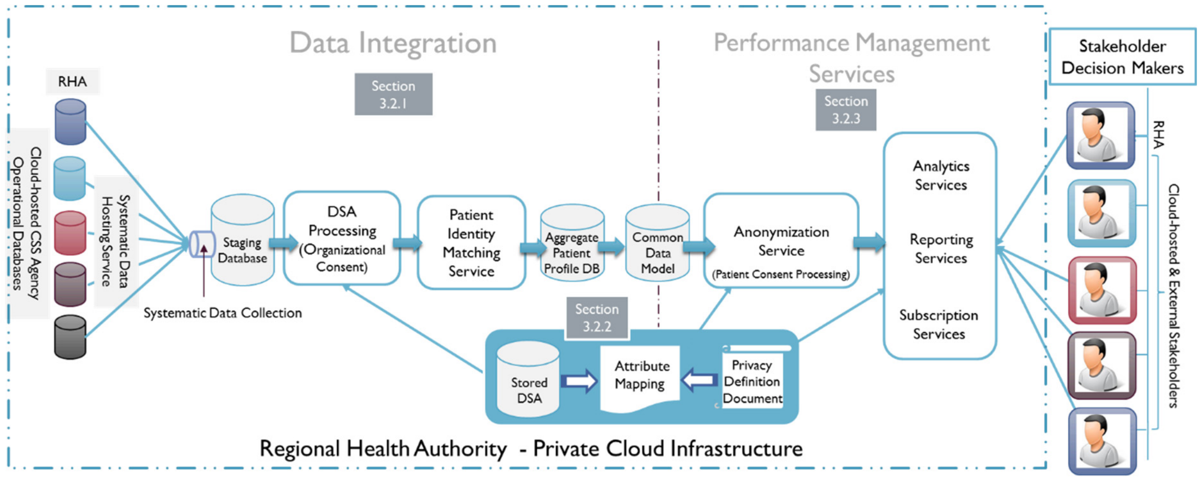

Figure 3: Cloud-based Performance Management Architecture for Community Care.

format) for services rendered by each agency and usually submitted by email to the RHA financial officers to process payments. The RHA depends on ad-hoc reports, mostly prepared for funding and budgeting needs.

Each CSS agency has their own data silo resulting in service duplication and limited coordination of care delivery.

3.2 Architecture

The multi-tenanted private cloud architecture shown in figure 3, hosts, for each of the 54 CSS agencies, their patient management applications and operational databases, while providing data integration and performance management services. This preserves the autonomy of each CSS agency, allowing for quick adoption by each organization.

As depicted in figure 3, the LHIN CSS agencies that want to participate in the performance management architecture must sign a Data Sharing Agreement (DSA) and provide patient consent. These are formally defined and enforced using Privacy Definition Documents (PDD). The three aspects of data integration, privacy compliance and performance management are described in detail in the sections that follow.

3.2.1 Data Integration to a Common Data Model

A Systematic Data Hosting Service ensures that the data from each CSS agency is in a secure, controlled environment. This provides the trust needed to allow systematic data integration into a Common Data model to support Performance Management services. As shown in Figure 3, each organization's patient management application is hosted in a load balanced cloud-hosted virtual machine (VM) using a cloud-hosted Microsoft SQL Server database cluster. Users from each organization access their respective application instances through a remote VPN service using an SSL VPN Client.

A Systematic Data Collection Service connects to the MS SQL Server cluster and systematically collects data from each database instance. This service supports heterogeneous data sources through data integration (Platform-as-a-Service) PaaS containers customized for the RHA and 54 CSS agencies. Data from a particular CSS is only collected if there is a signed DSA in place as described in section 3.2.2. The major challenge with this architecture is that CSS agencies and the Champlain LHIN do not share a common patient identifier such as government-issued health card number (HCN). In addition, identity attributes of the patient like first and last names, date of birth, gender, phone numbers, and addresses are not collected in a consistent manner across the agencies. It is therefore difficult to match data from different databases for the same patient. Imposing a common region-wide patient identifier would be a costly long-term initiative and was therefore not a viable short-term option. Instead, a patient-identity matching service was provided.

