Making performance indicators work

Studies exploring the actionability of healthcare performance indicators applied to primary health care and COVID-19 decision-making

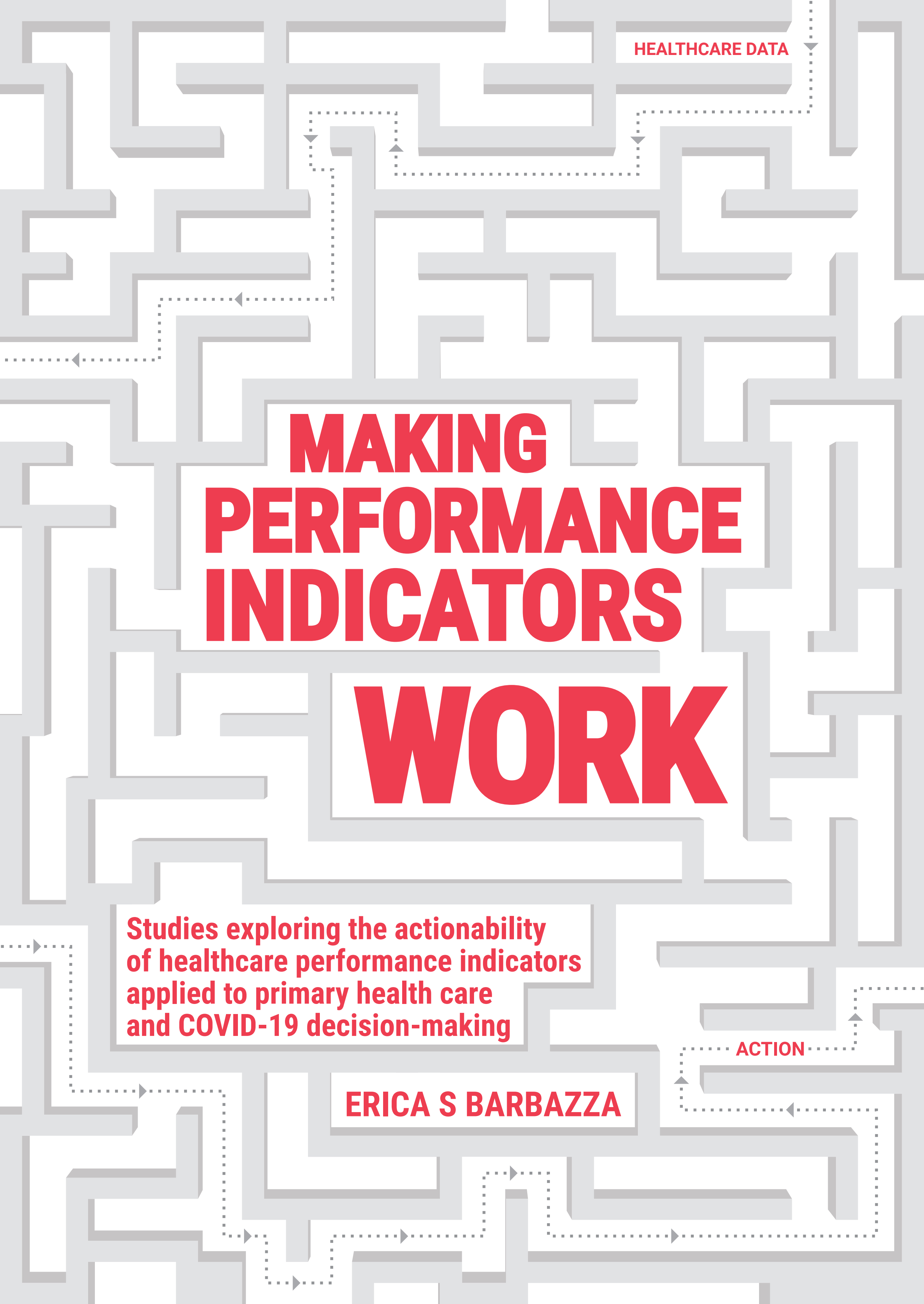
Barbazza, E.

Publication date
2022

Document Version
Final published version

Link to publication

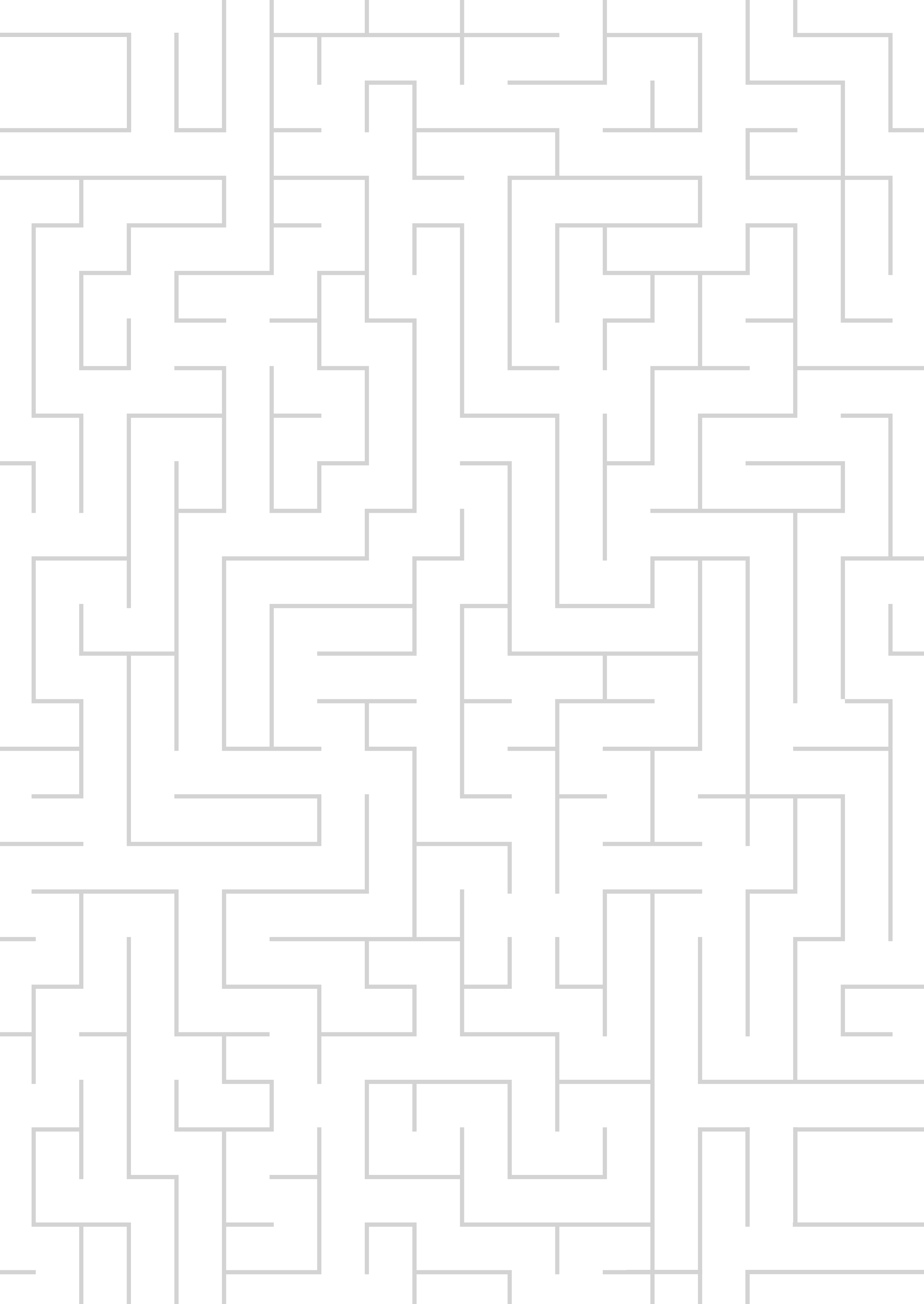
Citation for published version (APA):
Barbazza, E. (2022). *Making performance indicators work: Studies exploring the actionability of healthcare performance indicators applied to primary health care and COVID-19 decision-making*. [Thesis, fully internal, Universiteit van Amsterdam].



MAKING PERFORMANCE INDICATORS WORK

Studies exploring the actionability of healthcare performance indicators applied to primary health care and COVID-19 decision-making

ERICA S BARBAZZA



MAKING PERFORMANCE INDICATORS WORK

Studies exploring the actionability of healthcare performance indicators applied to primary health care and COVID-19 decision-making

Erica Stukator Barbazza

Making performance indicators work:

Studies exploring the actionability of healthcare performance indicators applied to primary health care and COVID-19 decision-making

Design and layout: Gabriel Bonța (Pointer Creative)

MAKING PERFORMANCE INDICATORS WORK

Studies exploring the actionability of healthcare performance indicators applied to primary health care and COVID-19 decision-making

ACADEMISCH PROEFSCHRIFT
ter verkrijging van de graad van doctor
aan de Universiteit van Amsterdam
op gezag van de Rector Magnificus
prof. dr. ir. P.P.C.C. Verbeek
ten overstaan van een door het College voor Promoties ingestelde commissie,
in het openbaar te verdedigen in de Agnietenkapel
op dinsdag 13 december 2022, te 15.00 uur
door Erica Stukator Barbazza
geboren te Toronto

Promotiecommissie

Promotor:	prof. dr. N.S. Klazinga	AMC-UvA
Copromotor:	dr. D.S. Kringos	AMC-UvA
Overige leden:	prof. dr. E.P. Moll van Charante	AMC-UvA
	dr. ir. R. Cornet	AMC-UvA
	prof. dr. S.E. Geerlingsprof.	AMC-UvA
	dr. R.A. Verheij	Tilburg University
	prof. dr. A.D. Brown	University of Toronto

Faculteit der Geneeskunde

Contents

General introduction 7

Part I: Conceptualising actionability 27

Chapter 1 Exploring the actionability of healthcare performance indicators for quality of care.. 29

Part II: Exploring actionability applied to primary health care 63

Chapter 2 Creating performance intelligence for primary health care strengthening in Europe.. 65

Chapter 3 The current and potential uses of Electronic Medical Record (EMR) data for primary health care performance measurement in the Canadian context.......93

Chapter 4 Optimising the secondary use of primary care prescribing data to improve quality of care in the Dutch context 125

Part III: Exploring actionability applied to COVID-19 dashboards.. 151

Chapter 5 Features constituting actionable COVID-19 dashboards.. 153

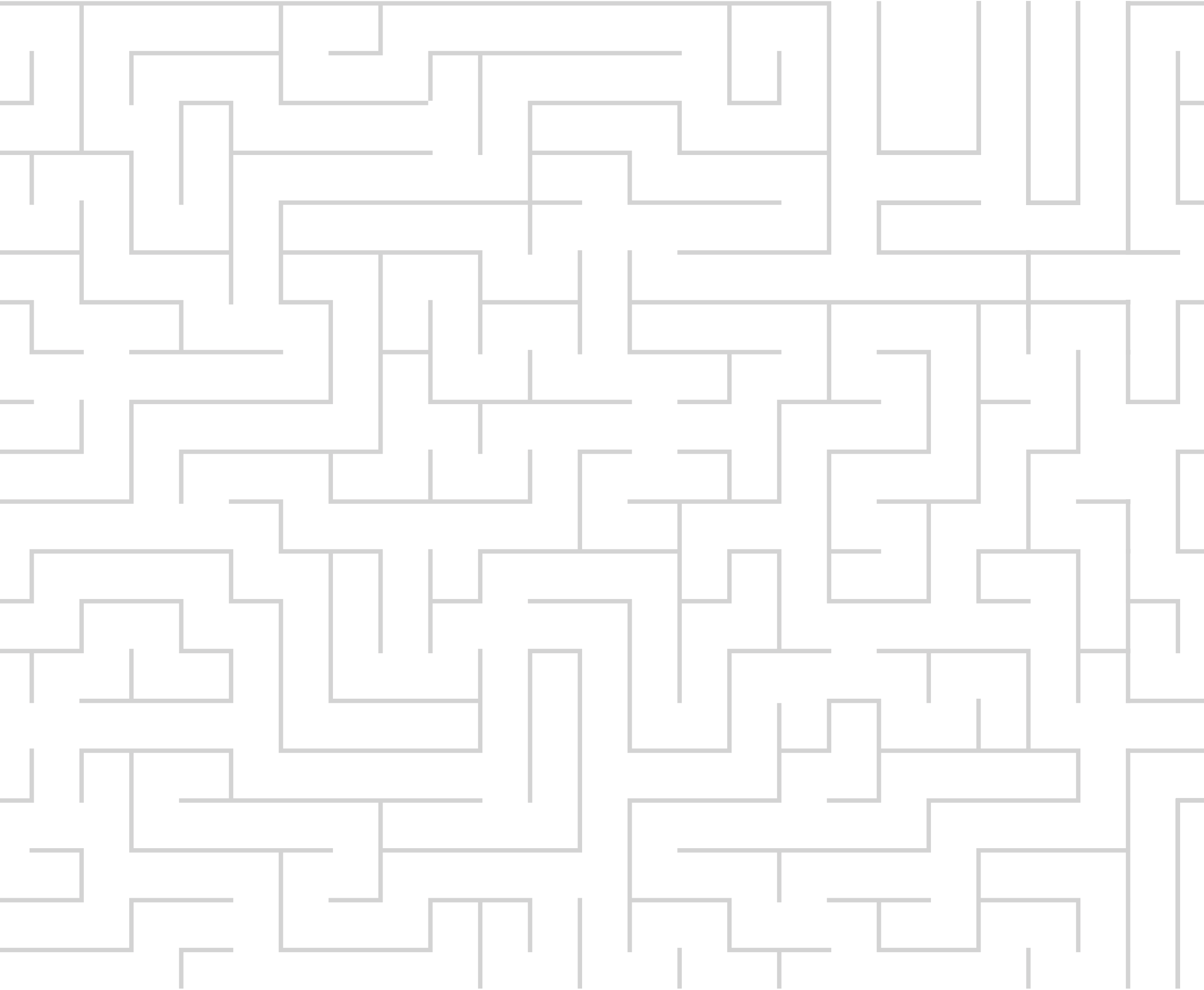
Chapter 6 Exploring changes to the actionability of COVID-19 dashboards over the course of 2020 in the Canadian context 207

Chapter 7 The experiences of 33 national COVID-19 dashboard teams during the first year of the pandemic in the WHO European Region 237

