An evidence-based framework for the implementation of digital health technologies in primary healthcare: what, where and for whom?

Jimenez Larrain, G.

PART II – DIGITAL TECHNOLOGIES FOR ENHANCING PRIMARY HEALTHCARE

Chapter 4 – The role of health technologies in multicomponent primary care interventions: A systematic review

Geronimo Jimenez, David Matchar, Gerald Koh, Rianne MJJ van der Kleij, Niels H. Chavannes, Josip Car

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ABSTRACT

Background: Several countries around the world have implemented multicomponent interventions to enhance primary care (PC), as a way of strengthening their health systems to cope with an ageing, chronically ill population, and rising costs. Some of these efforts have included technology-based enhancements as one of their features to support the overall intervention, but their details and impact have not been explored.

Objectives: To identify the role of digital/health technologies within wider, multi-feature interventions aimed at enhancing PC, and to describe their aim and stakeholder, type of technologies used, and potential impacts.

Methods: A systematic review was performed, following Cochrane guidelines. An electronic search, conducted on 30 May 2019, was supplemented with manual and grey literature searches in December 2019, to identify multicomponent interventions which included at least one technology-based enhancement. After title/abstract and full text screening, selected articles were assessed for quality based on their study design. A descriptive, narrative synthesis was used for analysis and presentation of results.

Results: Fourteen out of 37 articles (38%) described the inclusion of a technology-based innovation, as part of their multicomponent interventions to enhance PC. The most common identified technologies were the use of electronic health records, data monitoring technologies and online portals with messaging platforms. The most common aim of these technologies was to improve continuity of care and comprehensiveness, which resulted in increased patient satisfaction, increased PC visits compared to specialist visits, and the provision of more health prevention education and improved prescribing practices. Technologies seem also to increase costs and utilization for some parameters, such as increased consultation costs and increased number of drugs prescribed.

Conclusions: Technologies and digital health have not played a major role within comprehensive innovation efforts aimed at enhancing PC, reflecting that these technologies have not yet reached maturity or wider acceptance as a means for improving PC. Stronger policy and financial support is needed, as well as the advocacy of key stakeholders, to encourage the introduction of efficient technological innovations, backed by evidence-based research, so that digital technologies can fulfill the promise of supporting a strong, sustainable primary care.

INTRODUCTION

Primary care (PC) is often considered a cornerstone of health care systems. Health systems with strong primary health care produce better and more equitable health outcomes, are more efficient and can achieve higher user satisfaction in comparison to health systems with only a weak PC orientation.[1,2] Changing demographics, an increasingly ageing population, and the increased burden of non-communicable diseases have been identified as new challenges for health systems worldwide,[3-5] and strengthening PC has been proposed as one solution to address these.

Box: Useful definitions

Multicomponent interventions: programs or strategies composed of several innovations/ features to enhance PC.

Innovation features: individual innovation elements included in multicomponent interventions (see Appendix B).

Health technologies: application of scientific knowledge to solve healthcare-related problems, including its corresponding machinery and equipment (includes IT, digital health, eHealth, mHealth, etc.).

4Cs: the primary care core functions – first contact, comprehensiveness, coordination, and continuity

Quadruple aim outcomes: the four types of outcomes to measure successful health system improvements (population health outcome, healthcare utilization and costs outcomes, patient satisfaction, and provider satisfaction)

Many countries have implemented a wide array of innovations to enhance PC, ranging from policy initiatives, such as capitated reimbursement, to ground level improvements, such as improving access to PC practices or enhancing roles of nurses to provide comprehensive PC services.[6-8] As in other fields such as finance, retail, and agriculture, an increasingly important domain for innovation involves the incorporation of technology. Technologies are having an impact on health service delivery and health systems administration, and promise to provide solutions for improving PC.[9,10]

There have been many studies emphasizing individual digital technologies for improving specific aspects of healthcare and PC. Some of these include digital health assistants to help with administrative tasks, medical chatbots to engage patients more frequently, and the use of electronic health records and telemedicine, among others.[9-11] But no studies have explored the role of technologies within multicomponent efforts to enhance PC, i.e. whether within initiatives comprised of several components aimed at enhancing PC, there was a technology element being introduced and, if yes, what they were.

We aimed to systematically explore the role that health/digital technologies play in multicomponent efforts designed to improve PC, by identifying (1) the type of technologies implemented, (2) the functional objective of the technology, (3) the relevant stakeholders, and (4) whether they have an impact on enhancing the defining features of PC (first contact, comprehensiveness, coordination, and continuity),[12] denoted here as the "4Cs". We explored the overall outcomes of the multicomponent interventions in which technology is one component to attempt to discern the specific contribution of the technologies within these efforts.

METHODS

A systematic review was designed and performed following Cochrane guidance for conducting systematic reviews.[13] The detailed methods for this review are described elsewhere,[14] and a summary is provided in what follows.