After evaluating the data sets across the agencies, we came to three conclusions about identity matching. First, each agency had an identifier specific to their database for the patient. Second, agency data could have data entry errors. Third, patient identity matching could leverage attributes like current and historical addresses, phone numbers, to fine-tune and verify matches.

A probabilistic matching algorithm was implemented to address identity matching for the infrastructure. This algorithm derives from existing work in probabilistic record linkage domain like the Expectation-Maximization (EM) algorithm (Dempster et al., 1977), as well as the theories of record linkage (Fellegi and Sunter, 1969) This algorithm is described in details in a previous publication (Eze et al., 2017). It addresses the record linkage problem by dividing a data set into blocks to minimize comparisons to only records within the same block. A block is a combination of one or more identifier attributes with an associated weight. The matching process accumulates matches across all block passes for each patient identity attributes to determine the matches that are full, partial or ambiguous or non-matches.

Patient Identity Matching is carried out on all patient-level records across all the incoming data streams based on published matching rules. At the end of the process, a global identifier is issued to each cluster of profiles belonging to the same patient across the collaborating organizations. This identifier is then used to map the rest of their data into the Common Data Model (CDM).

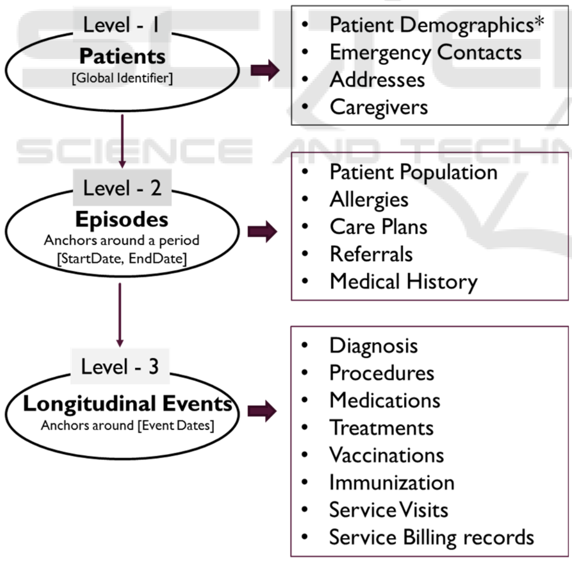

Figure 4: Common Data Model Depicted.

The CDM uses a hierarchical model (fig. 4). Data elements found in each source database must be organized into this hierarchical model. The 1st level is patient-centric data with patient identifiers, demographic data, contact details – phone numbers and addresses, personal and emergency contacts, caregivers, family physicians. The 2nd level captures episodes of care and data that map to each episode of care like the patient population (a categorization of patients into population groups with similar care needs), referrals, care plans, and medication history. The 3rd level is longitudinal events and maps to data on the care episodes defined at the 2nd level. These include service visits for home care, diagnoses and medications.

3.2.2 Data Sharing Agreements and Privacy Definition Documents

An essential need for community care data integration and performance management services is adherence to privacy legislation. Since the CSS agencies are independent organizations, they are not under any mandates to provide data to the LHIN apart from billing and support reports. Binding agreements that protect patient privacy and confidentiality need to be signed between these organizations to allow their data to be shared.

Privacy compliance is addressed through the creation of formal Data Sharing Agreements (DSA) for organizations and a Privacy Compliance Definition Document (PCDD) that captures both organizational and patient consent to configure and regulate the processing of data. DSAs consents regulate each incoming data stream from a CSS agency. The PCDD applies globally (across all data streams), locally (specific to each organization data stream), and partially (controlling access to specific data entities and attributes). Enforcing these consents can result in complete removal of patient data from the common data model. In some cases, there could be full or partial anonymization (data masking, generalization, suppression) of patient data to meet set risk thresholds for the infrastructure.

For this pilot project, an all-or-nothing type of privacy compliance was implemented. The PCDD provides meta-data on data elements that describe their semantic types, determining how the privacy of each attribute should be addressed. It also specifies fields that needs be nulled, removed, or even masked based on DSAs to ensure that restricted data never makes it to the CDM.

All stakeholders that signed the DSA, including the RHA, have access to all aggregate reports from the CDM. They and the RHA are also able to see patient-level report across all agencies except for those patients that did not consent.

While the all or nothing approach provides good privacy protection, it does impair the accuracy and completeness of performance management reporting. An anonymization service that improves accuracy and completeness is part of proposed future enhancements to the architecture.

