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Research paper

The informatics capability maturity of integrated primary care centres in Australia

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ABSTRACT

Context: Integrated primary care requires systems and service integration along with financial incentives to promote downward substitution to a single entry point to care. Integrated Primary Care Centres (IPCCs) aim to improve integration by co-location of health services. The Informatics Capability Maturity (ICM) describes how well health organisations collect, manage and share information; manage eHealth technology, implementation, change, data quality and governance; and use "intelligence" to improve care.
Aim: Describe associations of ICM with systems and service integration in IPCCs.
Methods: Mixed methods evaluation of IPCCs in metropolitan and rural Australia: an enhanced general practice, four GP Super Clinics, a "HealthOne" (private-public partnership) and a Community Health Centre. Data collection methods included self-assessed ICM, document review, interviews, observations in practice and assessment of electronic health record data. Data was analysed and compared across IPCCs.
Findings: The IPCCs demonstrated a range of funding models, ownership, leadership, organisation and ICM. Digital tools were used with varying effectiveness to collect, use and share data. Connectivity was problematic, requiring "work-arounds" to communicate and share information. The lack of technical, data and software interoperability standards, clinical coding and secure messaging were barriers to data collection, integration and sharing. Strong leadership and governance was important for successful implementation of robust and secure eHealth systems. Patient engagement with eHealth tools was suboptimal.
Conclusions: ICM is positively associated with integration of data, systems and care. Improved ICM requires a health workforce with eHealth competencies; technical, semantic and software standards; adequate privacy and security; and good governance and leadership.

1. Background

In Australia [1] and internationally [2], integrated primary care requires systems and service integration across primary, secondary and social care along with financial incentives to promote downward substitution to a single point of entry [3]. However, evidence of success has been variable [4]. Integrated Primary Care Centres (**IPCCs**) such as GP Super Clinics [5] are a strategy to improve integrated primary care by co-locating generalist and specialist medical, nursing and allied health services. Australian health reform in general practice and primary care is being implemented through the Medicare Locals (now called Primary Health Networks) program [6].

Health information systems (**HIS**) and associated digital (eHealth) tools can enable IPCCs to improve the quality, safety and efficiency of referrals, coordination of care and patient journeys, improving processes and avoiding duplicate tests and unplanned hospitalisations [7]. The Australian Primary Health Care (**PHC**) Strategy [8] and jurisdictional strategies, such as the NSW State Health Plan [9] and eHealth blueprint [10]. South Australian GP Plus Health Care services [11] and Victorian Primary Care Partnerships [12], have common aspirations for

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Dimension	Description
ICM 1. Data collection, integration and management in HIS/EHR*	This dimension measures the collection, management and display of high quality information across a health centre to ensure that the right users have the right access to the right information at the right time in a confidential and secure manner.
ICM 2. Information sharing in the health neighbourhood	This dimension measures the use of information and communication technology tools to enable seamless information flows within the health centre and with other services in the health neighbourhood to support cost-effective and patient-centred coordinated care.
ICM 3. Managing health information and communication technology implementation and change	This dimension measures a health centre's commitment and approaches to supporting innovative uses of information and communication technology tools to improve clinical and managerial processes to achieve efficiency gains and realise the full benefits of informatics enabled change.
ICM 4. Data Quality Management and Information Governance	This dimension measures a health centre's commitment and approaches to supporting informatics as a strategic asset and its capability to produce quality data and knowledge to deliver against their clinical and managerial objectives.
ICM 5. Using health "business intelligence" to improve care and population health	This dimension measures a health centre's approach to the analysis, production and presentation of the centre's information to inform and support clinical and managerial decision-making to monitor safety and quality of care, support quality improvement activities, engage and support patients/carers/community in self-care and health promotion, and undertake innovative research and development activities.

Fig. 1. Dimensions of Informatics Capability Maturity.

a cost-effective health system enhanced by effective HIS and digital tools. The Australian eHealth Practice Incentives Program supports accredited general practices to adopt and use digital tools [8]. The Australian Personally Controlled Electronic Health Record (PCEHR) system is a core component of the national eHealth strategy [13]; it is now called My Health Record.

The Informatics Capability Maturity (**ICM**) assesses how well an organisation collects and manages and shares information; manages information and communications technology, implementation and change; manages data quality and governance; and uses health "business intelligence" to achieve multidisciplinary integrated care [14,15]. The ICM instrument categorises the key informatics capability as '*basic*', '*controlled*', '*standardised*', '*optimised*' or '*innovative*' (Figs. 1 and 2). The ICM categories were illustrated with Australian examples by the authors (Supplementary File #1).

1.1. Definitions

The Australian Digital Health Agency defines eHealth (digital health) as "electronically connecting up the points of care so that health information can be shared securely" [16]. We used an outcome-focused definition: "the electronic management, communication and integration of health information, through interoperable tools, to deliver safer, more efficient, better quality healthcare".

Integrated care is a "coherent set of methods and models for the funding, administrative, organisational, service delivery and clinical levels designed to create connectivity, alignment and collaboration within and between the cure and care sectors" [17]; this does not address patient-centredness, access to and continuity of care [7]. The NSW Health definition best reflects the approach of this study:

Informatics Capability Maturity (ICM)	
	Basic: Systems and processes not completely reliable or coordinated.
	Controlled: Systems coordinated, manageable, performs consistently; But knowledge silos still exist.
	Standardised: Standards used to support sharing and collaboration.
	Optimised: Consolidated, efficient, accountable with good governance.
	Innovative: Facilitates innovation with enterprise level engagement.