An electronic database search was performed in order to identify: (1) multicomponent interventions or "innovation environments" aimed at enhancing PC (with at least three innovation elements); (2) influencing at least one of the PC core functions (4Cs), and (3) reporting on any of the of 4 basic outcomes of a successful health system (the so-called "quadruple aim" outcomes: population health, healthcare costs and utilization, patient satisfaction and provider satisfaction)[15]), and providing numerical values for at least five outcome measures.

A search strategy was developed, focusing on three main sets of terms: (1) primary care-related terms; (2) innovation/reform/enhancement-related terms, and; (3) study design filters (Appendix A). The electronic database search was performed in Ovid/MEDLINE on May 30, 2019 and supplemented by manual searches through the references of the included studies and by a grey literature search in opengrey.org, using "primary care" and "innovation", on Dec 12, 2019. From the studies fulfilling these criteria, we selected those that had technology-based enhancements as part of the elements in their multicomponent interventions.

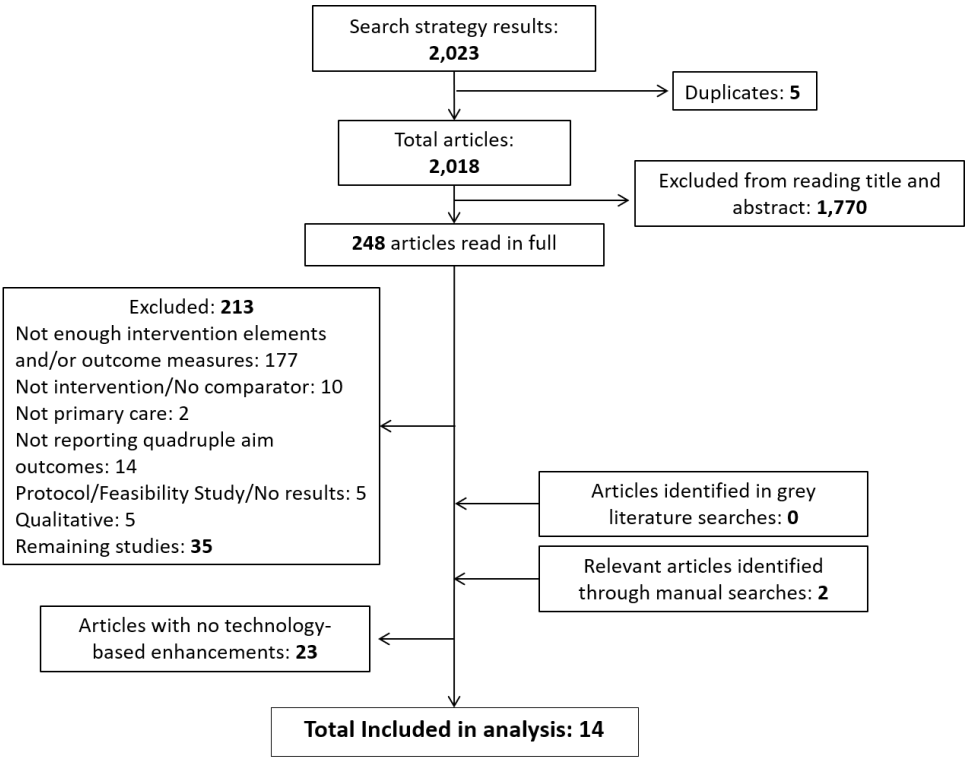
We defined health technologies as the "application of scientific knowledge for practical purposes, including its corresponding machinery and equipment, to solve healthcare-related problems and improve quality of life"[16] and encompassing digital health technologies -- the overarching term to include eHealth and mHealth, e.g. telemedicine, electronic health records (EHRs), wearable sensors, etc. -- and their corresponding medical and assistive devices.[9]

Quality evaluation of the included studies was based on study design, using the National Institutes of Health – National Health, Lung and Blood Institute's "Study Quality Assessment Tools",[17] a comprehensive suite of study evaluation tools, which has been used in a variety of systematic reviews.[18-20] Data extraction was performed using a predefined data extraction form including study characteristics and general information (author/year, setting/country, policy influence, study design and quality, patient population involved), PC intervention elements, and quadruple aim outcomes, including reported magnitudes for each outcome measure. A narrative, descriptive approach was utilized to identify and report type and specific details of the implemented technologies, involved stakeholders, whether and which 4Cs were arguably supported and outcomes influenced by the corresponding technology.

RESULTS

After the electronic search, subjecting the articles to the inclusion/exclusion criteria, manual reference and grey literature searches, resulted in 37 articles fulfilling the requirements for multicomponent innovations described above. From these, 14 studies had technology-based enhancements and were included for analysis (Figure 1).

Figure 1. PRISMA diagram describing study selection process.