3.2.3 Performance Management Services

Our architecture supports four performance management services – anonymization, analytics, reporting, and subscription services. For this pilot project, three performance management services were leveraged – anonymization, reporting and subscription services.

A simplified anonymization model - where all patients that opted out of data sharing are automatically excluded from performance management by the data collection service, was leveraged. Agencies only see aggregate service data for patients in their circle of care. Patient-level data from patients that belong to other providers are excluded. All performance management reports are made available to only those participating agencies that have signed the DSA.

The reporting service use two hosted MS SQL Server Reporting Services (SSRS) that mirror each other. Each analytics report created is published on both servers. Personnel from the LHIN and the agencies use the reporting portal to access the standard reports made available to them. Since SSRS has Web services support, these reports can also be streamed dynamically, using the subscription service.

Shared Services Subscription service is the component of the framework that closes the loop regarding pushing information from the shared data model to the stakeholders and decision makers at all levels across all collaborating organizations and their partners. It is also the component of the performance management framework that supports process interoperability described in (Benson, 2012; Kuziemsky, 2013). The subscription service leverages data from the CDM and LDAP to provide knowledge, collaborative, and operational data needed for performance management of community care processes.

The key features of the subscription service that make it adaptable to a cloud computing environment include 1) Support for dynamic data-driven subscriptions with declarative and SQL executable definitions for subscribers and report parameters. All settings for subscriptions and reports are in configurable XML definitions hosted in a source repository. 2) The ability to dynamically package and deliver multiple reports to users in these different formats – HTML, MS Word, MS Excel, and Acrobat PDF. 3) Support for multiple delivery modes – email, file system, and calendar appointments. 4) Dynamic scheduling – daily, day periods, weekdays, weekly, monthly, and quarterly, specific days of the week, month, quarter. 5) Supports rich failure notifications for administrators.

For each report developed and published, a custom report definition file that allows the subscription service to dynamically stream the report in many formats is also published to the resource library. They are created by Business Intelligence officers with more in-depth knowledge of the model and the framework. The key utility of the subscription service is its ability to dynamically package and deliver multiple reports in various formats through multiple delivery mechanisms to data recipients.

4 PRELIMINARY EVALUATION

The pilot project is considered a success within the LHIN. 48 of the 54 the CSS agencies with over 150,000 patients are currently cloud-hosted. 17 agencies with about 30,000 patients have signed the DSA and currently participate in the performance management infrastructure. There are nightly data collection and aggregation of the data across the CSS operational databases to the Common Data Model.

There are nightly patient identity matching and progressive clustering of patient profiles. Identity matching results show that at least 25,000 patients have matches from another agency or the LHIN with about 3,000 ambiguous matches that would require manual approval. However, research has been done to suggest improvements to the identity management framework (Eze et al., 2017b).

There are up to 8 active report subscriptions set up for the LHIN and CSS Agency contacts that publish and emails various reports. The subscription service has been adopted by the LHIN and is used to package and send via email and file transfer, hundreds of reports to LHIN employees multiple times a day. Data quality feedback is provided to CSS agencies on various data quality issues with patient profiles that need addressing.

The current implementation uses an all-or-nothing approach to address privacy consent (Eze et al., 2018). Ongoing research is looking at extending this through a privacy compliance framework that leverages anonymization to provide more complete and accurate reports.

5 CONCLUSION

Modern healthcare delivery is about connected healthcare delivery and patient care management across providers and settings. Achieving these require modern approaches to supporting patient care. Though there are many architectures for patient management, implementation has remained the last mile problem. But this is not a technological problem per se but rather an issue that encompasses multiple areas such as software design, patient needs, technical interoperability, privacy considerations, patient data interoperability (e.g. standards), and governance agreements across settings.

This paper describes an initial deployment of a cloud-based performance management system. A multi-tenanted private cloud infrastructure with cloud-hosted data services provide a trusted environment which can enable secure, well-regulated systematic data integration to a common data model (CDM) to facilitate comprehensive performance management for community care. Formal data sharing agreements (DSA) and a privacy compliance definition document (PCDD) provide a robust mechanism for controlled aggregation and data masking to protect privacy while enabling accurate reporting.