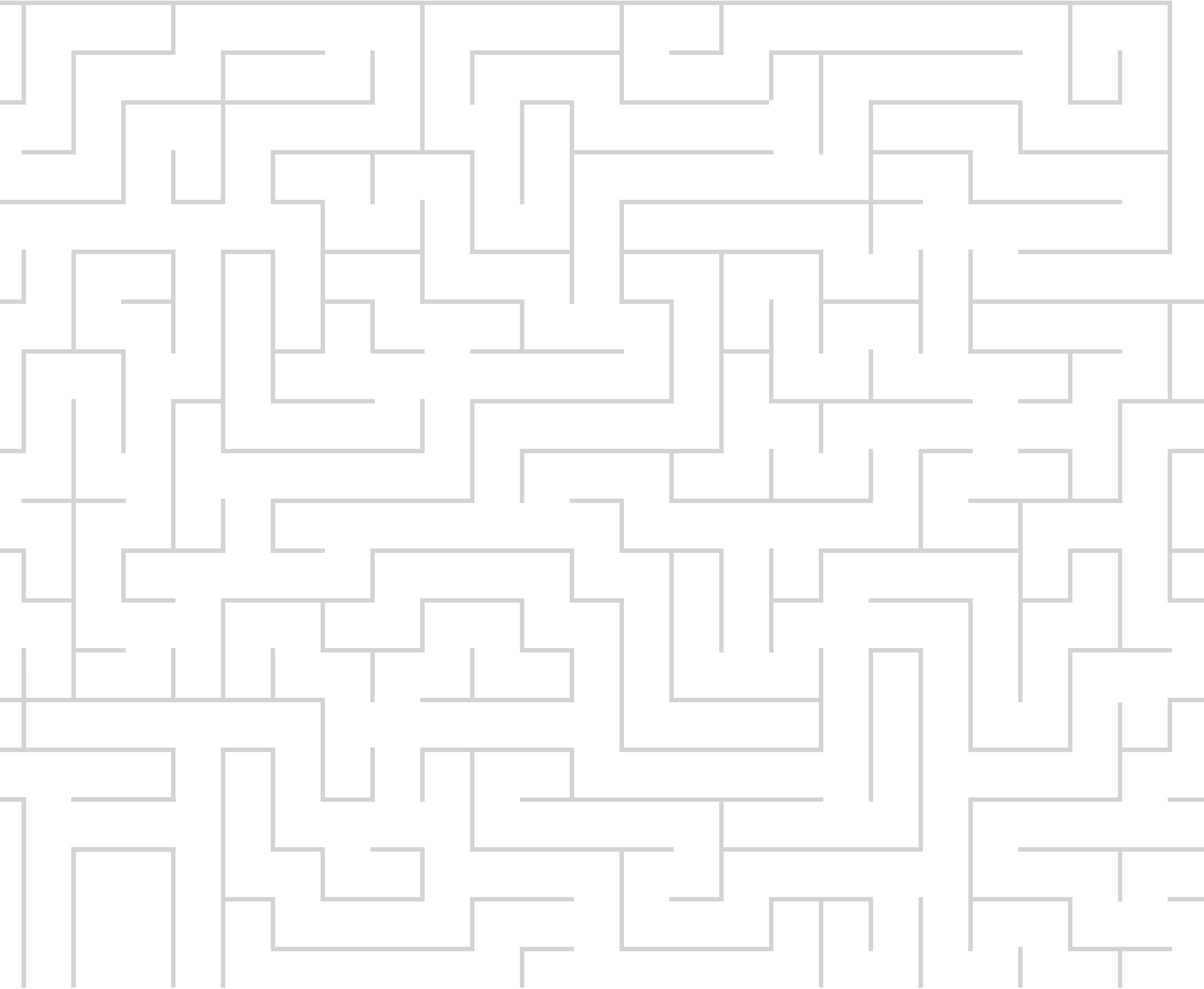
General discussion 271

Appendices.. 293

Summary 294
Samenvatting..299
PhD portfolio..305
List of publications.. 311
Author contributions 313
Funding.. 315
Acknowledgements.. 316
About the author.. 317



General introduction



The changing landscape of healthcare performance measurement

By definition, healthcare performance measurement 'seeks to monitor, evaluate and communicate the extent to which various aspects of the health system meet their key objectives' [1]. In doing so, performance measurement aims to quantify the work of healthcare professionals, organisations, and systems at-large. The information thus produced has applications across governance, management, and clinical decision-making [2,3].

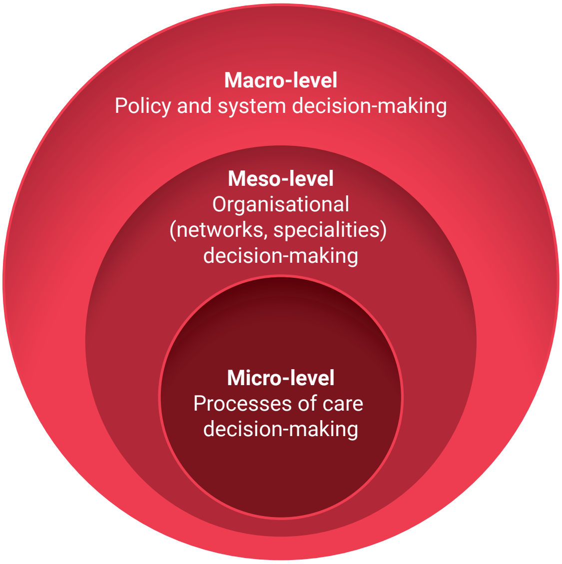
Formal arguments for the importance of performance measurement in healthcare are centuries-old, and stem from pioneers in the field like Florence Nightingale, Ignaz Semmelweis, Ernest Codman and Avedis Donabedian [1,4]. In the mid-1800s, Nightingale called attention to quality by assessing mortality and infection rates among soldiers in the Crimean War [4]. Around the same time, Semmelweis made the case for handwashing to reduce maternal mortality, after using measurement to make comparisons between maternity wards [5]. In the early 1900s, Codman championed the use of patient registries and systematic patient follow-up, demonstrating the use of measurement to learn from unsuccessful treatments in order to improve future care [6]. And, over the second half of the twentieth century, Donabedian famously introduced the structure–process–outcome model for measuring quality [7].

Over time, performance measurement has become increasingly commonplace in healthcare systems worldwide [1,8,9]. In the process, it has undergone a series of paradigm shifts. This includes moving from a focus on *volume-based* measurement to an emphasis on *outcome-based* measurement. That was spurred by developments in the 1980s and 1990s such as new public management, with its attention to performance outputs and outcomes, coupled with a judgment of quality [10,11]. Since the 2000s, a further fundamental shift has been witnessed as the focus has turned to *value-based* measurement. The Triple Aim, first described by Don Berwick and colleagues [12], made the case for population-focused high-value healthcare – improving people's experience of care, improving the health of populations, and reducing per capita costs of care for populations. The work of Michael Porter and colleagues extended value-based care and its measurement to the individual patient, emphasising the imperative of patient-reported measures of performance for gauging value [13].

Implementing *learning health systems* has been proposed as a key pathway towards value-based healthcare [14]. It represents yet another fundamental shift for healthcare performance measurement, its reporting, and its use as performance intelligence. Learning health systems, as first described by the American Institute of Medicine, represent an approach in which 'science, informatics, and care culture align to generate new knowledge as an ongoing, natural by-product of the care experience, and seamlessly refine and deliver best practices for continuous improvement in health and healthcare' [15]. As such, the concept of learning health systems sets out a new model for performance measurement, which 'harness[es] the power of data and analytics to learn from every patient and feed the knowledge of "what works best" back to clinicians, public health professionals, patients, and other stakeholders to create cycles of continuous improvement' [14].

Learning can be conceptually differentiated by levels of healthcare systems. These levels form distinct contexts which, at a minimum, include decision-making related to processes of care in the clinical context (micro-level); the context of organisations, including networks and specialities (meso-level); and the policy context of system decision-making (macro-level) (Figure 1). Importantly, learning must take place both within and across these contexts. Relatedly, healthcare system actors are heterogenous, differing according to the micro-meso-macro levels – from individual healthcare professionals, teams and managers to insurers, professional associations, inspectorates, academia, the public, and regional and national health authorities. Patients, as healthcare service users, are also an extremely relevant group of actors in the sphere of performance measurement and system learning. The use of performance measurement by patients merits special consideration, which is beyond the scope of this research. Theses dedicated to that topic through a healthcare performance intelligence lens are already available (eg, [10,16]).

Figure 1. Contexts of healthcare performance measurement for learning across healthcare systems



Source: Author's own.

Progress and pitfalls in the selection of healthcare performance indicators

Performance measurement is operationalised through the use of healthcare performance indicators, defined as 'measurable element(s) of practice performance for which there is evidence or consensus that [they] can be used to assess the quality, and hence change in the quality, of care provided' [17]. Indicator selection is an exercise of choice, with trade-offs between the prioritisation of what is measured and the limitations inherent to individual indicators. While there is no universal set of criteria for an error-free indicator, there are commonly agreed a priori characteristics [18]. These include the importance placed on indicators that are valid and reliable. The availability, comparability and feasibility of an indicator are other criteria it is often expected to satisfy, among other desirable attributes [3,18-20]. Additional criteria, such as parsimony and manageability [21], may be applied when indicators are used in combination as sets of performance indicators or as composite measures [22].

Over the past two decades, the field of performance measurement has been largely preoccupied with determining *what* to measure [23]. The scientification of this process, in the likeness of evidence-based medicine, has resulted in the refinement of rigorous methods and tools which can be applied to guide the indicator selection process. For example, the Delphi technique [24,25] and the RAND Appropriateness Method [26,27] are both structured processes by which scientific evidence is systematically combined with expert opinion and can be used to rate indicators. Other tools developed to systematise the rating and weighing of indicators include the Appraisal of Indicators through Research and Evaluation (AIRE) instrument [28], the Outcome Utility Index [29] and the Quality Indicator Critical Appraisal Tool [19].

The available methods and tools work to resolve the age-old challenge of selecting indicators and, as a result, they help to safeguard the use of indicators that are scientifically strong [18]. However, this focus on appraising indicators on their technical merits fails to fulfil the basic tenet of *good organisational governance and management* – that is, the up-front development of strategic measurement goals [23]. The use of indicators demands a conception of performance from the outset, one which should be shared by a single unit (eg, clinical practice), an organisation (eg, professional association or insurer), or a system as a whole [10,30,31]. In failing to root the selection of indicators in strategic goals, performance measurement is left ill-equipped to serve its basic function: to indicate a direction for improvement [18,32]. What is more, the resulting performance intelligence often lies outside, rather than embedded within, the systems of governance and the managerial cycles involved [33,34].

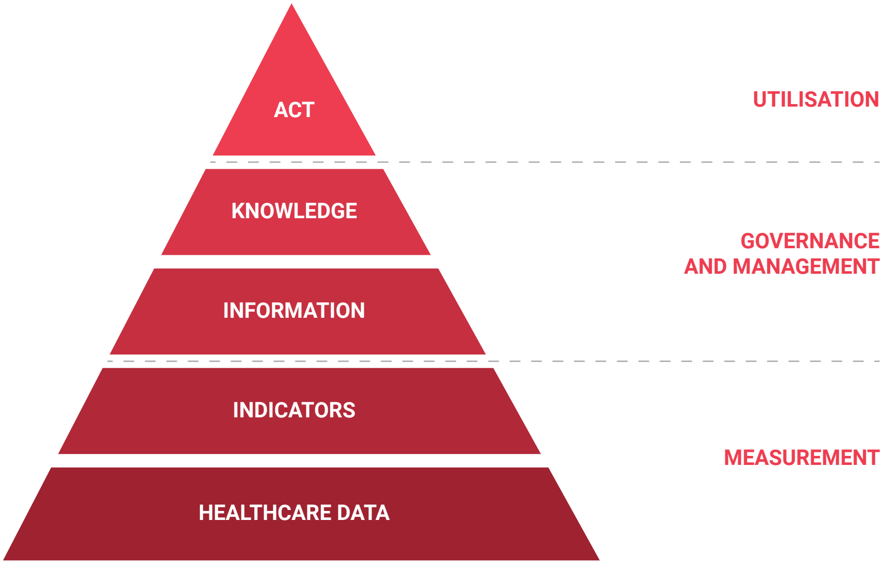
Mechanisms such as health system performance assessment (HSPA) have endeavoured to bring back a focus on measurement embedded in strategic priorities [35]. In the case of HSPA, these are typically macro-level system goals. Despite its strategic rooting, the questions of how to best integrate HSPA into policy processes, and how to *use* findings to contribute meaningfully to healthcare system improvement, remain a core challenge [35,36]. This enduring issue reflects the reality that '[data] has no intrinsic value unless put to work within an enabling institutional environment' [37]. It also underscores the nature of governance and management as *processes*. As a process, governance, and its execution through management, extends beyond the task of setting priorities. It also includes organising for action (ie, assigning mandates, allocating resources), measuring, and feeding back on performance in order to bring about improvement [38]. All aspects of this cycle require consideration when healthcare performance indicators are selected.

The case for a focus on actionability

In pursuit of greater value in healthcare, prioritising the execution, routinisation and acceleration of learning cycles has been necessitated. However, as emphasis is increasingly put on the systematic use of healthcare performance measurement, the absence of governance and management in the rhetoric surrounding indicators has become more and more apparent [35,37]. In response, attention is being called back to the use of measurement as performance intelligence [39,40] (Figure 2).

This return to measurement rooted in governance and management has put a spotlight on the importance of *actionable* healthcare performance indicators – on indicators that *work* [41]. That is, indicators are needed that generate information and knowledge that can be acted upon as performance intelligence. To prioritise actionability means to appraise indicators with view to two key constructs: (1) their *fitness for purpose* – gauging their rooting in alignment with strategic priorities; and (2) their *fitness for use* – appraising indicators in cycles of use in practice, including their data collection, linkages with data, dissemination of findings and, ultimately, their alignment with potential remedial actions to be taken by targeted decision-makers to ensure improvement [42].

Figure 2. Approach to creating healthcare performance intelligence



Source: [39].

In addition to responding to the shift towards learning health systems, actionable healthcare performance indicators have been necessitated by a number of other recent changes. For one, the volume of healthcare data has increased exponentially, amassing to the stature of big data [43]. Since the early 2000s coined the age of information [44], impressive growth has been achieved, not only in data volume, but also in terms of data quality and the ease and speed of access [37]. Previously paper-based clinical information in patient records is now increasingly structured and digitised [37,45]. The linkage capabilities between clinical and administrative data (insurance claims, medicines dispensed) and settings of care (primary care practices, pharmacies, hospitals, laboratories) have introduced new potential for delivering more person-centred care, but also for measuring performance by following individual patients throughout the healthcare system [46].

There are new types of data as well, including person-reported data collected through surveys, social media or wearables, among many other sources [47]. These types of data have opened up new opportunities both for primary data uses (enabling shared decision-making and patient self-management) and for secondary uses to promote learning and improvement. In effect, the lament of developed healthcare systems about deficits in the completeness, comprehensiveness, validity and timeliness of data has become more subdued [48].

In addition to these novel types of data, new technologies and open-source software for data management, analysis and the display of information have substantially reduced the time and resource investment that the measurement, analysis and reporting of performance data have traditionally demanded [37]. For example, previously static means of reporting performance measurement, such as print or digital reports, are increasingly replaced by reporting that iterates in real time and is interactive and customisable. The potential to put big data to work for public health has also grown [37] – enabling, for example, better outbreak surveillance by pairing health, geolocation, environmental and behavioural data.

Faced with such trends, healthcare performance measurement is increasingly data-rich and technology-enabled. Failure to harness this potential is, therefore, not merely a persisting data or technology obstacle, but rather a 'structural, organisational and institutional' barrier [37]. Moreover, inaction to resolve such barriers and improve the actionability of healthcare performance indicators presents its own risks. For example, when indicators fail to contribute useful information, the information may produce more noise than signals [29,31,48]. The consequences of this indicator chaos may include confusion, pro-forma reporting of indicators, bad decisions or, even worse, false assurances or the misuse, manipulation and gaming of indicators. Wider effects of suboptimal measurement include system waste, patient harm, burdens in workforce data collection and reporting, and many other inefficiencies [49]. The detrimental effects of too much information have also been witnessed in the context of the COVID-19 pandemic and have been labelled a parallel 'infodemic' [50].

Thesis aims, objectives and research questions

The premise of this thesis is that actionable healthcare performance indicators are crucial for working towards learning health systems for value-based healthcare. Despite the clarity with which actionability has been prioritised, its conceptualisation, and how it can be translated into practice within and across healthcare systems, still remains ambiguous. In the absence of insights about conceptualising and about operationalising actionability, the selection of healthcare performance indicators risks remaining an overly scientific exercise, rather than regaining focus within governance and managerial principles. The findings of this thesis are intended to augment existing theories about fitness for purpose and use, while also providing practical insights for major system actors – clinicians, healthcare managers, policy-makers – about working with healthcare performance measurement to improve quality across healthcare systems.

Three main objectives are defined, and these inform the sections of the thesis and the organisation of the seven research questions investigated (Table 1). The first objective (Part I of the thesis) is to explore and clarify the *conceptualisation of actionability* in order to work towards a more nuanced understanding of its constructs of *fitness for purpose* and *fitness for use* (Chapter 1).

Recognising that actionability fundamentally requires context and rooting in specific strategic uses, two vital areas of healthcare are explored in Parts II and III. The former section examines the notion of actionability in the context of *primary health care* (PHC). Chapter 2 investigates how actionable PHC performance intelligence can be generated across countries by developing a *framework* tailored to the WHO European Region. The next two chapters examine the uses of *electronic medical record data* (Chapter 3) and varied sources of *primary care prescribing data* (Chapter 4) for creating actionable PHC performance intelligence within healthcare systems – across the clinical, organisational and policy contexts (micro-meso-macro-levels).