Study characteristics

Articles were published between 2008 and 2017; half of them were published since 2016. Most described studies performed in the US (64%, n=9), four are from Europe (two from Germany, two from Spain), and one from Argentina. Eight articles mentioned policies influencing the implementation of the innovation programs, as broader country, regional or organizational efforts to enhance PC (Table 1).

Table 1. Studies' characteristics, organized by study type (n=14).

Author (Year)	Program name	Setting/ Context	Policy/ Government program influencing innovation	Study design	Quality evaluation rating*	Patient population (if any)	Innovation elements included in full intervention**	Types outcomes studied
Controlled Intervention Studies (n=3)								
Coderch et al (2016)[21]	N/A	Integrated health care organization in the region of Girona, Spain in 2011 (128,000 residents)	Catalonia's 2011-2015 health plan; creation of the Program for Chronic Condition Prevention and Care	Controlled, pragmatic, randomized clinical trial, with three arms: one blind control, and 2 open intervention groups	Fair	Complex chronic patients, who account for 5% of highest risk of highest health costs each year	- Accountability mechanisms - Care plan development - Improved access - Improved specialty care access - Enhanced coordination/ Information exchange efforts - Provider education or training - Technology enhancements	- Healthcare costs & utilization
Prestes et al (2017)[29]	DIAPREM study	Primary care units of La Matanza County, Argentina	N/A	Random selection of 30 PC providers and 30 nurses from 40 primary care units	Fair	T2DM patients	- Efforts to improve performance monitoring - Enhanced continuity/ transition-based efforts - Provider education or training - Technology enhancements	- Population health - Healthcare costs & utilization
Ruescas-Escolano et al (2014)[27]	PROPRES E Trial	Multicentric, primary care study (15 health centers), participating in the Cardiometabolic Valencian Study	N/A	Open randomized clinical trial with one-year follow-up	Good	Patients with ischemic heart disease	- Efforts to improve performance monitoring - Improved patient self-management - Provider education or training - Others - Team-based care - Technology enhancements	- Population health

Observational Cohort or Cross-Sectional Studies (n=6)								
Dale et al (2016)[22]	Comprehensive Primary Care (CPC) Initiative	A large and diverse set of practices in seven Center for Medicare and Medicaid Services (CMS) regions (in 4 states and 3 metropolitan regions in the US)	Launching of the Centers for Medicare and Medicaid Services' Comprehensive Primary Care Initiative, in October 2012	Pre-post design with comparison site	(Classified as retrospective cohort for quality evaluation) Fair	Medicare fee-for-service beneficiaries	- Care development plan - Case management - Improved access - Improved patient self-management - Payment-based enhancements - Social or community services engagement - Technology enhancements	- Healthcare costs & utilization - Patient satisfaction
Goff et al (2017)[23]	Buena Salud	Program implemented at Brightwood Health Center (BHC) in MA, an urban community health center with a largely Hispanic population (88%) insured primarily by either Medicaid (59%) or Medicare (28%)	N/A	Controlled before-and-after study	Fair	T2DM patients enrolled in the Buena Salud program	- Accountability mechanisms - Case management - Improved access - Improved patient self-management - Improved specialty care access - Social or community services engagement - Team-based care - Technology enhancements	- Population health
Maeng et al (2013)[24]	ProvenHealth Navigator	36 Geisinger-owned primary care practices, as well as 7 contracted primary care practices in GHP's provider	Patient-Centered Medical Home (PCMH) transformation in primary care.	Survey of patients in ''PHN sites''. A comparable survey of patients from non-PHN sites was	Fair	General patient population of PC practices enrolled in the	- Case management - Efforts to improve performance monitoring - Enhanced service capacity - Improved access - Improved patient self-management	- Patient satisfaction

		network. Geisinger's regional health care system is a provider to central, south-central and northeastern Pennsylvania and southern New Jersey		conducted for comparison		PHN program	- Payment-based enhancements	
Maeng et al (2012a)[26]				Multivariate logistic regression models with controls (members not in program)	(Classified as retrospective cohort for quality evaluation) Fair		- Social or community services engagement - Team-based care - Technology enhancements	- Population health
Phillips et al (2014)[28]	The Illinois Medicaid Health Connect and Your Healthcare Plus programs	Illinois Medicaid beneficiaries, corresponding to 15% of the total state population	The Memisovski v. Maram suit (2004) ruled that Illinois had violated federal law by not providing adequate access to primary care services for its Medicaid population, which made Illinois an early leader in comprehensive Medicaid reform	Analysis of Medicaid claims and enrollment data from 2004 to 2010, covering both pre- and post-implementation	(Classified as retrospective cohort for quality evaluation) Good	Medicaid beneficiaries	- Accountability mechanisms - Care plan development - Care management - Improved access - Payment-based enhancements - Provider education or training - Technology enhancements	- Healthcare costs & utilization
Wensing et al (2017)[33]	GP-centered care (GPCC) program	Introduction of a program to enhance the role of general practice for patients with chronic diseases in Baden-	N/A	Comparative evaluation based on two cross-sectional studies at 4 and 5 years after its start	Good	General population 18 years or older with at least primary	- Accountability mechanisms - Efforts to improve performance monitoring - Enhanced coordination/ information exchange efforts - Improved access	- Healthcare costs & utilization