ACKNOWLEDGEMENTS

This work was supported by the National Science and Engineering Research Council of Canada

REFERENCES

Adler-Milstein, J., Jha, A.K., 2012. Sharing clinical data electronically: *A critical challenge for fixing the health care system*. JAMA - J. Am. Med. Assoc.

Andry, F., Ridolfo, R., Huffman, J., 2015. Migrating healthcare applications to the cloud through containerization and service brokering, in: 8th International *Conference on Health Informatics*, Proceedings;. SciTePress, 164–171.

Benson, T., 2012. Why Interoperability is Hard. In *Principles of Health Interoperability HL7 and SNOMED SE - 2*, 21–32. Springer London.

Berler, A., Apostolakis, I., 2014. Research Perspectives on the Role of Informatics, Health *Policy and Management, El Morr*, C. (Ed.), IGI Global, 168–207.

Berwick, D.M., Nolan, T.W., Whittington, J., 2008. The triple aim: care, health, and cost. *Health Aff.* 27, 759–769.

Bhaskaran, S., Suryanarayana, G., Basu, A., Joseph, R., 2013. Cloud-Enabled Search for Disparate Healthcare Data,2013 *IEEE International Conference on Cloud Computing in Emerging Markets* IEEE, pp. 1–8. h

Bohmer, R.M.J., 2016. The hard work of health care transformation. *N. Engl. J. Med*. 375, 709–711.

Boissonnealth, P., Lafreniere, N., 2014. Deploying Information Systems throughout the Community Care Sector of the Champlain Region, in: *E-Health 2014 Conference*, Vancouver, BC. British Columbia.

CIHR, 2017. Community-Based Primary Health Care, *Can. Institutes Heal. Res*., accessed 10.15.17 at http://www.cihr-irsc.gc.ca/e/43626.html

Dempster, A.P., Laird, N.M., Rubin, D.B., 1977. Maximum likelihood from incomplete data via the EM algorithm. *J. R. Stat*. Soc. Ser. B 1–38.

Denis, J.-L., 2014. Accountability in healthcare organizations and systems. *Healthc. Policy* 10, 8–9.

Durovich, C., Roberts, P., 2018. Designing a Community-Based Population Health. *Popul. Health Manag*. 21.

Eze, B., Kuziemsky, C., Lakhani, R., Peyton, L., 2016. Leveraging Cloud Computing for Systematic Performance Management of Quality of Care. *Procedia Comput. Sci*. 98, 316–323.

Eze, B., Kuziemsky, C., Peyton, L., 2017a. Cloud-based performance management of community care services. *J. Softw. Evol. Process*.

Eze, B., Kuziemsky, C., Peyton, L., 2017b. A Patient Identity Matching Service for Cloud-based Performance Management of Community Healthcare, in: *Procedia Computer Science*.

Eze, B., Kuziemsky, C., Peyton, L., 2018. Operationalizing Privacy Compliance for Cloud-Hosted Sharing of Healthcare Data, in *Software Engineering in Healthcare Systems (SEHS)*. pp. 18–25.

Fellegi, I.P., Sunter, A.B., 1969. A theory for record linkage. *J. Am. Stat. Assoc*. 64, 1183–1210.

Foldy, S., Grannis, S., Ross, D., Smith, T., 2014. A Ride in the Time Machine: *Information Management Capabilities Health Departments* Will Need. Am. J. Public Health 104, 1592–1600.

Furht, B., Escalante, A., 2010. A Handbook of Cloud Computing, in: *A Handbook of Cloud Computing. Springer US*, pp. 3–19.

Gazzarata, G., Gazzarata, R., Giacomini, M., 2015. A Standardized SOA Based Solution to Guarantee the Secure Access to EHR. *Procedia Comput. Sci*. 64, 1124–1129.

Grant, R.W., Ashburner, J.M., Hong, C.C., Chang, Y., Barry, M.J., Atlas, S.J., 2011. Defining patient complexity from the primary care physician's perspective: a cohort study. *Ann. Intern. Med.* 155.

Griebel, L., Prokosch, H.U., Köpcke, F., Toddenroth, D., Christoph, J., Leb, I., Engel, I., Sedlmayr, M., 2015. A scoping review of cloud computing in healthcare. *BMC Med. Inform. Decis*. Mak.