The next section of the thesis (Part III) focuses on the global COVID-19 pandemic. It investigates actionability in relation to *COVID-19 dashboards*, in their function as tools for reporting pandemic data to the public. First, *features* conducive to highly actionable dashboards are investigated (Chapter 5). In view of the dynamic nature of dashboards and the speed in which they were developed and launched, next *changes* made to COVID-19 dashboards are analysed over the course of the first year of the pandemic (Chapter 6). Finally, drawing on insights from the teams responsible for national dashboards, the dashboard *development process*, including the enablers and barriers, and the lessons learned, are reviewed (Chapter 7).

Table 1. Overview of objectives and research questions

PART	OBJECTIVE	CHAPTER	MAIN RESEARCH QUESTION
I	To explore the conceptualisation of actionability of performance indicators	1	What characterises fitness for purpose and fitness for use?
II	To explore the actionability of performance indicators and data sources in primary health care (PHC)	2	How can actionable PHC performance intelligence be generated across countries?
		3	What are the uses of electronic medical records in PHC for performance measurement?
		4	What makes primary care prescribing data actionable for improving quality of care?
III	To explore the actionability of COVID-19 dashboards in terms of their features, changes and development process	5	How can COVID-19 dashboards be described and what makes them actionable?
		6	Does the actionability of COVID-19 dashboards increase over time?
		7	How can the process of developing COVID-19 dashboards be described?

Selection of two areas of application: primary health care and COVID-19

Actionability is explored in practice through two specific areas of application: primary health care (PHC) and the COVID-19 pandemic. Both are of crucial importance to public health. The latter represents the most serious acute threat to global public health in recent times, while robust PHC is widely recognised as an accelerator towards universal health coverage and the foundation of strong healthcare systems [51,52]. For both these areas, actionable healthcare performance intelligence is vital to system learning. In PHC, performance intelligence is needed for improving the work of individual doctors and teams, for managing facilities and for stewarding population health, among many other beneficial uses [53]. In the case of a crisis situation like the COVID-19 pandemic, performance intelligence can crucially inform decision-making in a dynamic environment, with respect to issues such as infection control measures, resource management and desired behaviour change [54,55].

Notwithstanding such similarities, the two areas diverge in a number of aspects – most notably in their development trajectories. PHC information systems have developed over decades, often through piecemeal policies and innovations [56,57]. In general, PHC has been slow to adopt digital solutions [45,58]. The small, independent, and often private practices that characterise primary care settings form one contributing factor to the slower pace and fragmented development of PHC measurement. Related issues of ambiguous data ownership, the structured, semi-structured and unstructured hybrid nature of primary care data, quality concerns, and resource constraints have likewise been found to hinder secondary uses of performance measurement in PHC [37,45,59].

In the absence of robust PHC data, countries have traditionally relied on one-off assessments and surveys, rather than linking with routine health information systems for measurement purposes. What is more, the ways in which countries – and different regions within countries – select, design, organise, manage and improve their PHC services are heterogeneous [60]. As a consequence, there is considerable diversity in the scope of primary care services (ie, maternity care, health promotion and disease prevention, treatment, management of chronic conditions, rehabilitation, and palliative care [51]) as well as in the types and profiles of health professionals and the settings where care is delivered. A range of instruments have been devised to facilitate a standardised, readily comparable approach to national and international PHC performance measurement, including the Primary Health Care Performance Initiative [61], the Primary Care Evaluation Tool [62] and the Primary Health Care Activity Monitor for Europe [63]. However, inadequate attention to the selection of indicators, together with prior data constraints, has kept PHC measurement initiatives largely siloed from governance and managerial cycles [64].

In contrast, the COVID-19 pandemic presents an example in which health information systems were enhanced and leveraged for immediate use. The acuteness of the situation triggered an unconventional pace of development and streamlining of decision-making processes. In contrast to the diverse and wide-ranging models in the PHC sector, infrastructures in public health are generally more cohesive and standardised in their organisation across countries [65]. The pandemic also sparked an opportunity to initiate novel tools such as dashboards. Dashboards mushroomed around the world in early 2020 in order to report COVID-19 data to the public [66]. Early dashboards, like that of the Johns Hopkins Coronavirus Resource Center [67], served as proof of concept. They set the bar globally for the delivery of pandemic-related information. The nearly universal use of dashboards can be credited in part to the availability of software solutions, the relative readiness of data sources, and the general digital literacy of the public. Dashboards themselves are highly suited to meet the information needs of decision-makers in a crisis situation. Their interactive and typically geographic reporting in a concise, visual manner caters to a pandemic's urgency and the need for precision [68]. They are also dynamic, and can hence accommodate to the ever-changing nature of what is considered critical information for decision-making, while also managing data updates in next to real time [69].

Nonetheless, dashboards for public reporting are relatively novel. Prior to the pandemic, dashboards were predominately used for internal strategic and operational decision-making in hospitals [70,71], as decision supports in clinical care [72], and for international benchmarking [73,74]. While some use of dashboards during earlier disease outbreaks has been reported [75,76], the scale and speed of development during the COVID-19 pandemic is beyond comparison. As a result, there is little to be found in the existing literature about the development and use of dashboards for public reporting in crisis situations.

These differing developmental trajectories of performance measurement in PHC and the context of the pandemic provide rich in-practice insights into the constructs of fitness for purpose and fitness for use. Differences aside, both areas of application remain high on policy agendas. At present, there is a renewed impetus to accelerate the development and use of PHC performance measurement. With the adoption of the Declaration of Astana in 2018, countries have globally reaffirmed their commitment to intensify efforts to strengthen PHC [51]. This is now accompanied by a first-ever globally endorsed PHC measurement and monitoring tool [77]. Trends towards increasing the digitisation of PHC data, accelerated by the COVID-19 pandemic [77], create an opportunity for rethinking PHC performance measurement, data sources, and their use.

With regard to dashboards, the pandemic has been described as 'not an end-point but rather a tipping point' [78]. Dashboards have numerous potential future uses for communicating with the public and other major system actors. These include monitoring other infectious diseases like the seasonal flu, as well as noncommunicable diseases like cancer, and supporting priority areas such as patient safety. While the pandemic was the ultimate stress test for dashboard development, the work to embed dashboards into managerial cycles and into governance systems lies ahead. Lessons learnt from the development process can provide the needed input to continue investment in dashboards and in the actionable performance indicators they contain.

Methods

The research in this thesis applies a range of qualitative methods to address the research questions. In view of the exploratory nature of the research aims and objectives as defined, qualitative methods were considered best suited to the research design, owing to their ability to study the nature of phenomena [79] and enable the discovery of patterns [79,80]. Qualitative methods also facilitate assessment of complex, multiple components [79]. This was an important criterion, given the ambition of the research questions to capture the *system-ness* of healthcare systems, including relevant nuances in micro-meso-macro contexts. Additionally, the ability of qualitative methods to value information generated through expert beliefs, attitudes and experiences was deemed to be well aligned with available or collectable data sources [80,81].

Relevant research checklists – the Standards for Reporting Qualitative Research (SRQR) [82] and the Consolidated Criteria for Reporting Qualitative Research (COREQ) [83] – are adhered to throughout the chapters of the thesis. The data collection methods include document analysis, semi-structured individual and group interviews [84], case studies [85], observational descriptive assessments, and scoring using the nominal group technique [24] (Table 2).

A range of data types are handled, including transcribed audio recordings, interview notes, literature (research publications, policies, reports, evaluations, fact sheets, presentations, surveys, indicator sets), and study-specific assessment results. The types of analysis applied include deductive and inductive thematic analysis [86], content analysis and descriptive statistics. A mix of techniques were also relied on during data collection (including purposive, quota and snowball sampling) as well as in data analysis (including elaborative coding [87] and data triangulation [88]). Strategies applied across studies for quality assurance included researcher reflexivity, piloting, co-coding and other calibration processes, member checking, and stakeholder involvement.

Other cross-cutting methodological techniques applied include the following: (i) *Study-specific tools* were developed for addressing the research questions. Specifically, the results of Chapter 1 on fitness for purpose and use informed the development of tools used for interviews in Chapters 3, 4 and 7. Chapter 1 also informed the development of an assessment tool employed in Chapters 5 and 6. (ii) The *tracer method* [89] was applied in order to anchor investigations. The use of tracers enables the observation of 'discrete, identifiable [health] problems – each shedding light on how particular parts of the system work, not in isolation, but in relation to one another' [89]. The tracer method informed the selection of priority health outcomes (Chapter 2) and specific prescription types for closer study (Chapter 4). (iii) The use of *panels* made it possible to capture multiple perspectives in studies using semi-structured interviews. This involved constructing panels of experts versus real-world data users (Chapter 1), system leaders versus researchers and clinicians (Chapter 3), and stakeholder panels differentiated by the stakeholders' affiliations in the micro-meso-macro context (Chapter 4).

All studies were completed between October 2018 and December 2021. They were conducted in collaboration with researchers from the Marie Skłodowska-Curie Innovative Training Network for Health Care Performance Intelligence (HealthPros) [90] as well as from partner organisations: the Canadian Institute for Health Information and the University of Toronto (Chapter 3), the Netherlands Institute for Health Services Research, Nivel (Chapter 4), and the World Health Organization (Chapters 2 and 7). Large and diverse study teams provided a wide range of perspectives, countries of expertise and language competencies to draw on. The co-coordination of three studies (Chapters 5, 6 and 7) with a fellow HealthPros PhD candidate added a managerial research lens to those studies.

Settings

The seven studies in the thesis were conducted in high- and middle-income country contexts, predominately in European and OECD countries (Table 2). Those settings shared a common focus on obtaining greater value from the increasingly data-rich and technology-enabled health information systems operating there [44]. That contrasts with more resource-constrained settings, where information systems are less mature and focused largely on initial digitisation, rather than on optimising data use. The studies also include a mix of international and country-specific samples. The research in the multi-country samples investigates the transferability of indicators *across* healthcare systems, while country-specific studies examine the cascading of indicators *within* healthcare systems, between micro, meso and macro contexts.

Multi-country samples

Four of the seven studies involve multi-country samples. In Chapter 1, experiences from ten OECD countries are captured, and Chapter 5 studies a global sample of COVID-19 dashboards extending over more than 50 countries. In both cases, geographically diverse samples were pursued to broadly investigate the status quo. Two other studies drew on the 53 Member

States of the WHO European Region. The region is diverse in geography, cultures, economic development and health situations [91]. Such differences aside, the region shares common policy priorities for PHC and commitments to PHC performance measurement as well as standards for reporting health data. These points of convergence are explored respectively in Chapter 2 and Chapter 7.

Country-specific samples

Three studies analyse country-specific samples in the context of Canada (Chapters 3 and 6) and the Netherlands (Chapter 4). The Netherlands presents a unique context for the case of PHC (Part II). It is renowned for its digitisation in primary care and has enabled more advanced secondary uses of primary care data than is possible in many other developed healthcare systems. This data-rich context allowed an exploration into the potential range of data sources and their uses for PHC performance measurement, investigated within the scope of primary care prescribing (Chapter 4). In Canada, digital advances involving PHC data are in progress, though the pace of change has accelerated in recent years. Over the past decade, the number of general practitioners using electronic medical records in their practices has more than doubled, from 37% in 2009 to 86% in 2019 [92]. As the adoption and sophistication of digital PHC data in Canada advances, the focus has increasingly shifted to its secondary uses. This change is evaluated in Chapter 3.

Canada also forms an interesting context in the realm of COVID-19 dashboards (Part III). In Canada, public health is the remit of federal, provincial or territorial, and local health authorities, which, together with provincial and territorial governments, are involved in pandemic monitoring and reporting. The range of actors across the Canadian national and provincial landscape, together with local, academic and private actors, resulted in a plethora of COVID-19 dashboards. Chapter 6 investigates this diverse landscape of actors and dashboards whilst examining changes to COVID-19 dashboards over time.

Structure of the thesis

This thesis is structured in three parts. These pertain to the conceptualisation of actionability (Chapter 1) and its application in the areas of PHC (Chapters 2 to 4) and COVID-19, specifically the use of dashboards for public reporting (Chapters 5 to 7). A final, general discussion chapter synthesises the findings across parts I, II and III. That chapter also provides a reflection on the overall validity and generalisability of the main findings and an interpretation of the results. Considerations for future research and policy-making are also proposed.

Table 2. Overview of chapters and study characteristics

SECTIONS		MAIN RESEARCH QUESTION	STUDY DESIGN	DATA SOURCES/SAMPLE	ANALYSIS	SETTING
Part I: Conceptualising actionability	Chapter 1	What constitutes the constructs of *fitness for purpose* and *fitness for use* of performance measures?	Multiphase approach comprising document review and multiple-perspective semi-structured interviews in two panels.	PubMed and grey literature Expert panel: 16 informants User panel: 16 informants	Stepwise content and thematic analysis	Global (HICs)
Part II: Exploring actionability in primary health care (PHC)	Chapter 2	How can actionable PHC *performance intelligence* be generated across the WHO European Region using existing data?	Document review. Selection of tracer conditions. Mapping and selection of indicators. Expert review and validation.	PubMed and grey literature Global and European WHO policies International indicator sets	Thematic analysis	WHO European Region (UMICs, HICs)
	Chapter 3	What is the current and potential use of EMR data for *performance measurement* in PHC in the Canadian context?	Case study design and descriptive assessment. Multimethod sampling. Semi-structured interviews.	PubMed and grey literature System leaders: 41 Clinicians and researchers: 20 Case studies: 6	Triangulation and thematic analysis	Canada (HIC)
	Chapter 4	What are the potential secondary uses of primary care *prescribing data* for improving quality of care?	Semi-structured interviews with panels of stakeholders at micro, meso, and macro levels in the Dutch healthcare system. Selection of tracer prescriptions.	Stakeholders: 26 Interviews: 28 informants	Elaborative coding and thematic analysis	Netherlands (HIC)
Part III: Exploring the actionability of COVID-19 dashboards	Chapter 5	How can COVID-19 dashboards be described, and what *features* are conducive to their actionability?	Multimethod sampling. Development of assessment tool. Descriptive assessment. Scoring using nominal group technique.	COVID-19 dashboards: 158 Panel of experts: 17	Descriptive statistics and thematic analysis	Global (UMICs, HICs)
	Chapter 6	Does the actionability of COVID-19 dashboards *increase* over time?	Descriptive assessment at two time points. Scoring using nominal group technique.	COVID-19 dashboards: 26 Panel of experts: 8	Descriptive statistics and thematic analysis	Canada (HIC)
	Chapter 7	How can the *process of developing* COVID-19 dashboards be described and what can be derived from this experience?	Multimethod sampling. Semi-structured group interviews. Validation workshop.	COVID-19 dashboard teams: 33 Interviews: 80 informants	Elaborative coding and thematic analysis	WHO European Region (UMICs, HICs)

EMR: electronic medical records; HIC: high-income country; PHC: primary health care; UMIC: upper-middle-income country

References

1. Smith P, Mossialos E, Papanicolas I, Leatherman S. Part 1: Principles of performance measurement. In: Smith P, Mossialos E, Papanicolas I, Leatherman S, editors. Performance measurement for health system improvement: experiences, challenges and prospects. Copenhagen: WHO Regional Office for Europe; 2008.
2. Klazinga N, Stronks K, Delnoij D, Verhoeff A. Indicators without a cause. Reflections on the development and use of indicators in health care from a public health perspective. Int J Qual Health Care. 2001;13(6):433–8.
3. Pringle M, Wilson T, Grol R. Measuring 'goodness' in individuals and healthcare systems. BMJ (Clinical research ed). 2002;325(7366):704–7.
4. Chun J, Bafford AC. History and background of quality measurement. Clin Colon Rectal Surg. 2014;27(1):5–9.
5. Loudon I. Ignaz Phillip Semmelweis' studies of death in childbirth. J R Soc Med. 2013;106(11):461–3.
6. Hines K, Mouchtouris N, Knightly JJ, Harrop J. A brief history of quality improvement in health care and spinal surgery. Global Spine J. 2020;10(1 Suppl):5S–9S.
7. Donabedian A. The quality of care. How can it be assessed? JAMA. 1988;260(12):1743–8.
8. Cassel CK, Conway PH, Delbanco SF, Jha AK, Saunders RS, Lee TH. Getting more performance from performance measurement. N Engl J Med. 2014;371(23):2145–7.
9. Panzer RJ, Gitomer RS, Greene WH, Webster PR, Landry KR, Riccobono CA. Increasing demands for quality measurement. JAMA. 2013;310(18):1971–80.
10. Jamieson Gilmore K. The role of managerial systems in promoting higher value care: Incorporating the patient voice in public health value management. Pisa: Sant-Anna Scuola Universitaria Superiore Pisa; 2022.
11. Institute of Medicine. Crossing the quality chasm: a new health system for the 21st century Washington, DC: National Academy Press; 2001.
12. Berwick DM, Nolan TW, Whittington J. The triple aim: care, health, and cost. Health Affairs. 2008;27(3):759–69.
13. Porter ME. What is value in health care? N Engl J Med. 2010;363(26):2477–81.
14. Friedman C, Rubin J, Brown J, Buntin M, Corn M, Etheredge L, et al. Toward a science of learning systems: a research agenda for the high-functioning Learning Health System. J Am Med Inform Assoc. 2015;22(1):43–50.
15. Institute of Medicine. Digital infrastructure for the learning health system: the foundation for continuous improvement in health and health care. In: Grossman C, Powers B, McGinnis J, editors. The foundation for continuous improvement in health and health care workshop series summary. Washington, DC: National Academies Press; 2011.
16. Brito Fernandes Ó. Citizen-driven health care system performance: Studies on care experiences and engagement. 2022.
17. Lawrence M, Olesen F. Indicators of quality in health care. Eur J Gen Pract. 1997;3(3):103–8.