		Wuerttemberg, a German federal state with about 10.7 million inhabitants.		(T1 and T2, respectively), based on data continuously collected for administrative control and reimbursement purposes		care one visit	- Improved patient self-management - Inclusion of new/enhanced roles - Payment-based enhancements - Pharmacy/ medication-related efforts - Provider education or training - Team-based care - Technology enhancements	
Case Control Studies (n=1)								
Freytag et al (2016)[32]	GP-centred programme	A major Statutory Health Insurance fund—AOK PLUS, which covers 41% of the population in central Germany—established a GP-centered healthcare program in 2011 in the German federal state of Thuringia	In Germany, enhanced primary care programs started in 2004 with the creation of a legal framework to support 'GP-centered health care'	Retrospective case–control study based on insurance claims data	Fair	General patient population	- Inclusion of new/enhanced roles - Payment-based enhancements - Pharmacy/ medication-related efforts - Provider education or training - Technology enhancements	- Healthcare costs & utilization
Before and After (Pre-Post) Studies with no control (n=4)								
Conrad et al (2016)[30]	Group Health Cooperative's Access Initiative	Primary care practices within the integrated care delivery system that serves the Puget Sound region in Washington state	N/A	Pre-post implementation productivity assessment	Good	Group health cooperative's enrollees	- Enhanced service capacity - Improved access - Improved specialty care access - Others - Payment-based enhancements - Technology enhancements	- Healthcare costs & utilization

Engel et al (2016)[34]	Geriatrics in Primary Care (GPC)	Two large medical center practices at the Veterans Affairs Boston Healthcare System in 2014	Adoption of the Patient Aligned Care Team model of care, which is adapted from PCMH, by the VA	Before-after evaluation of chart reviews	Poor	Veterans from the VA health system Boston, enrolled in the program	- Case/care management - Enhanced continuity/ transition-based efforts - Enhanced service capacity - Improved access - Team-based care - Technology enhancements	- Healthcare costs & utilization
Maeng et al (2012b)[25]	ProvenHealth Navigator	36 Geisinger-owned primary care practices, and 7 contracted primary care practices in GHP's provider network. Geisinger's regional health care system is a provider to regions of Pennsylvania and New Jersey	Patient-Centered Medical Home (PCMH) transformation in primary care.	Pre- post (measured at 6 points) and member fixed-effects model to measure within-member variation in the total cost and the PHN exposure variable over time	Good	GHP's Medicare Advantage plan members who were at least 65 years, and enrolled in clinics that became PHN sites	- Case management - Efforts to improve performance monitoring - Enhanced service capacity - Improved access - Improved patient self-management - Payment-based enhancements - Social or community services engagement - Team-based care - Technology enhancements	- Healthcare costs & utilization
Ralston et al (2009)[31]	Group Health's Access Initiative	Adult respondents (≥18 years) receiving care in Group Health's Western Washington Integrated Delivery System	Patient-centered system reforms (such as PCMH model of 2007) mentioned in the introduction as a shift in the way access to primary care is provided, which encouraged HMOs to change	Program impact evaluation, evaluating at three time points, based on the implementation dates of the Initiative's components	Fair	Adult respondents (≥18 years) receiving care in Group Health's Western Washington Integrate	- Accountability mechanisms - Improved access - Improved specialty care access - Others - Payment-based enhancements - Technology enhancements	- Healthcare costs & utilization - Patient satisfaction - Provider satisfaction

			their restrictive access system.			d Delivery System.		

*Ratings: Good/Fair/Poor. Study type linked to the tool used for quality evaluation.
** Full details of innovation elements in Appendix B.
Notes: N/A = Not applicable/available, or not reported in the articles; T2DM = Type 2 diabetes mellitus; GHP = Geisinger Health Plan; PHN = PatienHealthNavigator; AOK PLUS = health insurance scheme under Germany insurer AOK; VA = Veterans Affairs; PCMH = Patient centered medical home

In terms of study designs and quality evaluation results, three publications reported controlled interventions (2 of "Fair" and 1 of "Good" quality), six reported observational cohort or cross-sectional studies with controls (4 of "Fair" and 2 of "Good" quality), one reported a case-control study of "Fair" quality, and four were pre-post studies without controls (1 of "Poor", 1 of "Fair" and 2 of "Good" quality). Populations studied or linked to the results include general population enrolled in the programs (in 6 articles), chronically ill patients (either with one disease or complex chronic patients (in 4)), and special populations including elderly and disadvantaged (in 4).