Fig. 2. Key to assess Informatics Capability Maturity.

PHC strategic framework	eHealth tools and systems (examples)	Integration and shared care elements (examples)
Consumer-focused integrated PHC system	• Interoperable managerial and clinical systems • Shared eHealth record / PCEHR	• Patient and carer-centred • Comprehensive care • Coordinated care
Improve access and reduce inequity	• eHealth, mHealth, tele-health • Electronic service directory • Online presence	• Co-location and outreach • Bulk billing and Medicare items • Dimensions of access
Health promotion, prevention and screening	• Online resources • Systems for care planning, recalls and reminders • Clinical decision support tools	• Evidence-based best practice and protocols • Health literacy
Quality, safety, performance and accountability	• Secure communication systems • Clinical, managerial and financial systems for planning, quality improvement and research	• Clinical and corporate governance • Data quality protocols • Professional development and quality improvement programs

Fig. 3. Evaluation Framework with PHC, integration, eHealth dimensions.

"*provision of seamless, effective and efficient care that reflects the whole of a person's health needs, from prevention through to end of life, across physical and mental health, in partnership with the individual, their carers and family and across public/private and Commonwealth/State boundaries*" [18].

1.2. Conceptual framework

The framework encompasses the elements of integration [17,18] and eHealth activities [19,20] within the Australian PHC Strategic Framework. The integration framework included technology, data and information, application (clinical and managerial), organisation and inter-professional dimensions [21,22]. The eHealth elements are assessed as ICM dimensions (Figs. 1 and 2, Supplementary File#1) and integration elements as system, information and people factors that promote and support team and shared care (Fig. 3 & Supplementary File #2).

1.3. Research questions

- To what extent is ICM associated with integrated care in IPCCs?
- What patient, provider, team, organisation, ICM and usability factors act as enablers or barriers to the use of HIS and digital tools for integrated care?
- To what extent is ICM associated with patient perceptions of these approaches on access, continuity and integration of care?

2. Methods

We used a mixed methods design incorporating document review, interviews, non-participant observation and quality assessment of electronic health records (**EHRs**) data. The UNSW Human Research Ethics Committee approved this study (HREAP 2014-7-27).

2.1. Participating IPCCs

IPCCs were selected to represent a range of: (a) geography (state and rurality), (b) organisational size, structure, leadership and governance, (c) funding models and (d) clinical and managerial 2practices. They included:

- An enhanced private general practice in regional NSW (Site1-NSWregional)
- Four GP Super Clinics in three Australian states:
  - ○ outer urban and independently owned (Site2-Mel),
- outer urban and part of a larger organisation (Site3-Adl),
- outer urban and owner-operated across two sites (Site4-Syd),
- regional and linked to hospital and community health organisations (Site5-VicRegional), and

- A state-funded rural "HealthOne" (Site6-NSWRural), and
- A Community Health Centre (Site7-Mel) that has merged into a larger entity.

2.2. Data collection

- Document review of practice protocols and procedures to obtain information about integration-related tasks such as communication, information sharing, referrals, privacy and security of information, data quality management and information governance.
- Interviews, either face-to-face or by telephone with general practitioners (**GPs**), Practice Managers (**PMs**), IT staff, reception staff, Practice Nurses (**PNs**), Allied Health Professionals (**AHPs**) and other providers involved in integrated care. This explored the rationale for the use of digital tools in integration-related activities and what mechanisms supported their use.
- Non-participant observation of routines related to integrated care, how existing eHealth initiatives were negotiated in practice, and how providers undertook and completed tasks related to integrated care, such as initiating and completing referrals, and communicating and sharing care within the IPCC and with external providers

(Supplementary File #2).

- Telephone interviews were conducted with a purposive sample of patients, recruited by the IPCC staff to include a range of age, gender and chronic conditions. This explored patients' perceptions of the use of HIS and digital tools by the practice to facilitate integrated care (Supplementary File #3).
- Extraction of a subset of de-identified records from the IPCCs' HIS to benchmark against the quality indicators for patient records and health summaries in the Royal Australian College of General Practitioners (RACGP) Standards for General Practice [23].
- A self-assessment tool completed by senior leadership, augmented with the evaluators' assessments from their observations during visits to the IPCCs, to determine the ICM of the IPCC (Fig. 3) and key eHealth elements and tools used.

2.3. Analysis

NVivo 10 was used to thematically code and analyse qualitative data from interviews and non-participant observation. A critical analysis with comparison among IPCCs, using inductive and deductive methods, was conducted to understand associations between the ICM and extent of integration of data, systems and services. EHR data quality (completeness and consistency) was assessed and benchmarked using in-house methods [19,24]. Interpretation was in context, considering factors such as patient, provider, team organisation, health financing and regulations as enablers and barriers to adoption/use of eHealth tools [25]. Triangulation was through iterative communication among the research team (R, JT, OF, RL, MT, STL) as well as with practice staff.

3. Findings

The detailed findings are found in Supplementary File #4.