18. Campbell SM, Braspenning J, Hutchinson A, Marshall MN. Research methods used in developing and applying quality indicators in primary care. BMJ (Clinical research ed). 2003;326(7393):816.

19. Jones P, Shepherd M, Wells S, Le Fevre J, Ameratunga S. Review article: what makes a good healthcare quality indicator? A systematic review and validation study. Emerg Med Australas. 2014;26(2):113–24.

20. Carinci F, Van Gool K, Mainz J, Veillard J, Pichora EC, Januel JM, et al. Towards actionable international comparisons of health system performance: expert revision of the OECD framework and quality indicators. Int J Qual Health Care. 2015;27(2):137–46.

21. Schang L, Blotenberg I, Boywitt D. What makes a good quality indicator set? A systematic review of criteria. Int Qual Health Care. 2022;33(3):mzab107.

22. Kara P, Valentin JB, Mainz J, Johnsen SP. Composite measures of quality of health care: Evidence mapping of methodology and reporting. PloS One. 2022;17(5):e0268320.

23. Loeb JM. The current state of performance measurement in health care. Int J Qual Health Care. 2004;16 Suppl 1:i5–9.

24. Fink A, Kosecoff J, Chassin M, Brook RH. Consensus methods: characteristics and guidelines for use. Am J Public Health. 1984;74(9):979–83.

25. Linstone H, Turoff M. The Delphi survey: Method, techniques and applications. Reading, MA: Addison-Wesley; 1975.

26. Fitch K, Bernstein SJ, Aguilar MD, Burnand B, LaCalle JR, Lazaro P, et al. The RAND/UCLA Appropriateness Method User's Manual. Santa Monica, CA: RAND; 2001.

27. Campbell SM, Cantrill JA. Consensus methods in prescribing research. J Clin Pharm Ther. 2001;26(1):5–14.

28. de Koning J, Burgers J, Klazinga N. Appraisal of indicators through research and evaluation (AIRE). Amsterdam: University of Amsterdam; 2008.

29. McGlynn EA. The outcomes utility index: will outcomes data tell us what we want to know? Int J Qual Health Care. 1998;10(6):485–90.

30. Vainieri M, Noto G, Ferre F, Rosella LC. A performance management system in healthcare for all seasons? Int J Environ Res Public Health. 2020;17(15).

31. Meyer GS, Nelson EC, Pryor DB, James B, Swensen SJ, Kaplan GS, et al. More quality measures versus measuring what matters: a call for balance and parsimony. BMJ Qual Safe. 2012;21(11):964.

32. Kallen MC, Roos-Blom MJ, Dongelmans DA, Schouten JA, Gude WT, de Jonge E, et al. Development of actionable quality indicators and an action implementation toolbox for appropriate antibiotic use at intensive care units: A modified-RAND Delphi study. PloS One. 2018;13(11):e0207991.

33. Twersky F, Nelson J, Ratcliffe A. A guide to actionable measurement. Bill & Melinda Gates Foundation; 2010.

34. OECD. Situating health care quality measurement and improvement within the UHC agenda. Paris: OECD; 2014.

35. Papanicolas I, Rajan D, Karanikolos M, Figueras J. Assessing health system performance for UHC: rationale and approach. In: Papanicolas I, Rajan D, Karanikolos M, Soucat A, Figueras J, editors. Health system performance assessment: a framework for policy analysis. Health Policy Series, No. 57. Geneva: World Health Organization; 2022.

36. Smith P, Karanikolos M, Cylus J. Evolution of health system performance assessment: the roles of international comparisons and international institutions. Eurohealth. 2018;24(2).

37. OECD. Health in the 21st Century: putting data to work for stronger health systems. Paris: OECD; 2019.

38. Barbazza E, Tello J. A review of health governance: Definitions, dimensions and tools to govern. Health Policy. 2014;116:1–11.

39. Kringos D, Carinci F, Barbazza E, Bos V, Gilmore K, Groene O, et al. Managing COVID-19 within and across health systems: why we need performance intelligence to coordinate a global response. Health Res Policy Syst. 2020;18(8).

40. Menear M, Blanchette M-A, Demers-Payette O, Roy D. A framework for value-creating learning health systems. Health Res Policy Syst. 2019;17(1):79.

41. Porter ME. A strategy for health care reform — toward a value-based system. N Engl J Med. 2009;361(2):109–12.

42. Papanicolas I, Kringos D, Klazinga NS, Smith PC. Health system performance comparison: new directions in research and policy. Health Policy. 2013;112(1-2):1–3.

43. European Commission. Study on big data in public health, telemedicine and healthcare. Brussels: European Commission; 2016.

44. McIntyre D, Rogers L, Heier EJ. Overview, history, and objectives of performance measurement. Health Care Finance Rev. 2001;22(3):7–21.

45. Oderkirk J. Readiness of electronic health record systems to contribute to national health information and research. Paris: OECD; 2017.

46. OECD. Health data governance: privacy, monitoring and research. Paris: OECD; 2015.

47. European Commission. Study on health data, digital health and artificial intelligence in healthcare. Brussels: European Commission; 2022.

48. Quentin W, Partanen V, Brownwood I, Klazinga N. Measuring healthcare quality. In: Busse R, Klazinga N, Panteli D, Quentin W, editors. Improving healthcare quality in Europe: characteristics, effectiveness and implementation of different strategies. Copenhagen: WHO and OECD; 2019.

49. Slawamirski L, Auraaen A, Klazinga N. The economics of patient safety: Strengthening a value-based approach to reducing patient harm at national level. Paris: OECD; 2017.

50. The Lancet Infectious D. The COVID-19 infodemic. Lancet Infect Dis. 2020;20(8):875.

51. Declaration of Astana. The Global Conference on Primary Health Care; 2018; Astana, Kazakhstan.

52. WHO. Primary health care measurement framework and indicators: monitoring health systems through a primary health care lens. Geneva: World Health Organization; 2022.

53. Smith P, Mossialos E, Papanicolas I. Performance measurement for health system improvement: experiences, challenges and prospects. Copenhagen: WHO Regional Office for Europe; 2008.

54. World Health Organization. Global surveillance during an influenza pandemic. Geneva: World Health Organization; 2009.

55. WHO Regional Office for Europe. Strengthening and adjusting public health measures throughout the COVID-19 transition phases. Copenhagen: WHO Regional Office for Europe; 2020.

56. Bogaert P, Verschuuren M, Van Oyen H, van Oers H. Identifying common enablers and barriers in European health information systems. Health Policy. 2021;125(12):1517–26.

57. Chang F, Gupta N. Progress in electronic medical record adoption in Canada. Can Fam Physician. 2015;61.

58. The Commonwealth Fund. 2019 Commonwealth Fund International Health Policy Survey of Primary Care Physicians. New York, NY: The Commonwealth Fund; 2019.

59. OECD. Realising the potential of primary health care. Paris: OECD Publishing; 2020.

60. Kringos D, Boerma W, Bourgueil Y, Cartier T, Dedeu T, Hasvold T, et al. The strength of primary care in Europe: an international comparative study. Br J Gen Pract. 2013;63(616):e742–50.

61. Veillard J, Cowling K, Bitton A, Ratcliffe H, Kimball M, Barkley S, et al. Better measurement for performance improvement in low- and middle-income countries: the primary health care performance initiative (PHCPI) experience of conceptual framework development and indicator selection. Milbank Q. 2017;95(4):836–83.

62. WHO Regional Office for Europe. Primary care evaluation tool. Copenhagen: WHO Regional Office for Europe; 2010.

63. Kringos DS, Boerma WGW, Bourgueil Y, Cartier T, Hasvold T, Hutchinson A, et al. The European primary care monitor: structure, process and outcome indicators. BMC Fam Pract. 2010;11:81.

64. Young RA, Roberts RG, Holden RJ. The challenges of measuring, improving, and reporting quality in primary care. Ann Fam Med. 2017;15(2):175.

65. Policies. EOoHSa. Organization and financing of public health services in Europe: Country reports. Rechel B, Maresso A, Sagan A, Hernandez-Quevedo C, Williams G, Richardson E, et al., editors. Copenhagen: World Health Organization; 2018.

66. Peepls L. Lessons from the COVID-19 data wizards. Nature. 2022 [cited 2022 June 5]. Available from: https://www.nature.com/articles/d41586-022-00792-2.

67. Johns Hopkins University. COVID-19 dashboard by the Center for Systems Science and Engineering (CSSE) at Johns Hopkins University 2020 [cited 2022 June 5]. Available from: https://coronavirus.jhu.edu/map.html.

68. Kamel Boulos MN, Geraghty EM. Geographical tracking and mapping of coronavirus disease COVID-19/severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) epidemic and associated events around the world: how 21st century GIS technologies are supporting the global fight against outbreaks and epidemics. Int J Health Geogr. 2020;19(1):8.

69. Vahedi A, Moghaddasi H, Asadi F, Hosseini AS, Nazemi E. Applications, features and key indicators for the development of Covid-19 dashboards: A systematic review study. Inform Med Unlocked. 2022;30:100910.

70. Weggelaar-Jansen AMJWM, Broekharst DSE, de Bruijne M. Developing a hospital-wide quality and safety dashboard: a qualitative research study. BMJ Qual Safe. 2018;27(12):1000.

71. Lee K, Jung SY, Hwang H, Yoo S, Baek HY, Baek R-M, et al. A novel concept for integrating and delivering health information using a comprehensive digital dashboard: An analysis of

healthcare professionals' intention to adopt a new system and the trend of its real usage. Int J Med Inform. 2017;97:98–108.

72. Dowding D, Randell R, Gardner P, Fitzpatrick G, Dykes P, Favela J, et al. Dashboards for improving patient care: review of the literature. Int J Med Inform. 2015;84(2):87–100.

73. Ghazisaeidi M, Safdari R, Torabi M, Mirzaee M, Farzi J, Goodini A. Development of Performance Dashboards in Healthcare Sector: Key Practical Issues. Acta Inform Med. 2015;23(5):317–21.

74. Damman OC, van den Hengel YKA, van Loon AJM, Rademakers J. An International Comparison of Web-based Reporting About Health Care Quality: Content Analysis. J Med Internet Res. 2010;12(2):e8.

75. Kamadjeu R, Gathenji C. Designing and implementing an electronic dashboard for disease outbreaks response - Case study of the 2013-2014 Somalia Polio outbreak response dashboard. Pan Afr Med J. 2017;27(Suppl 3):22.

76. Meng Y, Zhang Y, Wang S, Wu S, Zhou H, Ke C, et al. Lessons learned in the development of a web-based surveillance reporting system and dashboard to monitor acute febrile illnesses in Guangdong and Yunnan Provinces, China, 2017-2019. Health Security. 2020;18(S1):S-14–22.

77. Primary health care measurement framework and indicators: monitoring health systems through a primary health care lens. Geneva: World Health Organization and the United Nations Children's Fund (UNICEF); 2022.

78. Koch T. Welcome to the revolution: COVID-19 and the democratization of spatial-temporal data. Patterns. 2021;2(7).

79. Busetto L, Wick W, Gumbinger C. How to use and assess qualitative research methods. Neurol Res Pract. 2020;2(1):14.

80. Sofaer S. Qualitative methods: what are they and why use them? Health Serv Res. 1999;34(5 Pt 2):1101–18.

81. Hammarberg K, Kirkman M, de Lacey S. Qualitative research methods: when to use them and how to judge them. Human Reproduction. 2016;31(3):498–501.

82. O'Brien BC, Harris IB, Beckman TJ, Reed DA, Cook DA. Standards for reporting qualitative research: a synthesis of recommendations. Acad Med. 2014;89(9):1245–51.

83. Tong A, Sainsbury P, Craig J. Consolidated criteria for reporting qualitative research (COREQ): a 32-item checklist for interviews and focus groups. Int J Qual Health Care. 2007;19(6):349–57.

84. Frey JH, Fontana A. The group interview in social research. Social Science Journal. 1991;28(2):175–87.

85. Baxter P, Jack S. Qualitative case study methodology: study design and implementation for novice researchers. TQR. 2008;13(4):544–59.

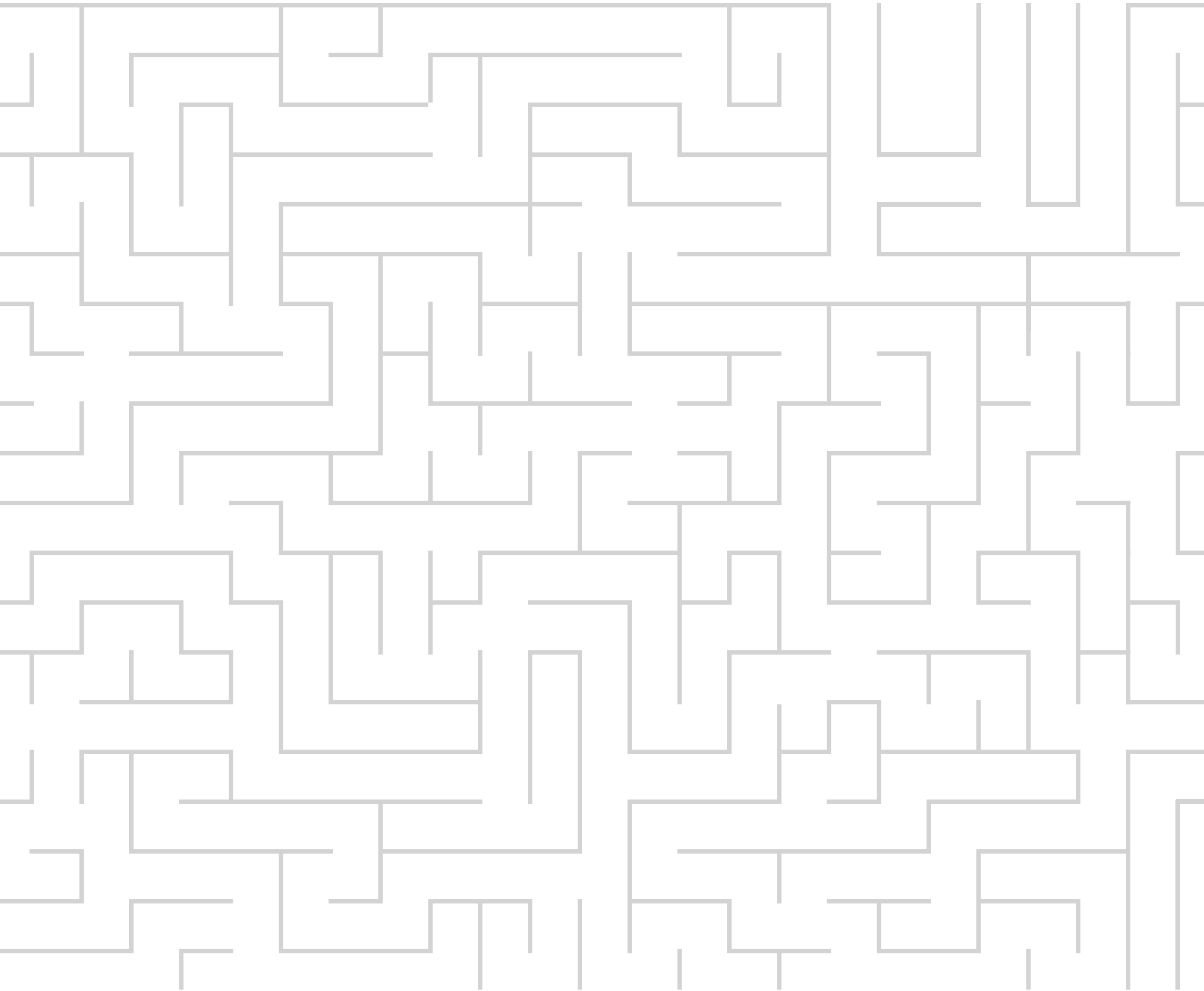
86. Braun V, Clarke V. Using thematic analysis in psychology. Qual Res Psychol. 2006;3(2):77–101.