The interventions in the articles include between 4 and 11 "innovation elements" (see Appendix B for definitions of innovation elements). The average number of innovation elements per intervention was 7 (median, 7), and the most common type of innovation element, besides technology-based enhancements (present in all interventions), were innovations to improve access (in 11 articles), payment-based enhancements (in 9) and care/case management (in 7). In terms of types of outcomes, the most commonly reported was healthcare costs and utilization (in 10 articles), followed by population health outcomes (in 4), patient satisfaction (in 3) and provider satisfaction (in 1). These are not mutually exclusive as one article reported on three outcomes, and two reported on 2 outcomes each. The remaining 11 articles reported on one outcome each.

Technology-based results

Thirty eight percent of the articles describing multicomponent interventions to enhance PC, e.g., "PC innovation environments" (14 out of 37), included technology-based enhancements as one of their innovation elements. According to the description of the articles, we were able to identify six broad categories for the types of implemented technologies (description below includes intended stakeholder and use) (Table 2):

Table 2. Technology types and details, stakeholders involved, 4C supported, and summary of outcomes (n=14).

Study	Technology based on	Specific technology innovation	Aim and stakeholder (patient/provider/admin-manager)	"4C" being supported by technology	General results and direction of the effects on quadruple health outcomes (of full intervention)
Coderch et al (2016)	- Electronic medical record	- Identification of patients: complex chronic patients are identified by labelling them in unique electronic medical record for providers - Proactive actions in PC: individualized care plan registered in unique electronic medical record for providers	For providers to be able to easily identify complex chronic patients under their care	Continuity	<u>Healthcare costs & Utilization</u> ↑ (significant increase in non-urgent primary care visits for partial and full interventions compared to each other and to control for both year 1 and 2) ↔ (mixed results for acute hospital admission and stay for year 1: significant decrease for partial intervention compared to control, but significant increase in full intervention compared to partial intervention; similar for readmissions <30 days in year 2, significant decrease for partial intervention and increase for full intervention when compared to each other) ↓ (increased number of prescriptions for full intervention compared to control for year 2)
Conrad et al (2008)	- Online messaging platform - Online patient portal/Website	- Patient-provider secure messaging through the MyGroupHealth enrollee website, including physician financial incentives for secure messaging patients - Internet access for enrollees to their electronic medical records (EMRs) through MyGroupHealth - Health promotion information on the MyGroupHealth secure website	For providers and patients, enhanced communication For patients to promote self-management (through access to their medical information and health promotion information)	Continuity Compr.	<u>Healthcare costs & Utilization</u> ↑ (significant increases in panel size per FTE and relative value unit per visit; significant decreases in visits per FTE and per member per quarter costs) ↔ (non-significant increase in relative value unit per FTE)
Dale et al (2016)	- Electronic medical record	- Optimal use of health IT, including:	For providers, to better use EHR, use	Compr. Coord. Continuity	<u>Healthcare costs & Utilization</u>

		- Improve EHR function and capability; develop practice capability for optimal use of EHR - Enable exchange of patient information to support care - Develop quality measurement and reporting from EHR	information to support patient care and improve quality monitoring		↑ (decreases in total Medicare expenditures (without initiative care-management fees), statistically significant decreases of PC visits and diabetes patients with no tests performed) ↔ (non-significant effects for hospitalizations, ED visits, specialist visits, admissions for ambulatory-care sensitive conditions, and likelihood of readmissions; no differences for test performed for diabetes or ischemic vascular patients) <u>Patient Satisfaction</u> ↑ (increased satisfaction with timely appointments, self-management support and discussion of medications) ↔ (non-significant differences for communication with providers, knowledge of providers of other services and patients' ratings of providers)
Engel et al (2016)	- Telephone - Electronic consultations	- Proactive telephone contact with veterans and caregivers, ready access to primary care colleagues, and informed use of telephone follow-up to enhance care while reducing nonessential clinic visits - Electronic consultation for formal referrals to Geriatrics in PC program	For providers, easier referral to services For patients, to reduce clinical visits, while enhancing care	First contact Continuity Coord.	<u>Healthcare costs & Utilization</u> ↑ (decrease in number of specialist visits after year 1 and 2, while maintaining number of PC visits)
Freytag et al (2016)	- Medication-specific IT tool	- Obligatory use of a specific IT–pharmacotherapy tool to support rational pharmacotherapy	For providers, to support rational prescription of medicines	Compr.	<u>Healthcare costs & Utilization</u> ↑ (decrease in cost of drug prescriptions; increase in GP consultations and decrease in specialist consultations, hospital use and remedies; decrease share of patient consulting more than one GP and accessing specialist without referrals, increased number of patients in disease management program, home visits, and decreased number of medical check-ups) ↓ (increases in cost of GP consultations and specialist consultations; increase in share of patients with 5 or more different medications)