The IPCCs showed varying organisational structures; balance of clinical and managerial leadership; stages of development and change; use of digital tools; team cohesion and effectiveness of service delivery. Most were general medical practices, with GPs and PNs forming the core, and relationships with a range of visiting or co-located AHPs and medical specialists through tenancy agreements, service agreements or associateships. The Commonwealth-funded Super Clinics or state-funded HealthOne NSW were established with specific integration objectives. Organisational stability and efficiencies varied across IPCCs depending on their size and whether they were part of a larger organisation. Generally, inter-professional teams delivered services effectively, especially with strong clinical leadership. The ICM varied across the IPCCs (Fig. 4).

Table 1 summarises the associations of the ICM with integration. Supplementary File #2 provides more details of the IPCCs, their inputs, mechanisms, structures and contexts.

Table 2 summarises the commonly reported enablers and barriers to the use of HIS and tools to support integration in the seven sites examined.

3.1. Findings synthesised and analysed by ICM dimensions

The findings were synthesised using the ICM and integration dimensions and, where appropriate, related to observations in the literature [21].

3.2. ICM 1: collecting and managing information within the IPCC

Communication and sharing of health information within the IPCC and with "parent organisations" was mainly through a shared HIS and/or internal messaging or email systems for care and inter-professional case conferencing. Some internal messaging systems were linked to patient records, which increased their usefulness beyond communication to being a referral system with tools to file and track relevant documents (*Site2-Mel* and *Site6-NSWrural*). Many co-located specialists and AHPs continued to use their own or other HIS imposed on them by external organisations such as Local Health Districts. Psychologists avoided sharing clinical information because of perceived confidentiality issues. Pharmacists associated with *Site6-NSWrural* used their own software to complete and print Home Medication Review reports which were then scanned into the IPCC system.

3.2.1. Information infrastructure

The managerial and clinical systems served their specific purposes reasonably well, but were inadequate to support integrated care. The multiple appointment systems used by co-located services were often non-interoperable. Despite conformance with Secure Message Delivery standards, different messaging systems could not communicate with one another within the IPCC or with external agencies. The organisational policies and requirements of "parent" bodies such as Local Health Networks often forced the use of non-interoperable disparate systems. Bandwidth was a problem for online digital tools in rural settings (*Site6-NSWrural*).

3.2.2. IT support

IT support, mostly provided remotely, varied with organisation size. *Site3-Adl* received IT support from the parent company operating the IPCC. The rest had external IT support provided by a commercial entity and/or partner organisation such as the Medicare Local (*Site1-NSWRegional* and *Site6-NSWrural*) and/or Local Heath Network (*Site2-Mel*, *Site6-NSWrural* and *Site7-Mel*). IPCCs were mostly satisfied with IT support. Software user training was often done in-house e.g. one-to-one or during a staff meeting, or by the Medicare Local. Staff were generally unaware of any available training or software manuals.

> "*Absolutely,…they're not using it to the best capacity because they haven't been shown how to…putting strategies in place now to make sure that (appropriate training) does happen.*" (*Site6-NSWrural*).

3.3. ICM 2: information sharing with others in the health neighbourhood

Conventional fax was widely used to share reports with pharmacists (*Site1-NSWregional*) and letters with specialists (*Site6-NSWrural*). All IPCCs used secure messaging to receive pathology results. Secure messaging was likely used interactively with a small proportion of the IPCC referral network that was motivated to use it. Web based services enabled GPs to view X-rays (*Site7-Mel*) or for coordination of care e.g. CDM-Net [26].

Digital faxes were more often sent than received. Incoming faxes of letters, discharge summaries or management plans were often printed and scanned, rather than imported directly as digital images into the patient record. These multiple paper copies, along with copies received by snail-mail, caused confusion and potential for errors.

> "*Most hospitals actually fax and send hard copies, which ends up duplicating things… (this is) confusing and time consuming*" (*Site7-Mel*).

> "*No streamline of information between systems (in the wider Local Health District). Results in misinformation, human error e.g. list of medications at pharmacy is different to practice records.*" (*Site6-NSWrural*).

All the IPCCs used their own service directory or one supplied by the Medicare Local or state government; the common problem noted was how to keep them current.

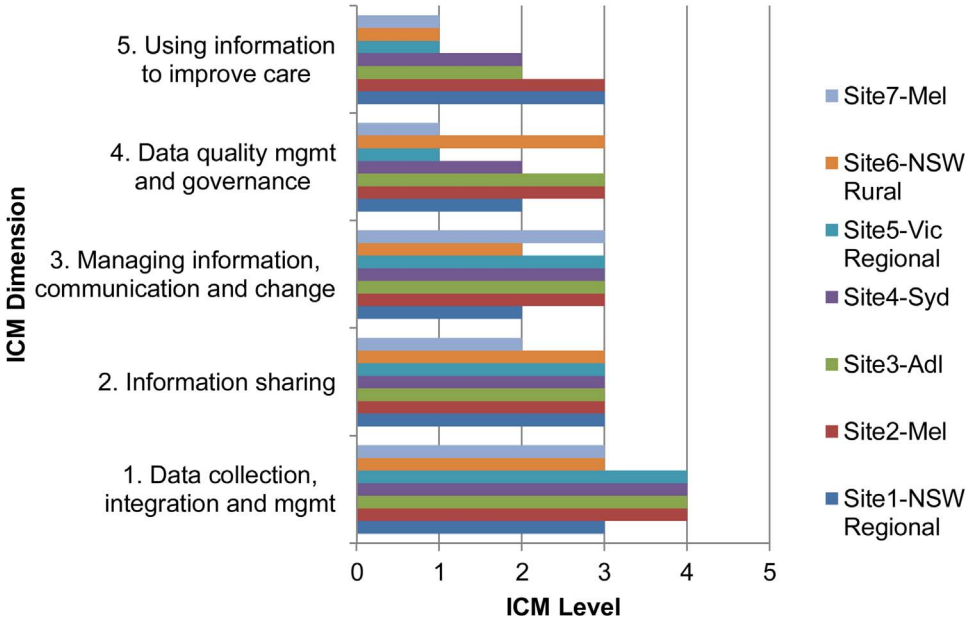

Fig. 4. Levels of informatics capability maturity of IPCC sites.