87. Auerbach CF, Silverstein LB. Analyzing your next study using elaborative coding. Qualitative data: an introduction to coding and analysis. New York: New York University; 2003.

88. Vogl S, Schmidt E, Zartler U. Triangulating perspectives: ontology and epistemology in the analysis of qualitative multiple perspective interviews. Int J Soc Res Methodol. 2019;22(6):611–24.
89. Kessner D, Kalk C, Singer J. Assessing health quality: the case for tracers. N Engl J Med. 1973;288.
90. HealthPros. International Training Network for Healthcare Performance Intelligence Professionals 2020 [Available from: https://www.healthpros-h2020.eu/.
91. WHO Regional Office for Europe. An introduction to WHO in the European Region. Copenhagen: WHO Regional Office for Europe; 2021.
92. CIHI. How Canada Compares: Results from the Commonwealth Fund’s 2019 International Health Policy Survey of Primary Care Physicians. Ottawa: Canadian Institute for Health Information; 2020.

Part I

Conceptualising actionability

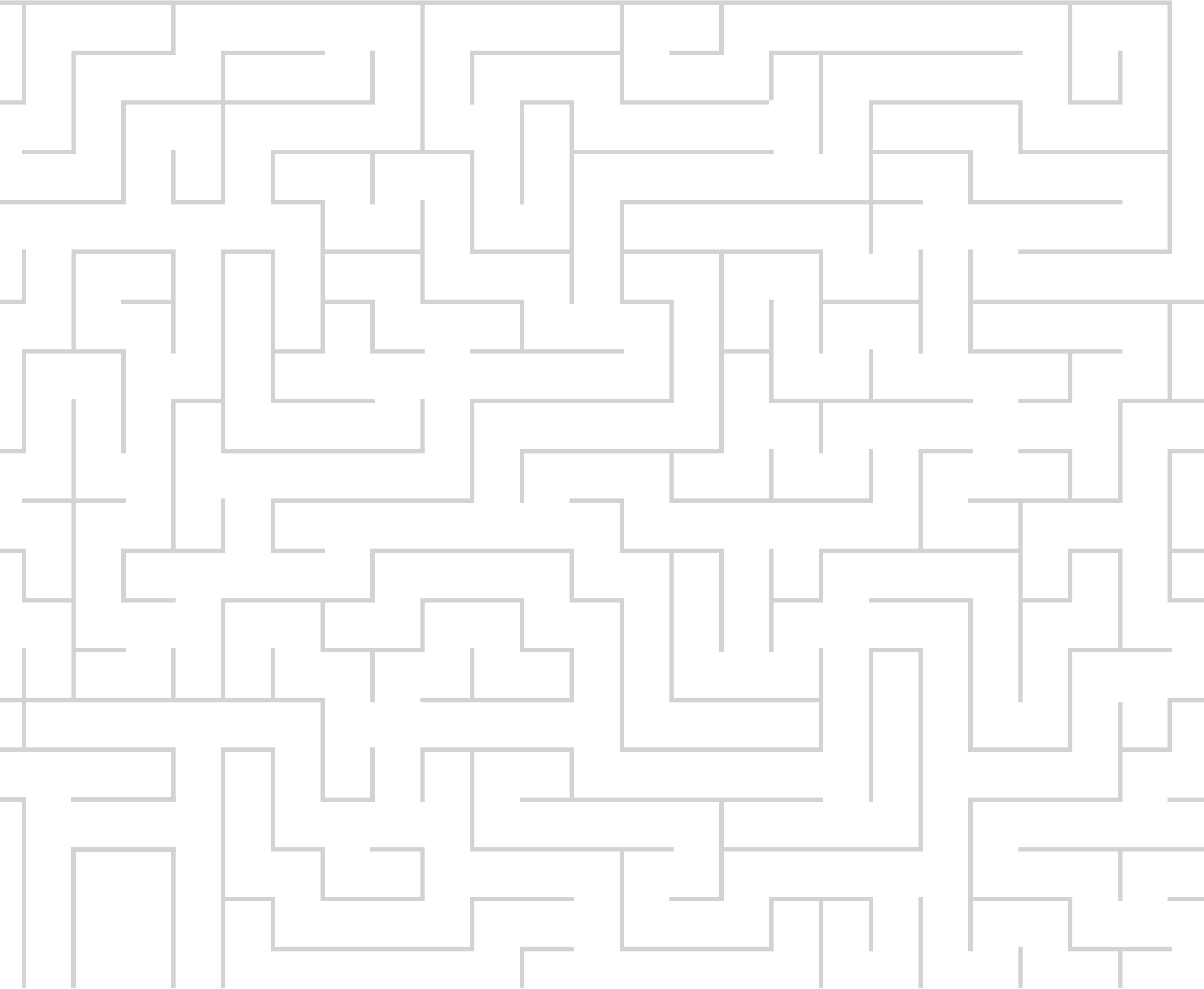


Chapter 1

Exploring the actionability of healthcare performance indicators for quality of care

This chapter was published as:

Barbazza E, Klazinga NS, Kringos DS. Exploring the actionability of healthcare performance indicators for quality of care: a qualitative analysis of the literature, expert opinion and user experience. BMJ Qual Saf. 2021;30:1010–20.



Abstract

Background

This study explores the meaning of actionable healthcare performance indicators for quality of care-related decisions. To do so, we analyse the constructs of *fitness for purpose* and *fitness for use* across healthcare systems and in practice based on the literature, expert opinion and user experience.

Methods

A multiphase qualitative study was undertaken. Phases included a literature review, a first round of one-on-one interviews with a panel of academics and thought leaders in the field (n=16), and a second round of interviews with real-world users of performance indicators (n=16). Thematic analysis was conducted between phases in order to triangulate findings in a stepwise process.

Results

Common uses of healthcare performance indicators were differentiated within micro-meso-macro contexts of healthcare systems. Each purpose of use signals different decision-making tasks, and in effect information needs. An indicator's fitness for use can be appraised by three clusters of considerations: methodological, contextual and managerial. Methodological considerations gauge an indicator's perceived importance, engagement potential, interpretability, standardisation, feasibility of remedial actions, alignment to care models and sensitivity to change. Information infrastructure, system governance, workforce capacity and learning culture were found as enabling contextual considerations. Managerial considerations influencing an indicator's use in practice were found to span the selection of indicators, data collection, analysis, display of results and delivery of information to decision-makers.

Conclusion

The actionability of a healthcare performance indicator should be appraised by its alignment with the intended purpose of use beyond aggregate healthcare system levels, in combination with the extent to which methodological, contextual and managerial fitness for use considerations are met. Striking a better balance between the importance weighted to an indicator's statistical merits and emphasis put to its fitness for purpose and use is needed for indicators that are ultimately actionable for quality of care-related decision-making.

Introduction

Healthcare performance measurement, and its use as performance intelligence, plays an important role in guiding the decisions of healthcare system actors with respect to quality of care [1]. Since the early-2000s, the importance of performance measurement in healthcare [2], its institutionalisation as standard practice within [3], and across healthcare systems [4-6], and more recently, its professionalisation [7], has received widespread prioritisation. This attention has increased scientific rigour around criteria for selecting indicators (eg, reliability, validity) [8,9], development of indicator sets (eg, parsimony, epidemiological relevance) [10], and methods, tools and approaches to guide these processes [11-13].

Importantly, adherence to agreed-upon criteria for a statistically sound indicator does not guarantee that it is useful for decision-making. The information needs of decision-makers across healthcare systems, including policy-makers, managers, clinicians and patients, are varied. The type of indicator, data sources, level of precision, timeliness and relevant comparisons are among the key differences [1,14,15]. For example, working to improve antibiotic prescribing: a primary care clinician may assess new and represcribing of antibiotics in their practice quarterly; an insurer, the adherence of practices to prescribing guidelines for issuing payment incentives annually; and a policy-maker, the total volume of antibiotics prescribed per 100 000 population by region, nationally and in comparison with other countries by policy cycle.

In effect, the ability for an indicator to meet the information needs of decision-makers goes beyond their statistical quality and is rather a measure of their actionability. To be actionable, it is generally agreed an indicator should be both *fit for purpose*—serving an intended decision-making function—and *fit for use*—getting the right information into the right hands at the right time [16-18]. While there is agreement on the importance of actionability [18-20], and increasing attention put to its two main constructs of fitness for purpose and use, it still remains an elusive concept to define, assess and operationalise. In the absence of a common understanding of the meaning of actionability, the tendency to select indicators on the merit of their *potential* to be actionable perpetuates [18,21-23]. And, while there are implicit criteria that appear to influence the actual use of indicators, such as data availability and ease of interpretation [1,15,24-26], how these relate across different healthcare systems remains under explored [1,14,15].

With the advancement of information systems and data analytics, there has been impressive growth in the speed, volume and range of data available for performance measurement [27,28]. COVID-19 and the ensuing surge in performance data reported is evidence of this [29,30]. It also serves to illustrate that an abundance of information does not translate to informed decisions. Our attention is increasingly called to this fact and the work still needed to advance methods for measuring quality of care [31-33] and patient safety [34] in order to obtain additional value from our data-rich systems [35-38].

In this study, we set out with the aim to gain further insights into the meaning of actionable healthcare performance indicators for quality of care-related decision-making across healthcare systems. To do so, we explore the notions of fitness for purpose and fitness for use derived through the existing literature, expert opinion and experiences of data users in varied developed country contexts. We pose two questions. The first aims to differentiate an indicator's purpose of use by micro-meso-macro decision-making levels, investigating what are the uses of healthcare performance indicators across healthcare systems. The second aims to consolidate the determinants of an indicator's fitness for use, exploring what are the key considerations influencing an indicator's use.

Methods

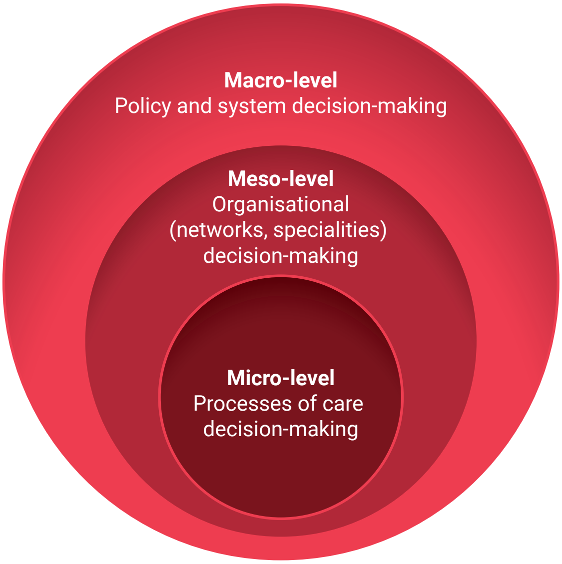
Design

We applied qualitative methods [39] in a multiphase approach, comprising a review to examine actionability according to the published literature [40] and multiple perspective semistructured interviews [39,41,42] to gain insights from two groups (panels) representing the scientific community and data users. We employed one-on-one interviews following our literature review rather than a questionnaire or focus groups for richer exchanges and the possibility to elicit the individual opinions of each participant [43]. Our stepwise approach to analysis allowed for the triangulation of findings across phases and to aggregate individual-level results for panel-wide themes [42]. The study adheres to the Consolidated Criteria for Reporting Qualitative Research [39].

Indicators refer to a quantifiable variable measured to provide simplified information about a larger area of interest [44], typically measured over time [9,45]. In the scope of this study, we focus on *healthcare performance indicators*: indicators for quality of care-driven decision-making to improve performance on one or more of the six dimensions of quality: safe, effective, patient-centred, timely, efficient and equitable care [8,46]. As an exploratory study, we prioritised the generalisability of findings and were inclusive of varied types of *healthcare* (eg, primary, acute, specialist, long-term care), settings (eg, primary care, hospitals), health system types and countries, though limited to developed country contexts.

To explore our first research question, we took as a basis the characterisation of decision-making in healthcare systems by three contexts: patient care (micro-level), organisational (meso-level) and policy (macro-level) as illustrated in figure 1 [47,48]. Indicators are used to inform decisions in each context, be it quality improvement, services management, population health planning or other strategic and tactical choices.

Figure 1 Decision-making contexts across healthcare systems



Data collection and analysis

Phase 1: literature review and content analysis

We reviewed the existing literature with the following aims: to examine the current scientific understanding of actionable healthcare performance indicators; to generate an initial core list of indicator purposes of use and fitness for use considerations; and to identify leading experts in the field. Our search was conducted using PubMed at the outset of the study in early 2019. The search was limited to the past 10 years and articles published in English using the following key terms in varied combinations: health care performance indicator, actionability, quality of care, measurement and use. We also reviewed reporting of relevant international organisations and networks, namely the WHO and its regional offices, the Organisation for Economic Co-operation and Development (OECD) and the European Commission Expert Group on Health Systems Performance Assessment. Reference lists of articles and reports identified were reviewed in a snowballing approach.

The results of the initial literature search were synthesised and used to inform a provisional approach and visualisation of the uses of healthcare performance indicators by micro-meso-macro context. Recurrent fitness for use considerations were also distilled and clustered. These findings were prepared as an expert panel brief for use as a background document in the second phase (Appendix 1).

Phase 2: interviews with expert panel and thematic analysis

The first panel aimed to engage prominent academics and thought leaders in the field of healthcare performance measurement and quality of care (hereafter, expert panel). Experts were identified based on the authorship of literature reviewed and with consideration to the following criteria for the panel's composition: a balance of expertise in areas related to quality of care, performance measurement, governance, data and information systems or management; senior academic or technical roles related to their area of expertise; and affiliation to varied healthcare systems and geographic contexts. A target of 15 experts was pursued for manageability and presumed saturation [49].

One pilot interview was conducted to ensure relevance and clarity. Piloting resulted in the addition of illustrative examples of data users and fitness for use considerations. Panellists were invited to participate via email and received a panel brief in advance. The brief provided relevant study details together with the findings of phase 1. All interviews were conducted by the primary researcher (EB, female) with experience in semistructured interviews and subject matter expertise. Interviews took place between August and September 2019 both in person and at distance based on the proximity and preference of panellists. Interviews lasted between 45 and 60 min. Records of the interviews were prepared as detailed summaries rather than verbatim transcripts in the approach described by Halcomb and Davidson [50]. The research adheres to the Dutch ethics guidelines stated in 'Medical Research Act with People (Wet medisch-wetenschappelijk onderzoek met mensen (WMO)) (Dutch), in BWBR0009408, W.a.S. Ministry of Health, Editor. 1998: Hague, Netherlands' [51], for which verbal consent was deemed adequate by the authors as no human data were retained. To ensure informed voluntary participation, participants provided written agreement to particiate in the study during the recruitment stage and restated verbally their consent at the start of all interviews.