					↔ (no change in number of ED hospitalizations or increases in nursery care level)
Goff et al (2017)	- Electronic health records - Use of insurer data	- Used electronic health registries to identify patients in need of care and services (quarterly, reviewed the data contained in EHRs and insurer data focusing on specific care parameters in care (i.e. ordered labs and mammography, scheduled PC visits, etc.))	For providers, to monitor care needs and ensure tests and visits	Continuity	<u>Population Health</u> ↑ (statistically significant changes in mean diastolic blood pressure and microalbumin/creatinine ratio test within 12 months) ↔ (no statistical difference for changes in A1C measures, lipid measures, or other blood pressure measures; changes for A1C tests, lipid panels)
Maeng et al (2012a, 2012b, 2013)	- Electronic health records - Online patient portal - Online messaging platform - Modeling and utilization data tools	- HIT optimized preventive and chronic care - EHR consistent and active delivery of information to other team members at point of care - Access to patient portal for reviewing medical records and secure messaging with providers - Predictive modelling and utilization data tools and normative management data to improve care	For providers, availability of patient information for all medical team members For providers and patients, enhanced communication For patients, access to their medical records to promote self-management For practices, improved monitoring for population care	Compr. Coord. Continuity	<u>Population Health</u> ↑ (decreased amputation and end-stage renal disease in intervention group) ↔ (no difference for myocardial infarction or stroke) <u>Healthcare costs & Utilization</u> ↑ (decreased per-member, per-month allowed costs; significant overall savings with and without Rx coverage interaction) ↓ (increases in cost of for Rx coverage, without considering other program costs) <u>Patient satisfaction</u> ↑ (improved perceived changes in care delivery, i.e. “noticed difference in care coordination and higher quality”; increased reporting of doctor’s office as usual care and decreased ER visits) ↔ (no significant changes for access to care or primary care provider performance)

Phillips et al (2014)	- Online registries/ report cards	- Multiple online tools such as registries and report cards to assist clinicians with population-based management	For providers, improved monitoring and population-based management	Continuity	<u>Healthcare costs & Utilization</u> ↑ (increased estimated cost savings and rate estimated annual savings; decreased hospitalization, bed-day, avoidable hospitalization rates; increased all quality measure changes (test and screenings)) ↔ (decreased ED visit rate for IHC but increased for YHP)
Prestes et al (2017	- Data monitoring system	- QUALIDIAB data system was used to verify the impact of the diabetes education intervention and the data collected is also useful to allocate resources (human and financial) considering real demand	For providers, to verify impact of intervention and allocate resources using collected data	Continuity	<u>Population Health</u> ↑ (statistically significant improvements for DBP, Glycaemia, HbA1c, Total cholesterol, LDL-c; increase of % patients with target SBP and HbA1c levels) ↔ (non-significant differences for Systolic BP, Creatinine, Proteinuria, HDL-c, DBP<80 mmHg, glycaemia < 100mg/dL, Cholesterol <200mg/dL, Triglyceride <150mg/dL) <u>Healthcare costs & Utilization</u> ↑ (statistically significant increases in dyslipidemia patients treated, eye tests and CV evaluations) ↔ (non-significant differences for dyslipidemia treated under target or any hypertension treatments)
Ralston et al (2009)	- Online patient portal - Online messaging platform	- Web Access for patients to provide: - Secure e-mail with physicians; Medical record access; Medication refills; Appointment scheduling; Discussion groups; Health promotion information	For patients, to facilitate access to physicians, making appointments and refill prescriptions, access medical records, supporting self-management	First contact Compr.	<u>Healthcare costs & Utilization</u> ↑ (improved “Getting Needed Care” and “Getting Care Quickly” scores) <u>Patient satisfaction</u> ↑ (improved satisfaction with ability to see personal doctor, time spent on phone and to appointment, ease of getting care and ratings of health care, health plan and opinion of Group Health) <u>Provider satisfaction</u> ↑ (improved perception of providers towards Group Health’s quality and services provided, and of Group Health as a good place to work)
Ruescas-Escolano et al (2014)	- Electronic medical records	- Use of unique EMR which allows for following control indicators and risk stratification	For providers, to monitor patients progress and manage risk	Continuity	<u>Population Health</u> ↑ (statistically significant improvements in smoking status, cholesterol and systolic BP) ↔ (non-significant differences for diastolic BP)

Wensing et al (2017)	- Medication-specific IT tool - Updated IT systems	- The practice has a data-orientated quality system and decision support for prescribing medication; prompts in software to support use of generic and discounted drugs - Practice has up-to-date information technology	For providers, to support medication prescription and promote generic medication use For practices, better organization to support easier patient' access	Compr. First contact	<u>Healthcare costs & Utilization</u> ↑ (decreased costs of medication therapy and of hospital admissions) ↑ (increased number of visits to family physician and mean number of prescription drugs; decreased number of prescriptions that should be avoided, contacts with specialist with and without referrals, hospital admissions, avoidable hospital admissions, number of days at hospital, readmissions)