3.4. ICM 3: managing information and communications technology, implementation and change

3.4.1. Sustainability

System and service integration is generally supported by IPCC organisational revenue, with additional funding through Medicare Benefits Schedule Enhanced Primary Care items [27] and externally-funded quality improvement projects. *Site2-Mel* found a sustainable service niche in mental and student health. *Site6-NSWrural* had funding from the NSW Integrated Care Strategy to develop eHealth and integration infrastructure and services. However, shortcomings of the rural digital infrastructure and workforce shortage are risk factors.

3.4.2. Marketing and patient engagement

Most IPCCs, except for *Site6-NSWrural*, had a website and Facebook presence, although patient engagement with Facebook was low. Apart from *Site1-NSWRegional* and *Site5-VicRegional*, IPCCs' web presence was through their parent organisation's website. *Site2-Mel* had a secure website where repeat prescriptions could be initiated although it was only used approximately four times a month by patients. Where the online appointment system was working well (*Site2-Mel*), it was popular with patients.

Patients interviewed were comfortable with their personal information being on a computer system at the IPCC and share-able among clinicians. They did not express a need for a PCEHR [13]. All IPCCs were registered, but only two had interacted with the PCEHR

Table 1
Associations of ICM with information, systems and inter-professional integration by site.

Site	Informatics Capability Maturity (ICM)	Examples used to categorise ICM (Fig. 2 shows scale: basic-controlled-standardised-optimised-innovative)
Site 1: Rural enhanced general practice in regional NSW	Controlled to standardised	• Management plans to support team care developed by GPs and Practice Nurses (**PN**) • Clinical information used to improve patient management by team. • Shared EHR facilitated PN & Allied Health Professionals (**AHP**) contribution to care • Regular recalls using health information system (**HIS**)
Site 2: Urban GP Superclinic (Melbourne)	Standardised to optimised	• Multiple billing, appointment and recording systems with some integration • Data to improve data quality and manage & monitor care. • **cdmNet** (an online care planning tool) used to share the management of chronic disease and preventive care with others
Site 3: Urban GP Superclinic (Adelaide)	Controlled to optimised	• Shared electronic health record (**EHR**) worked well for clinicians in sharing information • Interoperability problems between EHR, secure messaging & dispensing systems
Site 4: Urban GP Superclinic (Sydney)	Controlled to optimised	• Online appointments reduced errors • Coding of data was inconsistent which could impact on disease registers or searches • IPCC EHR not accessible to all clinicians who provided services in the IPCC
Site 5: Rural GP Superclinic (regional Victoria)	Basic to optimised	• Multiple clinical, billing & appointment systems were not integrated, leading to double entry of information within this Integrated Primary Care Centre (**IPCC**). • GPs, PNs & external providers did not consistently enter data into the IPCC EHR • Problems with online appointment, SMS reminder & internal messaging systems.
Site 6: Rural HealthOne in NSW	Controlled to standardised	• Integrated clinical, billing and appointment systems for practice & local health district (**LHD**) staff • Access to practice EHR was useful for LHD staff but double entry of information was still required for some patients. • Management plans/team care included GP, PN & LHD staff
Site 7: Urban community Health Centre (CHC) in Melbourne	Controlled to standardised	• Multiple clinical, appointment and billing systems (silos) • General Practice & CHC appointment systems not aligned • Access and use of shared EHR varied between clinical staff • CHC staff access but don't consistently add to IPCC EHR • Duplication of records for AHPs

Table 2
Enablers and barriers influencing the development and use of ehealth tools.

Enablers	Barriers
Adequate/additional resources to support the implementation of eHealth strategies: • Dedicated time and positions, eg. PN or Clinical Manager to retrieve and use clinical data, review data quality and train other clinicians. • Australian Primary Care (APC) Collaboratives sponsored quality improvement projects that facilitated the use of observational clinical data in EHRs **A positive and cooperative team and working environment:** • A supportive organisational culture promotes change and implementation of new eHealth tools and systems. **Clinician leadership:** • A knowledgeable local champion is important. • Champions need adequate/additional resources to promote and support sharing of information. **A shared EHR:** • Facilitates involvement of PNs and AHPs in care. • Improves information sharing between practice and LHD staff.	**Inadequate internal and/or external support for eHealth initiatives:** • Not all health providers have or use technology to share information. • A lack of clinician leadership and engagement limits implementation of HIS. • Difficult to sustain eHealth initiatives without external support, e.g. from Medicare Locals or APC Collaborative projects. • Slow network and inadequate infrastructure result in time inefficiencies. • Management level dysfunction impacts decision making and implementation of eHealth systems. **Inadequate information and communication technology systems to support integrated care:** • A lack of software packages meeting the needs of all clinicians forces the use of multiple systems. • Misinformation, human error and inefficiencies e.g. double documentation. **Problems with connectivity and interoperability between the managerial and clinical information systems:** • Challenging to interact with providers in the health neighbourhood • No universal secure messaging systems to share information. • Sites forced to use disparate systems because of disparate requirements of partnering/collaborating organisations. • No common terminology used in available HIS. • Limited "coding" by clinicians affects data quality and efficacy of systems.

system: *Site3-Adl* was uploading summaries; one GP in *Site7-Mel* used the PCEHR for methadone patients.