The interview records of this first panel were stored in an Excel-based tool for thematically analysing themes (EB). The analysis incorporated a deductive and inductive approach: topics explored in the interviews (Appendix 1) were used to guide the deductive thematic analysis [52] and new themes that emerged were identified using an inductive approach [53]. The data was also interpreted by redrawing conceptual diagrams. Two others (DSK, NSK) with complementary expertise in quality of care, performance measurement, health governance and management reviewed the findings to ensure consistency and reach agreement on the theme extraction.

Phase 3: interviews with user panel and thematic analysis

The findings from the expert panel were used to refine the mapping of uses of healthcare performance by micro-meso-macro level and fitness for use themes. The revisions were summarised in a new brief prepared for a second panel of one-on-one interviews (Appendix 2). This panel aimed to engage real-world data users for their first-hand experiences using healthcare performance indicators for quality of care-related decision-making (hereafter, user panel).

A target of 15 data users actively contributing to the further development of this field were pursued as panellists. The selection drew on existing membership lists of international networks, working groups and projects related to healthcare performance indicators, measurement and quality of care, such as the OECD Health Care Quality Indicator Project [54] and initiatives of the European Commission (eg, HealthPros [55]). The panel composition aimed to capture a range of perspectives, with representation of differing health system types, country affiliations and uses of healthcare performance indicators. Interviews were conducted in the same manner as the first panel and were completed between November 2019 and January 2020.

Interview records were consolidated in the existing Excel-based tool for further thematic analysis. The topics and themes explored were used to refine and/or confirm the classification resulting from the expert panel on uses of healthcare performance indicators and fitness for use considerations. Observing the convergence of themes, with this phase data collection and analysis were considered complete.

Results

Literature review and panel results

Based on the literature synthesis, 19 experts were identified and invited to participate in the first panel. Of these, 16 experts agreed to participate. Non-participants were either unreachable (n=1), unavailable (n=1) or referred to an alternative contact (n=1). Together, expert panellists had published more than 50 articles or reports on the use, selection or improvement of healthcare performance indicators at the time of study. This literature (Appendix 3) was reviewed in phase 1 together with other relevant works [22,34,44,48,56-64]. Expert panellists were predominately affiliated to academia and in senior or executive roles spanning eight countries (Australia, Canada, Denmark, Germany, Italy, the Netherlands, UK and USA). A range and balance of areas of expertise that included performance measurement, quality of care, governance, information systems and management were achieved.

The user panel comprised participants spanning the micro-level, meso-level and macro-level of healthcare systems. Participants included representatives of national health authorities, health standards and accreditation agencies, insurers, professional associations, as well as clinicians and patient advocates. In total, 31 participants were contacted from which 16 agreed to participate (Appendix 3). Non-participants reported the same reasons as the first panel, with the majority (n=6) referring to an alternative contact, and the remainder being either unreachable (n=5) or unavailable (n=4). User panellists spanned seven countries (Belgium, Canada, Germany, Ireland, the Netherlands, UK and USA). Table 1 summarises the key characteristics across panellists.

Table 1 Characteristics of panellists

EXPERT PANEL	N (%)	USER PANEL	N (%)
Total	16 (–)		16 (–)
Affiliation*		**Uses**	
Academia	10 (63)	Macro	7 (44)
International organisation	3 (19)	Meso	4 (25)
Think tank	3 (19)	Micro	3 (19)
Expertise		**Organisation type**	
Measurement	5 (31)	Government	5 (31)
Quality of care	3 (19)	Health services	4 (25)
Governance	3 (19)	Standards	3 (19)
Information systems	3 (19)	Research	2 (13)
Management	2 (13)	Improvement	2 (13)
Region			
Europe	9 (56)		9 (56)
North America	5 (31)		7 (44)
Oceania	2 (13)		–
Sex			
Male	11 (69)		9 (56)
Female	5 (31)		7 (44)

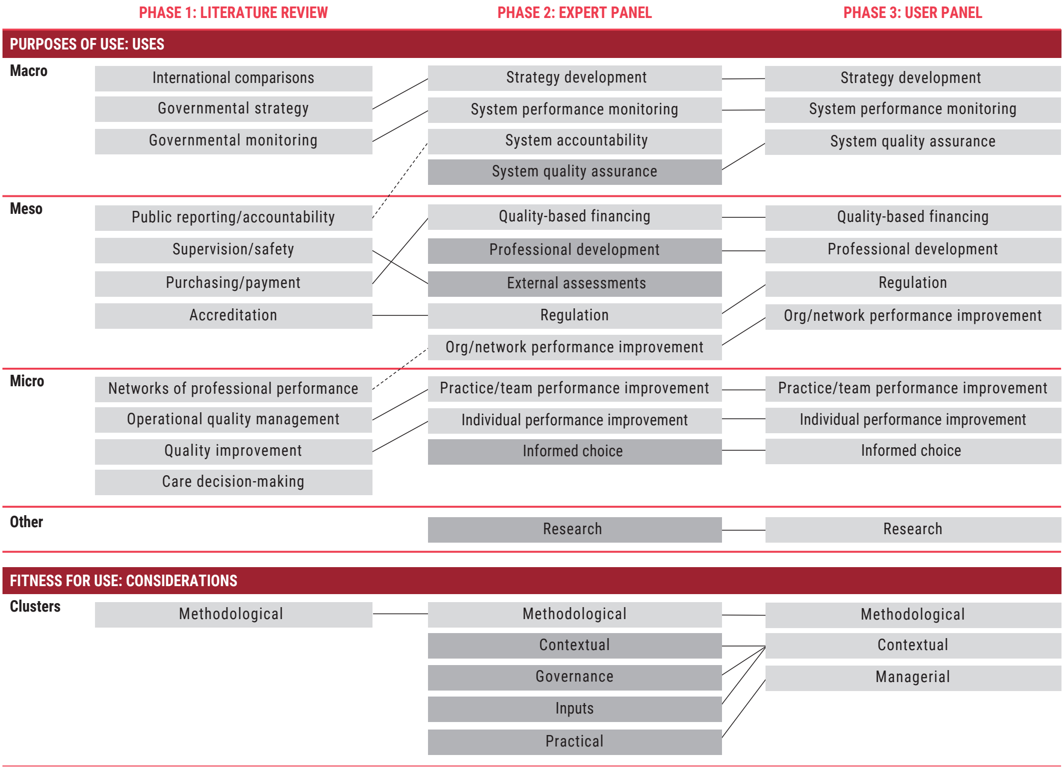
*Primary affiliations.

From the literature reviewed, 11 clusters of uses of healthcare performance indicators and fitness for use considerations related to the methodological quality of an indicator were identified (figure 2). In the second phase, there was agreement across experts on the relevance and importance to distinguish purposes of use of healthcare performance indicators beyond aggregate micro-level, meso-level and macro-level. The panel shared strong views to avoid a hierarchy within levels, finding this introduced a rigidity that may not translate across contexts. Rather, the framing of uses identified as common or frequent was found more transferable.

The experts introduced further consistency, refinements and additional purposes of use and fitness for use considerations. Specifically, the uses of indicators for functions such as regulation or strategy development were differentiated from mechanisms to achieve these functions, such as international comparisons or public reporting. Refinements to the distribution of uses across levels were introduced for consistency, for example, recategorising *improvements of organisations and networks* to the meso-level. Additions included emphasis on the use of indicators by patients as a decision-maker for informed choice and the cross-cutting function of research. The clustering of fitness for use considerations was disaggregated, with emphasis on the importance of considering an indicator's use in a specific setting (where it is used) and as a process (how it is used).

In the third phase, user panellists agreed with the categorisation of uses by micro-level, meso-level and macro-level. *Accountability* was viewed as an aim rather than specific use and *external assessments* were viewed rather as a mechanism. There were detailed discussions on fitness for use considerations, with agreement to classify considerations that underscored the importance of the setting in which an indicator is used for its contextualisation. The case was made to view *practical* considerations as *managerial* aspects related to the process of using indicators.

Figure 2 Summary of key findings across study phases



Note: boxes denote key themes emerging by study phase. Broken lines denote a change in level. Solid lines denote agreement between phases with possible adjustments to phrasing. Darker grey shading denotes the introduction of new elements. Ordering within cells is not indicative of importance.

Purposes of use of healthcare performance indicators

Through our stepwise approach to data collection and analysis, common uses of healthcare performance indicators were differentiated beyond the aggregate decision-making contexts of patient care (micro-level), organisations (meso-level), and policy (macro-level). In table 2, we list the uses for healthcare performance indicators identified, each serving different managerial decision-making functions, users and information needs. The purposes of use are not exhaustive and may take varied forms by healthcare system. Specifically, expert and user panellists noted variation in the degree of patient choice, role of insurers or mandate of professional bodies.

The detailed differentiation of uses of healthcare performance indicators signals important, yet often overlooked, distinctions in information needs *within* system levels. To illustrate these differences, we take the macro-level as an example. While uses of healthcare performance indicators in this context share an overall aim of informing policy decisions, distinctions between uses include system performance monitoring—signalling to system stakeholders, often including the public, the performance of the system as a whole, answering 'How is my healthcare system doing?'; or strategy development—signalling to ministries, departments of health or similar with the aim of identifying priority areas, monitoring trends and ultimately answering 'Have I chosen the right areas to prioritize?'; or system quality assurance—informing decisions of health service executives, quality inspectors or quality observatories for an overview of care processes and signalling of incidents, answering 'Is care being delivered as intended?'

Table 2 Differentiating uses of healthcare performance indicators across healthcare systems

CONTEXT	PURPOSE OF USE	ILLUSTRATIVE USES	ILLUSTRATIVE USERS	ILLUSTRATIVE INFORMATION NEED
Macro	System performance monitoring.	Signalling the performance of the system as a whole; comparing performance internationally; publicly reporting system performance.	Public; ministry of health; regional (provincial, state) authorities; health service executive (authority).	How is my healthcare system doing? How does it compare with others?
	Strategy development.	Setting health policy priorities; identifying emerging health priority areas; and monitoring trends in current priority areas.	Government and ministries; regional (provincial, state) authorities; accountable care organisations; health maintenance organisations.	Have I chosen the right areas to prioritise? What is the impact of strategies that are in place?
	System quality assurance.	Measuring care processes; reporting of incidents and never events.	Quality inspectorate; national quality observatory; health and safety executive.	Is care being delivered as intended? Where do problems in the delivery of care lie?

CONTEXT	PURPOSE OF USE	ILLUSTRATIVE USES	ILLUSTRATIVE USERS	ILLUSTRATIVE INFORMATION NEED
Meso	Regulation (professional, facility, pharmaceuticals).	Informing accreditation, certification and/or licensing processes.	Medical councils, chambers, college of physicians; medicines and healthcare products regulatory agency.	Does the performance of organisations, facilities, medicines, etc, meet established standards?
	Professional development.	Reporting internally and benchmarking within profession or specialty.	Societies of medical professionals; professional associations; training institutions.	How do healthcare professionals of a specific specialty perform?
	Quality-based financing.	Issuing performance-based payment (pay-for-performance); value-based contracting.	Healthcare insurers; healthcare providers.	Are existing guidelines or standards being adhered to? Does this merit the issuing of incentives?
	Organisation/ network performance improvement.	Improving performance of hospitals, networks, care groups; assessing local needs and geographic differences.	Hospital management; integrated care; networks/ groups; local collaboratives of care.	Are affiliated practices/facilities performing optimally?
Micro	Practice or team performance improvement.	Convening audit and feedback, plan-do-study-act, and/or collaborative, team-based improvement cycles; comparing across practices.	Primary care practices; specialist departments or units; pathways of care.	How is my team performing? How can we improve our performance? How do I perform relative to my team members?
	Individual performance improvement.	Identifying trends in the management of patients; tailoring services to target groups.	Individual physicians; nurse/practitioners; other healthcare professionals.	How am I managing my practice panel? How can I improve my performance?
	Informed choice.	Selecting a healthcare provider; participating in care decision-making; self-managing care needs.	Patients; family members and carers; public.	What treatment options or providers are best for me?
Cross-cutting	Research.	Exploring the use of indicators across contexts.	Academia and academic networks; think tanks, research groups; topic-specific associations.	Secondary user-directed.

Fitness for use of healthcare performance indicators

Three main clusters of considerations influencing the second construct of actionability—fitness for use—were found. These include methodological, contextual and managerial considerations (table 3).

Methodological considerations

Methodological considerations pertain to the indicator itself, although beyond its statistical quality. Seven recurrent considerations were identified. First, an indicator should measure what matters. User panellists emphasised the importance that the target audience *cares* about the results, explaining an indicator that 'moves' people makes everyone uncomfortable that the right thing is not already being done. Second, the extent to which an indicator resonates with a range of stakeholders was emphasised as a key gauge of its ability to facilitate a 'what can *we* do' approach, rather than limiting action to an individual user [65]. Third, an indicator's inherent ease of interpretation was described by panellists and in the literature [18,66,67] to strongly influence an end user's confidence in their interpretation of its meaning. Fourth, the extent to which an indicator is clearly defined was described as a key contributor to trust in what it signals, as well as the likelihood of wide uptake. Fifth, an indicator should be able to be broken down into its constituent parts to make change points clear [8]; with panellists finding a remote or disconnected indicator from a user's performance difficult to act on [59,63]. Sixth, an indicator should measure a phenomenon as true to lived experience as possible [27,68]. The tendency to focus on specific (siloed) areas of care was described to reduce performance to overly narrow aspects of care, and as one user panellist described, misses the 'system-ness' of quality. Lastly, the ability of an indicator to be sufficiently sensitive to change based on its intended use was described by both panels as intuitive, yet often a challenge for an indicator to meet.

Contextual considerations

Contextual considerations refer to critical factors pertaining to the setting in which an indicator is used. Four main clusters emerged. One, the information infrastructure was met with consensus across panellists as a key predictor of use, determining the ability to collect, store and extract information. Relevant considerations repeatedly raised included the interoperability of information systems (ie, linkages, output format) and overall data quality (ie, consistency in field, codes, maintenance). Second, characteristics of governance were emphasised, with panellists citing the importance of political will and vision, regulatory arrangements for data exchanges, as well as cross-sector partnerships and aligned financing structures. Third, workforce capacity considerations were underscored, specifically the data literacy skills of actors across the healthcare system and the availability of protected time for the healthcare workforce to use data. Lastly, pertaining to culture and professional norms, be it in clinical practice, healthcare organisations, professional networks or government agencies, the importance of a learning orientation and shared sense of responsibility was emphasised as a predictor of the importance placed to measurement and ultimately the use of an indicator.

Managerial considerations

The importance of embedding indicators into performance management systems is well established [60,63,69-72]. Based on the literature and insights from the panels, we conceptualised an indicator's use cycle (figure 3). This cycle was used to consolidate considerations brought forward around embedding indicators into management systems to safeguard an indicator's use in practice. The considerations reflect key decisions to be managed across the cycle and include selecting an indicator with consideration to define clear parameters of its intended use [18,38,73], gain clarity around its construction [60], assess data needs and define measurement considerations; accessing data to ensure data are available, of quality or can feasibly be collected [48]; applying methods of analysis for the relevant calculation of values that correspond to the intended purpose [63]; displaying findings, including decisions around how data is visualised [74] and the degree of *story-telling* to describe and interpret results to support understanding of what is meant and any caveats [48,75,76]; and actually reaching decision-makers, with decisions needed as to the frequency of dissemination, channel used for delivering information and guidance (if any) to facilitate the use of information provided [63].