Notes: Compr. = Comprehensiveness; Coord. = Coordination; FTE = Full time equivalent; IT = Information technologies; HER = Electronic health record; ED/R = Emergency department/Room; GP = General Practice/Physician; HbA1c/A1c = Glycated hemoglobin; IHC = ; YHP = ; D/SBP = Diastolic/Systolic blood pressure; L/HDL = High/Low-density lipids; CV = Cardiovascular

- Enhancements leveraging electronic medical/health records (EHRs):[21-27] most common category (reported in 7 studies from 5 interventions) and aimed at providers. Their use is related to identifying specific groups of patients (e.g. chronically ill) or specific needs of patients (e.g. services needed), exchange patient information, and develop quality measurements/control and risk stratification.
- Data monitoring technologies/online registries:[23-26,28,29] second most common category (in 6 studies from 4 interventions) and aimed at providers and practices. Related to the management of utilization data to allocate resources and improve care, help with population-based management, and check on the impact of programs.
- Web-based online portals and messaging platforms,[24-26,30,31] included in 5 studies (reporting on 3 interventions) and aimed at patients to access their medical records, obtain additional health promotion information and promote self-management, and facilitate access and communication with providers.
- Medication-specific eHealth/IT tools,[32,33] included in 2 studies and aimed at providers, to support pharmacotherapy and medication prescription.
- Telephone-based enhancements,[34] described in one article and aimed at providers to communicate with patients and caregivers, and provide follow-up to reduce patients' non-essential clinic visits.
- Electronic consultations between providers,[34] also in one study, to enhance geriatric referrals.

Based on the description of the technological enhancements included in the studies, we were able to link them to the 4Cs in the following way:

- First contact. Three programs aimed to apply technology to impact this feature through telephone-facilitated access to PC colleagues, facilitated appointment scheduling through web portals, and updated digital health systems for easier patient access.
- Comprehensiveness. Six interventions sought to increase the ability to manage a wider range of problems with technology, including providing additional health promotion information through patients' web-portals, and enhancing capacity for providers to better use EMRs, improving medication prescribing, and providing improved preventive and chronic care.
- Coordination. Three programs used technology to improve care coordination by improving EHR-enabled information exchange, and by allowing electronic consultations to facilitate care among PCs and specialists.
- Continuity. Nine interventions sought to enhance the personal and temporal relationship between patients and providers by enhancing the identification and follow-up of patients for individualized care, more comprehensive identification and monitoring of service needs, and by improving communication between patients and providers via online messaging or telephone contact.

Outcomes

Since this technology-based innovation elements are part of wider innovation environments, i.e., they include other types of enhancements, it was not possible to attribute outcomes specifically to the identified technologies. However, we still present the outcomes of the full innovation environments in

an effort to see whether it is possible to elucidate the potential role of these technologies in the outcomes. The numerical magnitudes for each outcome are presented in Appendix C (along with the details of the full intervention), and Table 2 and the paragraphs below present a descriptive summary and general direction of the effects for these outcomes.

Overall, the studies presented mixed results (i.e. non-significant changes, or significant benefits and deteriorations simultaneously for a specific outcome) for all types of outcomes, except for provider satisfaction, reported only in one study. The most consistent improvements, per type of outcome, include:

- Healthcare costs and utilization: increased costs savings and decreased costs for some parameters (e.g. Medicare expenditures decreased US$11 per beneficiary/month;[22] drug prescriptions decreased €44 per patient[32]); increased PC visits compared to specialists.
- Population health: improved blood pressure control, improved glycated hemoglobin, decreased amputations and end-stage renal disease, decreased smoking status.
- Patient satisfaction: increased satisfaction with timely appointments and self-management support, increased satisfaction with ability to see usual doctor.
- Provider satisfaction: improved perception towards place of work's quality and services provided, and as good place to work.

The most consistent mixed results by type of outcome include:

- Healthcare costs and utilization: non-significant changes, or simultaneous improvements and deteriorations depending on the study, for hospital admissions, readmissions, and emergency department visits.
- Population health outcomes: non-significant changes for cholesterol and lipid levels, myocardial infarction, and stroke.
- Patient satisfaction: no differences for communication with providers and for PC provider performance.

The most consistent deteriorations were found for some healthcare cost and utilization outcomes, such as increased number of prescriptions, increased costs for GP (e.g. intervention €27 more expensive than control, per patient) and specialist (intervention €22 more expensive than control, per patient) consultations,[32] and increased cost in prescriptions' coverage.