3.4.3. Engagement of health care professionals

All IPCCs identified at least one local champion from among the clinical and managerial staff, with the degree of enthusiasm varying according to the positivity of the organisational culture and environment. *Site1-NSWRegional* was owner-operated and clinician-led. *Site4-Syd* was owner-operated and management-led, with a focus on corporatisation and expansion. Not surprisingly, *Site4-Syd* scored better with information management, especially managerial, and *Site1-NSWRegional* scored better with implementation and change management. *Site2-Mel*, *Site3-Adl* and *Site5-VICRegional* were management-led; however, only *Site2-Mel* and *Site3-Adl* had management structures that included a Clinical Director. Medical and nursing professionals in IPCCs were usually employees, while other co-located health professionals had tenancy or service agreements. There was an underlying tension between the clinical and managerial professions and, to a lesser extent, between allied health and medical-nursing professions.

3.4.4. Team culture, roles and responsibilities

Apart from *Site5-VICRegional* and *Site7-Mel*, the multidisciplinary teams appeared to be cohesive and functional. While the GPs and PNs in *Site4-Syd* worked well together in service delivery, there was no formal structure to develop and support a multidisciplinary team. The key difference appeared to be clinician leadership generally, and specifically with Clinical Directors in the managerial model. *Site6-NSWrural* worked particularly well, which was likely associated with being in a small rural community, with local champions and additional resources from the state. Good existing working relationships promoted positive team working environments. The complexity and extent of professional division in the organisation (*Site7-Mel*) adversely affected team function, while good clinical and managerial leadership, a less hierarchical management structure and inclusive governance promoted it.

3.5. ICM 4: managing data quality and governance

3.5.1. Data security

The Practice Manager was responsible for HIS security, often with assistance from external IT agencies. *Site4-Syd* had a privacy policy that included written consent for use of personal health information during patient registration. *Site6-NSWrural* sought written consent to share health information with third parties e.g. hospital. *Site3-Adl* obtained verbal informed consent for inter-professional record-sharing. *Site2-Mel* sought consent for particular purposes, rather than a general consent at registration. The parent organisation of *Site7-Mel* assisted with privacy policy and information exchange. Certain areas of the patient record could be "locked down" to restrict access to others. Most participants were not aware that unencrypted email is insufficiently secure for use to share personal health information.

3.5.2. Data quality

Data quality was organisation-wide, involving the Practice Manager and clinicians (*Site1-NSWRegional*, *Site4-Syd* and *Site6-NSWrural*) in activities like "coding", data cleaning and archiving inactive records. PNs usually did the data cleaning as did the Clinical Director in *Site3-Adl*. *Site2-Mel* reported duplication of patient records. *Site6-NSWrural* reported information gaps due to use of standalone systems to do health assessments, leading to issues with follow-up and review which uses the IPCC's HIS. *Site4-Syd* informally monitored "coding" of the managerial data, after a traumatic experience with data corruption when merging the systems from two sites. They also reported that universal access to patient records could cause record corruption. Clinicians didn't always update or enter data in the HIS, partly because not all patients in the IPCC were their patients.

PNs in *Site6-NSWrural* conducted regular audits/data cleaning, focusing on data accuracy and "coding" of diseases and medications. PNs coded their records, including with diagnoses from discharge summaries and specialist letters. All *Site6-NSWrural* staff had been taught to use standardised terms to code data within the IPCC, with plans to include Local Health District staff as part of the NSW Integrated Care strategy. Participation in a Medicare Local Quality Improvement group enabled the PN from *Site7-Mel* to learn how to clean data and implement a diabetes register.

3.6. ICM 5: using health "intelligence" for individual and population health

3.6.1. ePrescribing and eDispensing

Patients at *Site2-Mel* can request repeat prescriptions through a secure website. Most of the IPCCs (*Site2-Mel*, *Site3-Adl*, *Site4-Syd*, *Site6-*

NSWrural, *Site7-Mel*) had digital tools (Medisecure or eRx systems) to transmit prescriptions to a central repository that dispensing pharmacies could access. Barcodes to scan prescription details into the pharmacy's dispensing system, greatly reducing the risk of error, were available. Australia does not have an electronic prescribing system because digital signing has not been implemented, requiring GPs to manually sign computer-generated paper prescriptions.

3.6.2. Appointments and scheduling

Scheduling services for a range of medical, nursing and AHP providers were particularly problematic with larger IPCCs (*Site2-Mel*, *Site3-Adl*, *Site5-VICRegional* and *Site7-Mel*) because of greater volumes, more complex workflows and more systems. Communication tools ranged from verbal to paper to electronic to online. Workflow challenges were best exemplified by *Site5-VICRegional* where systems from the partnering services were non-interoperable, requiring separate processes to schedule patients in the same location; the IPCC reception merely directed patients to their clinician. There were inefficiencies with double entry and manual generation of lists to share and transfer around. *Site7-Mel* had separate allied health and medical booking systems. However, reception staff could access both systems, resulting in more functional management. *Site6-NSWrural* had the advantage of being rural and small, where relationships were more established and facilitated change management.