Figure 3 Use cycle for managing healthcare performance indicators

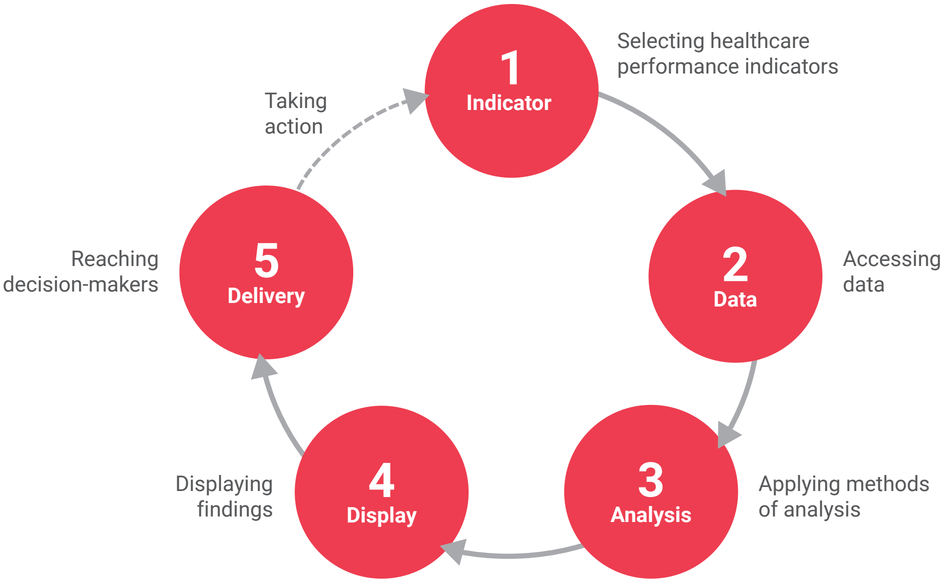


Table 3 Overview of methodological, contextual and managerial fitness for use considerations

CLUSTERS	CONSIDERATIONS	GUIDING QUESTIONS FOR CONSIDERING AN INDICATOR'S USE
Methodological		
	Measures what matters.	Does anybody care?
	Wide engagement.	What can we do?
	Easily interpreted.	Does the indicator signal a clear direction?
	Clear standardisation.	Is the indicator clearly defined and replicable?
	Alignment of accountability.	Are entry points for taking action feasible?
	Measurement matches delivery.	Is the indicator a reflection of the system?
	Sensitive to meaningful change.	Is the indicator sufficiently sensitive to change?
Contextual		
Information infrastructure	Interoperability.	Can needed data be accessed?
	Data quality.	Is the data of quality?
Governance	Political will and vision.	Is there high-level commitment and direction for use?
	Regulation for data protection.	Does existing legislation facilitate use?
	Cross-sector partnerships.	Are cross-sector partnerships in place?
	Aligned financing structures.	Do financing structures encourage the intended use?
Workforce capacity	Data and quality expertise.	Are the competencies to interpret and use data in place?
	Time dedicated to improvement.	Is time allocated to encourage use?
Culture	Learning orientation.	Is an environment for learning cultivated?
	Shared responsibility for health.	Do users feel accountable for improvement?
Managerial		
Selecting healthcare performance indicators	Clear purpose of use.	What is the purpose of use? (eg, strategy development)
	Target end user is known.	Is the target audience known? (eg, clinicians, public)
	Conceptual framework.	Is the dimension of quality pursued clear?
	Indicator quality.	Is the indicator scientifically sound?
	Source, type and availability of data.	What data is needed and is it available? (eg, administrative, clinical, survey data, wearables)
	Standards for appraisal.	How will improvements in performance be assessed?
	Degree of public disclosure.	Is the indicator for internal or external (public) use?
	Accompanying indicators.	Are there relevant accompanied indicators?
	Previous use.	Has the indicator been used previously?
Accessing data	Representativeness of data.	Is the data complete?
	Data linkages.	Can relevant data sources be linked?
	Data collection tools.	How will data be collected? (eg, paper-based, automated electronically, manual electronic entry)
	Unity of language/coding.	Is there consistency in coding across data to be used?

CLUSTERS	**CONSIDERATIONS**	**GUIDING QUESTIONS FOR CONSIDERING AN INDICATOR'S USE**
Applying methods of analysis	Type of analysis.	How will the data be analysed? (eg, benchmarking, time trend, case mix correction)
	Aggregation of indicators.	How can composites/indices be used to simplify data?
	Reference group.	Who is the reference group?
	Breakdowns/cohorts.	How will the data be disaggregated? (eg, age, sex, ethnicity, geographically)
	Calculation of values.	How will values be calculated? (eg, means, median, SD, top 10% mean)
	Time interval.	Should a time trend be reported and at what interval?
	Application of risk adjustments.	How will risk adjustments be applied? (eg, variable specification, source, weighting scheme)
	Managing missing data.	How will missed data points be handled?
	Contextualising data.	What other data is needed to give the indicator meaning?
Displaying findings	Chart options.	How will the data be visualised? (eg, chart, map, table)
	Simplification techniques.	What techniques to simplify the meaning can be applied? (eg, colour, size variation, icons)
	Customisation of display.	How can users customise the data? (eg, change of display, change of information)
	Narrated interpretation.	How can the quality and the meaning of data be narrated?
	Format of reporting.	How will it be reported? (eg, print, mobile, web-based)
Reaching decision-makers	Frequency of reporting.	What is the relevant reporting cycle (eg, real time, quarterly, annually, biennially)
	Dissemination channels.	How will users be reached? (eg, mail, email, champions)
	Guidance on use.	How can users be supported to make use of findings?

Discussion

Principal findings

Healthcare performance indicators share a common aim to provide simplified, readily understood information to facilitate decision-making [9,44,45]. An indicator's ability to do so in practice extends beyond its statistical quality and rather is characterised by its actionability [16-18,67]. In this study, we explored actionability through the two constructs of fitness for purpose and fitness for use and observe the following main findings into their further operationalisation.

First, the different uses of an indicator within micro-meso-macro and research contexts stress the importance of clarity and precision on the intended use of an indicator. The relevance of precision regarding an indicator's use has been stressed in the literature [15,18-20,23] and previously explored from the perspective of different end-users [1]. Our findings further differentiate uses of indicators across healthcare systems. While not pursuing a universal, exhaustive listing of purposes of use—recognising varied healthcare system types and contextual considerations that deem this irrelevant—our findings signal the imperative of clarity regarding an indicator's intended use and user to gauge its potential usefulness. The taxonomy of uses of healthcare performance indicators can be an input to further operationalise the construct of fitness for purpose.

Second, we find an indicator's fitness for use is captured by three types of considerations. These relate to an indicator's technical qualities, its intended context of use and its handling across what can be characterised as a use cycle. It means, to gauge an indicator's fitness for use, a range of considerations should be assessed that span, for example: 'Does the indicator signal a clear direction?' to 'Can needed data be accessed?' and 'What is the relevant reporting cycle?' The listed considerations (table 3) based on the literature and views of panellists are a testament to the wide range of variables weighing on an indicator's use that require thoughtful handling.

Third, an indicator's fitness for purpose and fitness for use should be taken together to appraise actionability. For example, a policy-maker may identify a target to be measured in the scope of a strategy, yet for this specific purpose fitness for use considerations may not be met due to information system constraints or other contextual limitations. In another instance, an indicator may meet fitness for use considerations yet lack a clear and specific purpose and in effect, misses a target audience. In both cases, the actionability of the indicator is compromised.

Lastly, as the expertise and lived experience of panellists served to highlight, the actionability of an indicator is not a guarantee of impact. Literature on the misuse, manipulation of data, and unintended consequences of performance measurement depict this [45,73].

This distinction between action and impact underscores that while actionable healthcare performance indicators may be a precursor to better decision-making, the impact of an indicator weighs on considerations of its own.

Applications and further research

This study has sought to consolidate the relevant literature and engage informants from differing contexts, areas of expertise and first-hand experiences for diverse insights. Future research should test the findings empirically, investigating purposes of use and fitness for use considerations by specific country contexts, governance structures, services delivery systems or areas of specialisation.

The findings of this study have a range of potential applications. In the context of the COVID-19 pandemic, actionable healthcare performance indicators have proven of paramount importance [29,77] and surges in publicly reported data illustrate the increased demand for information [78,79]. The extent to which this information informs decision-making is a reflection of the alignment between an indicator's intended purpose of use and related fitness for use considerations. The findings could also inform the selection of indicators for measurement frameworks and indicator sets that cascade healthcare system levels by priority areas (eg, tackling the misuse of antibiotic prescribing, strengthening integrated care), where different decision-making functions need to work in combination.

Limitations

These findings may not be generalisable beyond the context of developed countries. The effect of system conditions such as level of decentralisation, public-private mix and development status, have not been captured nor investigated given the targeted sample of informants and as suggested, should be explored empirically. The initial literature review was limited to English-language materials which may also impact the generalisability of findings. Engaging expert panellists beyond English-speaking countries sought to minimise this. Some nuances may have become lost in choosing to summarise rather than transcribe interviews, although the advantages of our approach were found better suited for the study aims and design. In exploring performance indicators in the scope of healthcare, the study has not captured the broader use of indicators for public health despite its importance. Distributing panellists between panels was to the discretion of the study team for the purposes of the two-panel design, although many participants held positions or memberships suitable to both. The value of engaging panellists from different perspectives and stages took precedent. The prominence of panellists meant some were known to the authors. In order to avoid bias, a consistent interviewer was selected with the least previous engagement with panellists.

Conclusion

Clarifying the meaning of actionable healthcare performance indicators is a perquisite to its further operationalisation. This study has explored the body of literature on the actionability of healthcare performance indicators for quality of care-related decision-making together with expert opinion and data user experiences in an effort to unpack the constructs of fitness for purpose and fitness for use. The study aimed to capture these constructs from a system perspective. The findings signal the importance of clarity and precision on an indicator's purpose of use and context for the handling of methodological, contextual and managerial considerations weighing on its use in practice. Striking a better balance between the importance weighted to an indicator's statistical merits and emphasis put to an indicator's fitness for purpose and use is needed for indicators that are actionable for quality of care-related decision-making.

Acknowledgements

We thank the following individuals for their contribution at varied stages of this work: JohnMarc Alban; Thomas Boeckz; Jeffrey Braithwaite; Emma Cartwright; Louise Clement; Cheryl Damberg; Greg Dempsey; Gail Dobel; Tejal Gandhi; Oliver Groene; Torsten Hecke; Peter Hibbert; John Lavis; Doreen MacNeil; Jan Mainz; Stephanie Medlock; Rob Nelissen; Sabina Nuti; Jillian Oderkirk; Irene Papanicolas; Lotte Ramerman; Ari Robiscek; Alexandru Rotar; Eric Schneider; Peter Smith; Jorien Soethout; Juan Tello; Rob Tollenaar; Michael van den Berg; Jeremy Veillard; Robert Verheij; and Naira Yeitsvan.

References

1. Smith P, et al. Part 1: Principles of performance measurement. In: Performance measurement for health system improvement: experiences, challenges and prospects. Copenhagen: WHO Regional Office for Europe; 2008.
2. WHO Regional Office for Europe. The Tallinn charter: health systems for health and wealth. Copenhagen: WHO Regional Office for Europe; 2008.
3. Fekri O, Macarayan ER, and Klazinga N. Health system performance assessment in the WHO European Region: which domains and indicators have been used by Member States for its measurement? In: Health Evidence Network synthesis report 55. Copenhagen: WHO Regional Office for Europe; 2018.
4. World Health Organization. The world health report 2000: health systems: improving performance. Geneva: World Health Organization; 2000.
5. Kelley J, Hurst J. Health care quality indicators project conceptual framework paper. In OECD health working papers No. 23. Paris: OECD; 2006.

6. Perić N, Hofmarcher-Holzhacker MM, Simon J. Health system performance assessment landscape at the EU level: a structured synthesis of actors and actions. Arch Public Health. 2017;75:5.

7. Kringos DS, Groene O, Johnsen SP. Training the first generation of health care performance intelligence professionals in Europe and Canada. Acad Med. 2019;94:747–8.

8. Mainz J. Developing evidence-based clinical indicators: a state of the art methods primer. Int J Qual Health Care. 2003;15:5i–11.

9. Mainz J. Defining and classifying clinical indicators for quality improvement. Int J Qual Health Care. 2003;15:523–30.

10. Boerma T, AbouZahr Z, Evans D, et al. Monitoring intervention coverage in the context of universal health coverage. PLoS Med. 2014;11:e1001728.

11. McGlynn EA. The outcomes utility index: will outcomes data tell us what we want to know? Int J Qual Health Care. 1998;10:485–90.

12. de Koning J, Burgers J, Klazinga N. Appraisal of indicators through research and evaluation (AIRE). Amsterdam: University of Amsterdam; 2008.

13. Fitch K, et al. The RAND/UCLA appropriateness method user's manual. Santa Monica, CA: RAND; 2001.

14. Quentin W, et al. Measuring healthcare quality. In: Busse R, ed. Improving healthcare quality in Europe: characteristics, effectiveness and implementation of different strategies. Copenhagen: WHO and OECD; 2019.

15. Damberg CL, Sorbero ME, Lovejoy SL, et al. An evaluation of the use of performance measures in health care. RAND Health Q. 2012;1:3.

16. OECD. Health in the 21st century: putting data to work for stronger health systems. Paris: OECD; 2019.

17. McDowell R. Signs to look for: criteria for developing and selecting fit for purpose indicators. Wellington, New Zealand: PricewaterhouseCoopers; 2017.

18. Smith P, Mossialos E, Papanicolas I. Performance measurement for health system improvement: eperiences, challenges and prospects. Copenhagen: WHO Regional Office for Europe; 2008.

19. Carinci F, Van Gool K, Mainz J, et al. Towards actionable international comparisons of health system performance: expert revision of the OECD framework and quality indicators. Int J Qual Health Care. 2015;27:137–46.

20. European Commission. Expert group on health system performance assessment, so what? strategies across Europe to assess quality of care; 2016.

21. Smith P, et al. Principles of performance measurement. In Performance measurement for health system improvement. Cambridge: Cambridge University Press; 2009.

22. Klazinga N, Stronks K, Delnoij D, et al. Indicators without a cause. Reflections on the development and use of indicators in health care from a public health perspective. Int J Qual Health Care. 2001;13:433–8.

23. Hilarion P, Suñol R, Groene O, et al. Making performance indicators work: the experience of using consensus indicators for external assessment of health and social services at regional level in Spain. Health Policy. 2009;90:94–103.

24. Smith P. Health system performance assessment. Brussels: European Commission, 2014.
25. Secanell M, Groene O, Arah OA, et al. Deepening our understanding of quality improvement in Europe (DUQuE): overview of a study of hospital quality management in seven countries. Int J Qual Health Care. 2014;26:5–15.
26. iHD. Transform introduction enriching knowledge and enhancing care through data; 2016. Available: https://www.i-hd.eu/index.cfm/resources/ec-projects-results/transform/.
27. Nuti S, Noto G, Vola F, Vainieri M. Let's play the patients music: A new generation of performance measurement systems in healthcare. Manag Decis. 2018;56:2252–72.
28. Verheij R, et al. Reuse of routine care data for policy and science: how things can be improved [Dutch]. Utrecht: Nivel; 2019.
29. Kringos D, Carinci F, Barbazza E, et al. Managing COVID-19 within and across health systems: why we need performance intelligence to coordinate a global response. Health Res Policy and Syst. 2020;18:80.
30. The Lancet Infectious Diseases. The COVID-19 infodemic. Lancet Infect Dis. 2020;20:875.
31. National Academies of Sciences, E.a.M., Crossing the global quality chasm: improving health care worldwide. Washington DC: National Academies of Sciences, Endineering and Medicine; 2018.
32. World Health Organization, World Bank Group, and Organisation for Economic Co-operation and Development. Delivering quality health services: a global imperative for universal health coverage. Geneva: World Health Organization; 2018.
33. Kruk ME, Gade AD, Arsenault C, et al. High-quality health systems in the sustainable development goals era: time for a revolution. Lancet Glob Health. 2018;6:e1196–252.
34. Salzburg Global Seminar. The Salzburg statement on moving measurement into action: global principles for measuring patient safety. Institute for Healthcare Improvement and Salzburg Global Seminar; 2019.
35. Panch T, Szolovits P, Atun R. Artificial intelligence, machine learning and health systems. J Glob Health. 2018;8:020303.
36. Panch T, Pearson-Stuttard J, Greaves F, et al. Artificial intelligence: opportunities and risks for public health. Lancet Digit Health. 2019;1:e13–4.
37. Verheij RA, Curcin V, Delaney BC, et al. Possible sources of bias in primary care electronic health record data use and reuse. J Med Internet Res. 2018;20:e185.
38. Braithwaite J, Hibbert P, Blakely B, et al. Health system frameworks and performance indicators in eight countries: A comparative international analysis. SAGE Open Med. 2017;5:2050312116686516.
39. Tong A, Sainsbury P, Craig J. Consolidated criteria for reporting qualitative research (COREQ): a 32-item checklist for interviews and focus groups. Int J Qual Health Care. 2007;19:349–57.
40. Baumeister RF, Leary MR. Writing narrative literature reviews. Rev Gen Psychol. 1997;1:311–20.
41. Kvale S. Doing interviews: The SAGE qualitative research kit. Los Angeles, Calif: Sage; 2009.
42. Vogl S, Schmidt E, Zartler U. Triangulating perspectives: ontology and epistemology in the analysis of qualitative multiple perspective interviews. Int J Soc Res Methodol. 2019;22:611–24.