Kemper, H.G., Rausch, P., Baars, H., 2013. Business Intelligence and Performance Management: Introduction. *Bus. Intell. Perform. Manag*. 3–10.

Kuziemsky, C., Liu, X., Peyton, L., 2010. Leveraging goal models and performance indicators to assess health care information systems, *Quality of Information and Communications Technology Conference*, 222–227.

Kuziemsky, C.E., Randell, R., Borycki, E.M., others, 2016. Understanding Unintended Consequences and Health Information Technology. *IMIA Yearb*. 53–60.

Lemieux-Charles, L., Greengarten, M., 2014. Performance management systems and the reality of Canadian healthcare organizations from industrial to learning models. *Heal. Q* 17, 5–7.

LHIN, 2018. Local Health Integration Network accessed 15.10l.18 at http://www.lhins.on.ca/

Li, Y., Guo, Y., 2015. Wiki-Health: From Quantified Self to Self-Understanding. Futur. Gener. *Comput. Sys*t. 8

Ma, J., Peng, C., Chen, Q., 2014. Health Information Exchange for Home-Based Chronic Disease Self-Management -- A Hybrid Cloud Approach, *4 5th International Conference on Digital Home*. 246–251.

Maruthappu, M., Hasan, A., Zeltner, T., 2015. Enablers and Barriers in Implementing Integrated Care. *Heal. Syst. Reform*.

Mcgregor, J., Mercer, S.W., Harris, F.M., 2016. Health benefits of primary care social work for adults with complex health and social needs: *A systematic review. Heal. Soc. Care Community*.

Molinari, C., 2014. Does the Accountable Care Act aim to promote quality, health, and control costs or has it missed the mark? Comment on “Health system reform in the United States”. *Int. J. Heal. policy Manag*.

Ochian, A., Suciu, G., Fratu, O., Voicu, C., Suciu, V., 2014. An overview of cloud middleware services for interconnection of healthcare platforms, *Communications Conference,* 1–4.

OPM.GOV, 2017. Performance Management Overview [WWW Document]. URL https://www.opm.gov/policy-data-oversight/performance-management/overview-history/ (accessed 20.10.18).

Ringard, Å., Sagan, A., Sperre Saunes, I., Lindahl, A.K., 2013. *Norway: health system review. Health Syst. Transit*. 15, 1–162.

Roughead, E.E., Kalisch, L.M., Ramsay, E.N., Ryan, P., Gilbert, A.L., 2011. Continuity of care: When do patients visit community healthcare providers after leaving hospital? *Intern. Med. J*. 41, 662–667.

Sabooniha, N., Toohey, D., Lee, K., 2012. An evaluation of hospital information systems integration approaches, Advances in Computing, *Communications and Informatics. ACM Press*, New York, New York, USA, p. 498.

Sanchez, H., Robert, B., 2010. Measuring Portfolio Strategic Performance Using Key Performance Indicators. *Proj. Manag. J*. 41, 64–73.

Sheikh, A., Sood, H.S., Bates, D.W., 2015. Leveraging health information technology to achieve the “triple aim” of healthcare reform. *J. Am. Med. Inform. Assoc.* 22, 849–856.

Vanhaecht, K., De Witte, K., Depreitere, R., Van Zelm, R., De Bleser, L., Proost, K., Sermeus, W., 2007. Development and validation of a care process self-evaluation tool. *Heal. Serv. Manag. Res*. 20, 189–202.

Veillard, J., Huynh, T., Ardal, S., Kadandale, S., Klazinga, N., Brown, A., 2010. Making Health System Performance Measurement Useful to Policy Makers: *Aligning Strategies, Measurement and Local Health System Accountability in Ontario. Healthc. Policy*.

Vida, M., Lupse, O., Stoicu-Tivadar, L., 2012. Improving the interoperability of healthcare information systems through HL7 CDA and CCD standards, *7th International Symposium on Applied Computational Intelligence and Informatics*, 157–161.

Wilk, S., Michalowski, M., Michalowski, W., Rosu, D., Carrier, M., Kezadri-Hamiaz, M., 2017. Comprehensi-ve mitigation framework for concurrent application of multiple clinical practice guidelines. J. *Biomed. Inform*. 66.