3.6.3. Clinical decision support tools

Clinical decision support tools were not used consistently. The Cardiovascular Disease Absolute Risk Calculator and on screen prompts, e.g., about drug-drug interactions, were the most commonly reported. Information resources used were mostly online or available locally in the HISs. PNs also used mobile devices, such as tablets. Patients were often referred to websites including government-funded online resources, such as HealthInsite.

3.6.4. Generation of clinical and managerial reports

Practice reports were generated regularly. Management-led IPCCs did managerial reports well and clinician-led IPCCs did clinical reports well. PNs generated reminder lists for health assessments, clinical reports to create registers (*Site1-NSWRegional*, *Site2-Mel*, *Site3-Adl*, *Site4-Syd* and *Site6-NSWrural*), track diabetes cycles of care (*Site1-NSWRegional*, *Site2-Mel*, *Site4-Syd*, *Site6-NSWrural* and *Site7-Mel*), and enable participation in quality improvement activities (*Site1-NSWRegional* and *Site4-Syd*). Managerial reports may be as frequent as weekly in the larger IPCCs, and focused on billing, financial, service utilisation, productivity and clinical indicators. Productivity metrics for psychologists (*Site3-Adl*) and PNs (*Site4-Syd*) were monitored by these managerial reports.

3.6.5. Quality of data extracted from the HIS

Data was extracted from five IPCCs. Data completeness did not meet RACGP benchmarks for clinical practice [23]. The completeness, including accuracy and consistency, may be acceptable for research and quality improvement purposes [19,24].

3.7. Findings synthesised and analysed by integration dimensions

The findings are presented as the following integration dimensions: technology, data and information, health information system (HIS) and inter-professional and service integration [21].

3.7.1. Technology integration and interoperability

Managerial and clinical HIS performed consistently within knowledge silos. ICM was assessed as "controlled" (Fig. 2) based on non-interoperable appointments and scheduling systems described. The ability to view documents from other services (e.g. as scanned or faxed letters) was advantageous. However, these information resources were stored as images and not usable by computer systems to generate health summaries, warnings and other decision-support guidance. Where the digital information is exchanged directly between systems, any changes or errors as a result of this process may not be obvious. *Site6-NSWrural* emphasised that information must be quality assured. Non-interoperable HISs can adversely impact workflow, human resources and health information exchange.

3.7.2. Data and information integration and interoperability

To support integrated care, managerial and clinical HIS must be able to exchange data without loss of meaning. This requires a common health terminology, standardised data models and integrated software to ensure consistent implementations. Reported challenges with "coding" and "work-arounds" highlighted that systems interoperability and information consistency needed improvement. Along with limited use of the PCEHR system, we assessed data, information and knowledge interoperability as "basic".

3.7.3. Application integration and interoperability

HIS must be stable and data/information fit for purpose. The lack of use of electronic decision support was more prevalent with clinical than managerial implementations. Appointment and scheduling systems were difficult to manage and integrate. Integrated care planning between IPCC and partner hospital systems was hindered by non-interoperable HISs. Information portals and other information focused decision support tools did not appear well used. The ICM of all IPCCs ranged from "controlled" to standardised.

3.7.4. Service integration: care plans and referral templates

Care plans and referral templates were generally available in GP but not hospital systems. When they existed in both systems, they were often non-interoperable. IPCCs used care plans that included Medicare Benefits Schedule (MBS) Items [27], recall and reminders information (*Site1-NSWRegional*), in quality improvement and cycle of care projects (*Site4-Syd*) and in Continuing Professional Development programs (*Site3-Mel*). *Site3-Adl* developed templates for staff to access online. *Site5-VICRegional* used a hybrid system where care plan-based questions were printed and sent to patients; the PN subsequently entered the answers into the Local Health Network system. *Site6-NSWrural* and *Site7-Mel* used the tools available in GP systems because they were more user-friendly than those available in hospitals:

> "… *we all tended as a team to be more happy with (the GP system), their basic care plan, … it tends to work best with patients because they can understand what's actually written on it*" (*Site6-NSWrural*).

3.7.5. Patient perceptions of integration and integrated care

The extent of information-sharing, system and service integration was neither apparent nor of particular concern to patients interviewed. Perceptions and use of the PCEHR system, consumer health information portals and other patient decision aids was variable, ranging from "basic" to "optimised". International evidence suggests that patients most want online communication to enable making appointments, repeat prescriptions and tele-consultations by telephone, email or video with their doctors. There are complex inter-related reasons why many patients, particularly those with poor literacy, complex needs or who lack a usual GP or general practice, will struggle to navigate a health system despite physical and online resources [28–30]. Health information exchanges to address gaps in information flows between primary health care and services in other sectors of society are growing but facing sustainability challenges [31].