DISCUSSION

Only 38% of our identified multicomponent innovations aimed at enhancing PC included technology-based enhancements, highlighting the fact that technology has not played a major role in comprehensive efforts aimed at enhancing PC. This is not surprising, as it has been widely acknowledged that innovation in healthcare has always been difficult,[35] especially if it has involved digital or technological efforts.[36-38]

Most of the included articles reported on healthcare costs and utilization outcomes, signaling that technology-based efforts are either aimed at decreasing costs and utilization or at least not increasing costs without contributing to other aspects of system success. In fact, the only statistically significant unintended consequences were increased costs for GP and specialist visits, and increased costs of prescription coverage (in some studies), suggesting that introducing technologies in healthcare can lead to increased costs, as it has been consistently reported in the literature.[39-41]

The most common technology identified within these efforts was EHRs, which is also not surprising given the widespread advocacy for this technology,[42,43] and was aimed mainly at providers or practices to facilitate information exchange among them and improve monitoring efforts. The only identified technology aimed at patients was the deployment of online patient portals, where they can see their records, message their providers and access additional health information mostly for health promotion, which is in line with the idea that patients are ever more active participants in their own healthcare.[43,44]

When analyzing the interventions in terms of their impact on the 4Cs, the technologies implemented are mostly aimed at improving continuity, by increasing the identification and follow-up of patients (with labels in EHRs and telephone communication), enhanced monitoring efforts for identifying care and service needs (also mostly through EHRs and online registries), and more constant communication between provider and patient via online messaging. This reflects the growing importance of continuity of care, which in the past has had weak evidence linked to its benefits, but was recently highlighted as important, especially its link to decreased mortality risk.[45,46] Technologies have been promoted to improve comprehensiveness by providing additional health promotion information for patients and by improving the ability of providers for prescribing medications, reinforcing the ability of PC providers to cover a broader amount of issues themselves, and avoid over-referring.[46]

In terms of outcomes, the literature provides limited but useful information. For example, increased patient satisfaction with timeliness of care, scheduling, and better self-management support could be in part explained by the use of online patient portals. Such portals allowed patients to schedule appointments, see their own medical records and access additional prevention information. Increased PC visits, relative to specialist visits, appear to result from innovations that enhanced monitoring of services needed and follow-ups of patients (identified through EHRs and/or by telephone follow-ups). The introduction of medication-specific digital/IT tools could be associated to differing impacts: while studies reported a decrease in cost of drug prescriptions and medication therapies, they also reported an increase in the mean number of drugs prescribed, and was also associated to more costly consultations (around €25 extra per consultation).

In order for digital technologies to play a more prominent role in PC enhancement efforts, there is, first, a need for responsible policy to support their development and introduction.[47] For example, some of the PC enhancement environments have included explicit policy encouraging the introduction of technology or IT initiatives as part of their efforts.[22,32,48] To make this happen successfully, the technology must be seen as a tool to provide needed functions in a way that is effective, humane, and sustainable. Here the context in which the technology is to be used must be considered. It is essential to engage relevant stakeholders' to deeply understand their environment and capabilities so the

technology that is introduced will be truly useful, improve (or at least not disrupt) existing workflows, and have tangible value.[36,49] With regard to establishing value, there is a need for technologies to be linked to well-established, positive outcomes when introduced, taking into account their potential to improve health outcomes, costs, and patient and provider satisfaction.

There are some limitations for this study. The nature of the search and the specific requirements for including studies (i.e. those describing multicomponent innovation strategies aimed at enhancing PC, which provided numerical magnitudes for reporting quadruple aim outcomes) may have made us overlook other important technological innovations aimed at improving PC that had qualitative assessments only or did not measure quadruple aim outcomes. Additionally, the fact that technological enhancements were one of many components within a PC enhancement effort, our study eligibility criteria did not allow us to establish the actual and specific impact of the technologies on outcomes. However, it did help situate these technologies within multi-component innovation strategies and to gain preliminary insight into how technological enhancements may support other non-technologically based innovation elements, and their impact on the 4 PC pillars.

CONCLUSIONS

Although technology and digital health have been proposed and encouraged as possible solutions to improve PC, they have not played a major role in multicomponent efforts aimed at enhancing PC. Other type of non-technologically based innovations, such as those aimed at improving access, restructuring payments for providers and providing team-based care, have been much more widely implemented, reflecting that digital health technologies have not yet reached maturity or wider acceptance as a means for improving PC. Leveraging technologies already in use, such as EHRs, and internet-based technologies, such as online patient portals, seem to provide promising avenues to improve continuity and comprehensiveness in PC, which may eventually lead to better health outcomes and improved patient satisfaction. A stronger push is needed if technologies are meant to support wider efforts aimed at enhancing PC, and for them to play a more substantial role within these efforts. High level policy and financial support must be designed to focus on the needs of a diversity of stakeholders, and to encourage evidence-based research based on a coherent set of methods and measures. In this way we can hope to fulfil the promise of technologies and digital health to enhance health care through a strong, sustainable primary care.

Conflicts of Interest
None declared.

Multimedia Appendix 1
Search strategy.
[DOCX File, 14 KB-Multimedia Appendix 1]

Multimedia Appendix 2
Innovation elements and definitions.
[DOCX File, 16 KB-Multimedia Appendix 2]

Multimedia Appendix 3
Details of interventions and magnitudes of outcomes.

[DOCX File, 71 KB-Multimedia Appendix 3]

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