4. Conclusions

4.1. Is ICM associated with integrated care?

The pattern of variation summarised in Table 1 suggested that increasing ICM can increase service integration and integrated care. The context is important as the IPCCs showed a range of size, organisational structures, managerial and clinical leadership, stability, team function and cohesion and independence (Supplementary File #1). This is also reflected in the direct relationship between managerial ICM and managerial leadership; similarly for clinical ICM and clinical leadership. The managerial and clinical teams appeared to have a positive influence on each other. Multidisciplinary teams, especially those with strong clinical leadership, appeared to be delivering coordinated services effectively. There was an implicit recognition that a good functional team of clinical and administrative staff is essential for the success of the IPCC.

4.2. Enablers or barriers to the use of HIS and digital tools for integrated care (Table 2)

The largely suboptimal collection of coded and accurate data for integrated care reported is likely to be due to the health system [32], poorly-designed HIS that are not fit for clinical or managerial purposes [33,34], and poor training in eHealth competencies and information literacy and support of end users [33,35]. Required improvements in information sharing, data quality management, incentives and governance were also highlighted [20,36].

4.3. Patient perceptions of eHealth and integration of care

Patients in this study appeared more concerned with how digital tools improve quality, continuity and accessibility of care than with integration. This may be a problem of semantics and/or a non-recognition that systems and service integration are intermediate steps to quality of care.

4.4. Implications

The Australian national eHealth strategy requires strong inter-professional governance and leadership to ensure safety, quality and integration of care, supported by standards for data, metadata and secure messaging; a common terminology; integrated electronic decision support tools; data quality management and information governance. Clinician and patient engagement is integral to policy, governance and service delivery [2,22].

Strong leadership by clinical, managerial, software, health financing, government and community stakeholders is required to drive the regulatory and policy elements to support and sustain eHealth and integration, a standards-based infrastructure to share information cost-effectively, and implementation of robust and usable systems across all sectors of care.

The national policy and strategy for data governance, eHealth and integration must be complemented by a national approach to audit, feedback, continuous quality improvement, research and outcomes monitoring. A skilled clinical informatics profession, knowledgeable in semantic integration and interoperability [37,38] is required to sustain a culture that values good health information documentation and sharing to support good care and health.

Author contributions

Siaw-Teng Liaw conceived of the idea, developed the protocol and wrote the proposal for funding. He led the development of the instruments with Jane Taggart and Sarah Dennis.

Siaw-Teng Liaw, Rachael Kearns, Jane Taggart, Oliver Frank, Riki Lane, Michael Tam contributed to the qualitative data collectionand interpretation.

Sarah Dennis, Christine Walker, Grant Russell, Mark Harris provided input and advice during the course of the study.

STL wrote the paper and all co-authors contributed to the review and improvement of the paper.

Competing interests

None.

Summary points

- Mixed data collection methods included self-assessed ICM, document review, interviews, observations in practice and assessment of electronic health record data.
- Data was analysed and compared across the Integrated Primary Care Centres (IPCC) studied in metropolitan and rural Australia: an enhanced general practice, four GP Super Clinics, a “HealthOne” (private-public partnership) and a Community Health Centre.
- The IPCCs demonstrated a range of funding models, ownership, leadership, organisation and Informatics Capability Maturity (ICM).
- ICM is positively associated with integration of data, systems and care.
- Improved ICM requires a health workforce with eHealth competencies; technical, semantic and software standards; adequate privacy and security; and good governance and leadership.

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Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.ijmedinf.2017.06.002.

References

[1] G. Powell-Davies, D. Perkins, J. McDonald, A. Williams, Integrated primary health care in Australia, Int. J. Integr. Care 9 (4) (2009) 9.
[2] World Health Organisation Secretariat, Framework on Integrated, People-centred Health Services, World Health Organisation, Geneva, 2016 15 Apr. Report No.: A69/39.
[3] M. Johri, F. Beland, H. Bergman, International experiments in integrated care for the elderly: a synthesis of the evidence, Int. J. Geriatr. Psychiatry 18 (3) (2003) 222–235.
[4] G. Powell Davies, A.M. Williams, K. Larsen, D. Perkins, M. Roland, M.F. Harris, Coordinating primary health care: an analysis of the outcomes of a systematic review, Med. J. Aust. 188 (Suppl. 8) (2008) S65–S68.
[5] Australia Department of Health and Ageing, GP Superclinics National Program Guide, Australia Department of Health and Ageing, Canberra, 2010.
[6] M. Wiese, G. Jolley, F. Baum, T. Freeman, M. Kidd, Australia's systems of primary healthcare: the need for improved coordination and implications for Medicare Locals, Aust. Fam. Physician 40 (12) (2011) 995–999 Melbourne.
[7] S. Shaw, R. Rosen, B. Rumbold, What Is Integrated Care? An Overview of Integrated Care in the NHS London, Nuffield Trust, 2011 June.
[8] Commonwealth of Australia Standing Council on Health National Primary Health Care Strategic Framework, Commonwealth of Australia, Canberra, 2013.
[9] NSW Health, NSW State Health Plan Towards 2021, N.S.W. Health, Sydney, 2014.

[10] NSW Health, A blueprint for eHealth in N.S.W, N.S.W. Health, N.S.W Health, Sydney, 2011.
[11] South Australia Health Departmenr. GP Plus Health Care Services and Centres, (2015) (Available from: http://www.sahealth.sa.gov.au/wps/wcm/connect/public+content/sa+health+internet/health+services/gp+plus+health+care+services+and+centres).
[12] Victoria Department of Health Primary Care Partnerships, Victoria State Government, 2016 (Available from: Health.vic).
[13] C. Pearce, M. Bainbridge, A personally controlled electronic health record for Australia, J. Am. Med. Inform. Assoc. 21 (4) (2014) 707–713.
[14] UK Health & Social Care Information Centre, Developing Informatics Skills and Capability (DISC), (2016) (Available from: http://www.hscic.gov.uk/informaticsintro).
[15] T. Mettler, Maturity assessment models: a design science research approach, Int. J. Soc. Syst. Sci. 3 (1-2) (2011) 81–98.
[16] Australian Digital Health Agency What Is Digital Health, (2016) (Available from: https://www.digitalhealth.gov.au/get-started-with-digital-health/what-is-digital-health).
[17] D.L. Kodner, C. Spreeuwenberg, Integrated care: meaning, logic, applications, and implications-a discussion paper, Int. J. Integr. Care 2 (2002) e12.
[18] NSW Health Integrated Care Strategy 2014-17, in: NSW Health (Ed.), NSW Health, Sydney, 2014.
[19] S. Liaw, S. de Lusignan, An 'integrated health neighbourhood' framework to optimise the use of EHR data, J. Innov. Health Inform. 23 (3) (2016) 547–554.
[20] S. Liaw, G. Powell-Davies, C. Pearce, H. Britt, L. McGlynn, M. Harris, Optimising use of EHR data: current issues, evolving opportunities, strategies and scope for collaboration, Aust. Fam. Physician 45 (3) (2015) 153–156.
[21] S. Liaw, J. Taggart, H. Yu, S. de Lusignan, C. Kuziemsky, A. Hayen, Integrating electronic health record information to support integrated care: practical application of ontologies to improve the accuracy of diabetes disease registers, J Biomed. Inform. 52 (2014) 364–372.
[22] J. McDonald, G.P. Davies, M.F. Harris, Interorganisational and interprofessional partnership approaches to achieve more coordinated and integrated primary and community health services: the Australian experience, Aust. J. Prim. Health. 15 (4) (2009) 262–269.
[23] Royal Australian College of General Practitioners. Standards for General Practices, 4th edition; updated 2013, RACGP, Melbourne Victoria, 2010.
[24] J. Taggart, S.-T. Liaw, H. Yu, Structured data quality reports to improve EHR data quality, Int. J. Med. Inf. 84 (2015) 1094–1098.
[25] R. Pawson, N. Tilley, Realistic Evaluation, Sage, London, 1997.
[26] K. Jones, T. Dunning, B. Costa, K. Fitzgerald, A. Adaji, C. Chapman, et al., The CDM-Net project: the development, implementation and evaluation of a broadband-Based network for managing chronic disease, Int. J. Fam. Med. 2012 (2012) 7.
[27] Medicare Australia, Medicare Benefits Schedule, Medicare Australia, Canberra, 2017 (Available from: www.health.gov.au/internet/mbsonline/publishing.nsf/Content/Downloads).
[28] J. Levesque, M. Harris, G. Russell, Patient-centred access to health care: conceptualising access at the interface of health systems and populations, Int J Equity in Health 12 (2013) 18.
[29] D.C. Norman, A.H. Skinner, EHealth literacy: essential skills for consumer health in a networked world, J. Med. Internet Res. 8 (2) (2006) e9.
[30] D. Nutbeam, Health literacy as a public health goal: a challenge for contemporary health education and communication strategies into the 21st century, Health Promot. Int. 15 (3) (2000) 259–267.
[31] J. Adler-Milstein, D.W. Bates, A.K. Jha, Operational Health Information Exchanges Show Substantial Growth, But Long-Term Funding Remains A Concern, Health Affairs 32 (8) (2013).
[32] J. Brennan, A. McElligott, N. Power, National health models and the adoption of E-Health and E-Prescribing in primary Care—New evidence from europe, J. Innov. Health Inform. 22 (4) (2015) 399–408.
[33] D. Kaufman, V. Patel, C. Hilliman, P. Morin, J. Pevzner, R. Weinstock, et al., Usability in the real world: assessing medical information technologies in patients' homes, Biomed. Inform. 36 (1–2) (2003) 45—60.
[34] B. Middleton, M. Bloomrosen, M.A. Dente, B. Hashmat, R. Koppel, J.M. Overhage, et al., Enhancing patient safety and quality of care by improving the usability of electronic health record systems: recommendations from AMIA, J. Am. Med. Inform. Assoc. 20 (2013).
[35] V.C. Chan, R.D. Kaufman, A framework for characterizing eHealth literacy demands and barriers, J. Med. Internet Res. 13 (4) (2011) e94.
[36] S. Liaw, C. Pearce, H. Liyanage, G. Cheah-Liaw, S. de Lusignan, An integrated organisation-wide data quality management and information governance framework: theoretical underpinnings, Inform. Prim. Care 21 (4) (2014) 1–8.
[37] D.E. Detmer, Capacity Building in e-Health and Health Informatics: A Review of the Global Vision and Informatics Educational Initiatives of the American Medical Informatics Association IMIA Yearbook vol. 1, (2010), pp. 101–105.
[38] S. Liaw, K. Gray, Clinical health informatics education for a 21st century world, in: E.K.M. Hovenga, S. Garde, C.H.L. Cossio (Eds.), Health Informatics: An Overview. Studies in Health Technology and Informatics, vol. 151, IOSPress, 2010.