43. Keeney S, Hasson F, McKeena H. The Delphi technique in nursing and health research. United Kingdom: Wiley-Blackwell; 2011.

44. Hammond AL, et al. Environmental indicators: a systematic approach to measuring and reporting on environmental policy performance in the context of sustainable development; 1995.

45. Astleithner F, Hamedinger A, Holman N, et al. Institutions and indicators – the discourse about indicators in the context of sustainability. J Hous Built Environ. 2004;19:7–24.

46. Institute of Medicine. Crossing the quality chasm: a new health system for the 21st century 2001. Washington, DC: National Academy Press; 2001.

47. Plochg T, Klazinga N. Community-based integrated care: myth or must? Int J Qual Health Care. 2002;14:91–101.

48. Raleigh VS, Foot C. Getting the measure of quality: opportunities and challenges. London: The King's Fund; 2010.

49. Fink A, Kosecoff J, Chassin M, et al. Consensus methods: characteristics and guidelines for use. Am J Public Health. 1984;74:979–83.

50. Halcomb EJ, Davidson PM. Is verbatim transcription of interview data always necessary? Appl Nurs Res. 2006;19:38–42.

51. Ministry of Health. Medical research act with people (Wet medisch-wetenschappelijk onderzoek met mensen (WMO)) [Dutch], in BWBR0009408. Hague, Netherlands: Ministry of Health; 1998.

52. King N. Using templates in the thematic analysis of text. In: Essential guide to qualitative methods in organizational research. Sage; 2004.

53. Virginia B, Victoria C. Using thematic analysis in psychology. Qual Res Psychol. 2006;3(2):77–101.

54. OECD. OECD Health Care Quality Indicators Project - background. Available: http://www.oecd.org/els/health-systems/oecdhealthcarequalityindicatorsproject-background.htm

55. HealthPros. International Training Network for Healthcare Performance Intelligence Professionals, 2020. Available: https://www.healthpros-h2020.eu/

56. Freeman T. Using performance indicators to improve health care quality in the public sector: a review of the literature. Health Serv Manage Res. 2002;15:126–37.

57. Grover V, Chiang RHL, Liang T-P, et al. Creating strategic business value from big data analytics: a research framework. J Manag Inf Syst. 2018;35:388–423.

58. Esquivel A, Meric-Bernstam F,. Bernstam EV. Accuracy and self correction of information received from an Internet breast cancer list: content analysis. BMJ. 2006;332:939–42.

59. Compton-Phillips A, Lee TH. The "give a darn" method for outcomes measurement, in NEJM Catalyst; 2018.

60. van den Berg MJ, Kringos DS, Marks LK, et al. The Dutch health care performance report: seven years of health care performance assessment in the Netherlands. Health Res Policy Syst. 2014;12:1.

61. Berwick DM, James B, Coye MJ. Connections between quality measurement and improvement. Med Care. 2003;41:I–30.

62. Arnaboldi M, Lapsley I, Steccolini I. Performance management in the public sector: the ultimate challenge. Financial Account Manag. 2015;31:1–22.

63. Brehaut JC, Colquhoun HL, Eva KW, et al. Practice feedback interventions: 15 suggestions for optimizing effectiveness. Ann Intern Med. 2016:164;435–41.

64. Saver BG, Martin SA, Adler RN, et al. Care that matters: quality measurement and health care. PLoS Med. 2015;12:e1001902.

65. Nuti S, VOla F, Bonini A, et al. Making governance work in the health care sector: evidence from a 'natural experiment' in Italy. Health Econ Policy Law. 2016;11:17–38.

66. Hibbard JH, Peters E. Supporting informed consumer health care decisions: data presentation approaches that facilitate the use of information in choice. Annu Rev Public Health. 2003;24:413–33.

67. Marshall MN, Romano PS, Davies HT. How do we maximize the impact of the public reporting of quality of care? Int J Qual Health Care. 2004;16:i57–63.

68. Nuti S, De Rosis S, Bonciani M, et al. Rethinking healthcare performance evaluation systems towards the people-centredness approach: their pathways, their experience, their evaluation. Healthc Pap. 2017;17:56–64.

69. CIHI. How is an indicator developed at CIHI? 2019. Available: https://www.cihi.ca/en/how-is-an-indicator-developed-at-cihi [Accessed 3 Feb 2020].

70. Michel P, Fraticelli L, Parneix P, et al. Assessing the performance of indicators during their life cycle: the mixed QUID method. Int J Qual Health Care. 2020;32:12–19.

71. Hibbert PD, Wiles KL, Cameron ID, et al. CareTrack Aged: the appropriateness of care delivered to Australians living in residential aged care facilities: a study protocol. BMJ Open. 2019;9:e030988.

72. Pronovost PJ, Miller MR, Dorman T, et al. Developing and implementing measures of quality of care in the intensive care unit. Curr Opin Crit Care. 2001;7:297–303.

73. Mannion R, Braithwaite J. Unintended consequences of performance measurement in healthcare: 20 salutary lessons from the English National Health Service. Intern Med J. 2012;42:569–74.

74. Ballard A. Promoting performance information use through data visualization: evidence from an experiment. Public Perform Manag Rev. 2020;43:109–28.

75. Robicsek A. Six modest proposals for health care measurement. Waltham, MA: NEJM Catalyst; 2019.

76. Canadian Institute for Health Information. Better information for improved health: a vision for health system use of data in Canada. Ottawa: CIHI; 2013.

77. WHO Regional Office for Europe. Strengthening and adjusting public health measures throughout the COVID-19 transition phases. Copenhagen: WHO Regional Office for Europe; 2020.

78. Kennedy H. Simply data visualizations have become key to communicating about the COVID-19 pandemic, but we know little about their impact in LSE Impact Blog 2020. London, UK: London School of Economics and Political Sciences; 2020.

79. Fisher D, Teo YY, Nabarro D. Assessing national performance in response to COVID-19. Lancet. 2020;396:653–55.

Supplementary appendices

Appendix 1: Questions to expert panel

Appendix 2: Questions to user panel

Appendix 3: Panelists

Appendix 1: Questions to expert panel

Summary of users and users of health care performance data

Through our exploratory literature review we have identified a range of data uses that transcend the levels of a healthcare system. This list is not exhaustive, nor does it intend to be. Importantly, it is also limited to the use of data for the purposes of clinical care rather than a broader population health perspective. Nonetheless, it does ambition to capture a minimum or core set of purposes for use and actors that resonate across different healthcare systems. Similarly, the listing of actors is not exhaustive and is to the exclusion of other actors that may carry out multiple functions. The classification has attempted to illustrate a unique user by each managerial function and actors that are explicitly assigned a mandate to improve quality of care and made directly accountable to a healthcare system. As such, actors such as professional and patient associations, academia and other research groups are excluded.

This listing of distinct uses has been distinguished at the micro-level (clinical practice), meso-level (institutions/organisations) and macro-level (policy) as shown by the nested sublevels of the figure below and listed again in the table that follows for an editable version.

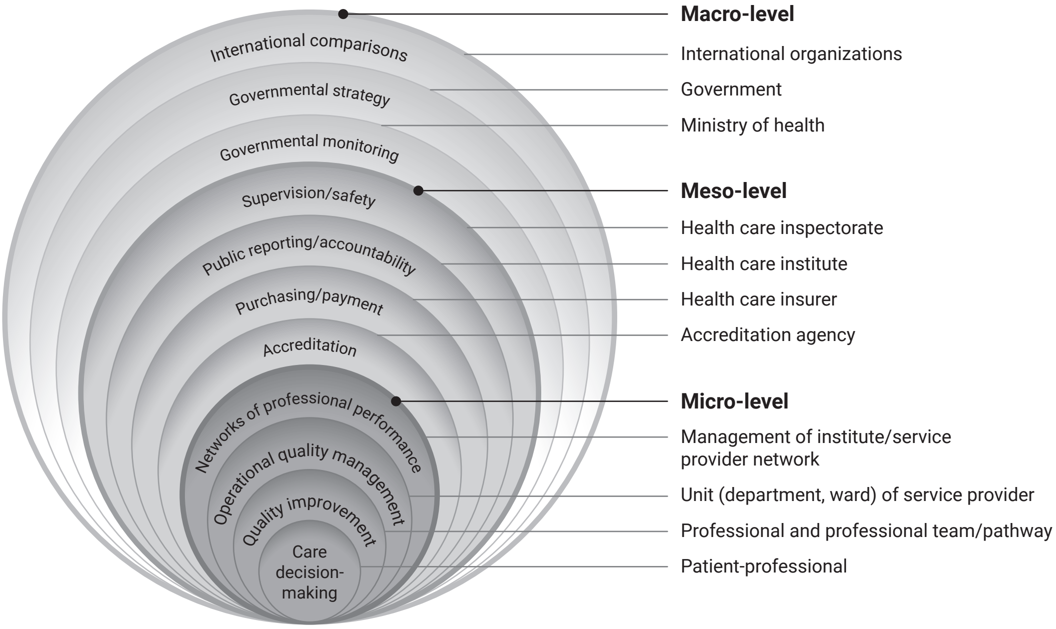
At each sublevel, a unique user can be identified, characterised as the primary actor with the responsible authority for a specific function (purpose of use). These purposes of use form different layers to decision-making, each embedded within one another. The interactions between layers signal the ways in which the users are related and co-dependent on the use and transfer of information, or as other authors have referred to as a ‘data food chain’, as some may reuse data collected and used by others.

- Is the list of purposes for use complete and accurate? If not, what is missing? Are there purposes for use that appear overlapping?
- Is the list of users complete and accurate? If not, what is missing?
- Is the cascading of users and uses accurate? If not, how can it be improved?

Table A1 Uses and users of healthcare performance indicators: listed

LEVEL	MANAGERIAL FUNCTION (USES)	USER
Macro Policy	International comparisons	International organisations
	Governmental strategy	Government
	Governmental monitoring	Ministry of health
Meso Institutional/ organisations	Supervision/safety	Healthcare inspectorate
	Public reporting/accountability	Healthcare institute
	Purchasing/payment	Healthcare insurer
	Accreditation	Accreditation agency
Micro Clinical practice	Networks of professional performance	Management of institute/service provider network
	Operational quality management	Unit (department, ward) of service provider
	Quality improvement	Professional and professional team/pathways
	Care decision-making	Patient-professional
Other	…	…

Figure A1 Uses and users of healthcare performance indicators across the health system: visualised



Methodological considerations

For each purpose for use, a range of methodological consequences (data requirements) can be anticipated. For example, the type of measure (eg, more process measures at the micro-level vs more outcome measures at the macro-level) or confidence intervals (eg, narrow for precision decisions of health practitioners vs wide for policy-makers). We have consolidated a range of methodologically relevant considerations (features of data) that has been highlighted in the literature as potentially relevant depending on the intended purpose of use. Examples to illustrate the variation for each of these considerations are listed in the table.

To further illustrate these considerations in practice, we have mapped existing indicators for measuring the performance of breast cancer services to different users and uses. The mapping serves to demonstrate the variability in information needs by user/use.

- Are the listed considerations meaningful? What is missed? What would you phrase differently? How can this list be expanded upon to serve its intended purpose of supporting users based on their intended purpose of use?
- How do you expect these considerations to vary based on specific uses and users from the table above?

Table A2 Fitness for use considerations and examples

RELEVANT CONSIDERATIONS	EXAMPLES OF VARIATIONS
Type of measure	process, outcome, patient-reported
Sources	administrative, medical records or clinical, registries, patient
Reference group	unit or department, types of units, region, province, country etc.
Reference period	previous 1–6 quarters; 1–12 months; 1–6 years; previous year, etc.
Comparators	past performance, targets, reference group
Compounds (composites)	selection of indicators, weights
Calculation of values	standard deviation, means, median, other percentiles (75th), rank, top 10% mean (ABC method), individual peer scores, ranges
Statistical chart options	funnel plot, Shewhart chart, scan statistics, moving average, sets method
Types of analysis	benchmarking, time trend, international comparison
Confidence intervals	narrow for precision decisions (practitioners) vs wide for policy-makers
Risk adjustments	variable specification (demographic, clinical factors, socio-economic, health related, patient preferences), source, weighting scheme
Others…	…

General reflections

- Do you agree with the construction and approach to exploring fitness for use of healthcare performance data as pursued in this study?
- Are you aware of any existing studies that should be consulted in the scope of this work?

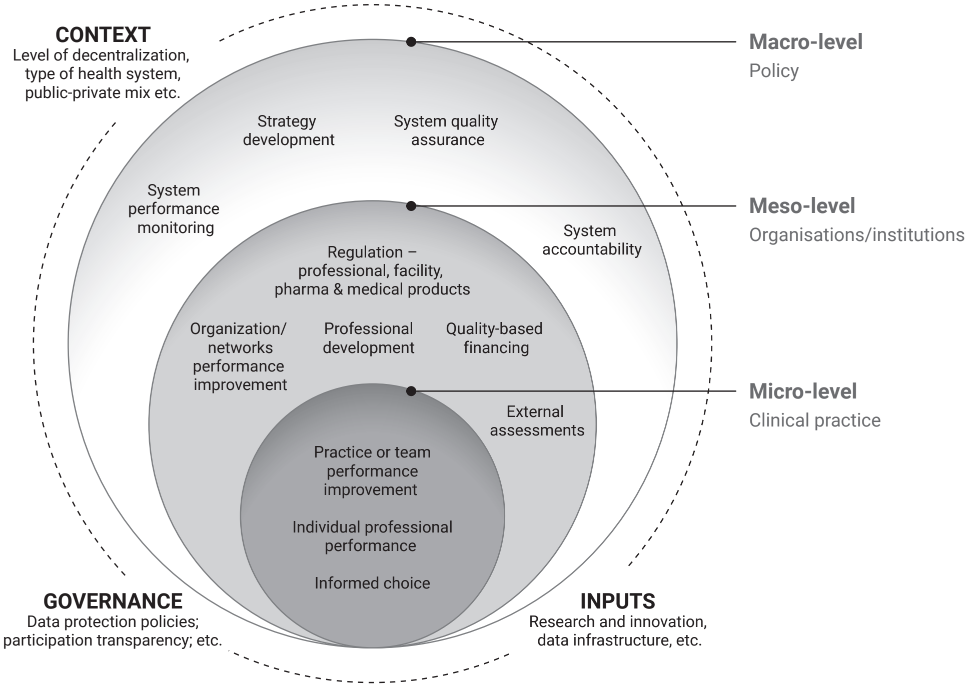
Appendix 2: Questions to user panel

Purposes of use of healthcare performance indicators

Uses of healthcare performance indicators can be differentiated at the micro-level (clinical practice), meso-level (institutions/organisations) and macro-level (policy) of healthcare systems. Methodologically relevant distinctions by the purposes for using healthcare performance indicators are shown in the nested sublevels of the figure below. For example, at the micro-level, uses of healthcare performance indicators include for informed choice (eg, by patients), individual professional performance improvement and practice or team performance improvement. Cross-cutting these uses are factors that ultimately weigh on the extent to which a specific purpose of use can be met. These feed-in factors can be clustered around the specific country context, governance and inputs (eg, research, data infrastructure).

1. Based on the figure (A2), how would you describe your most predominate purpose for using healthcare performance indicators?
2. For this purpose, what in your opinion constitutes a good indicator? That is, what information do you need? Can you give examples?
3. Can you describe how you make use of healthcare performance indicators? Who is your target end-user? What specific strategies or mechanisms are relied on (eg, public reporting, licensing or accreditation, financial incentives, etc.)?

Figure A2 Uses and users of health care performance indicators across the health system: visualised



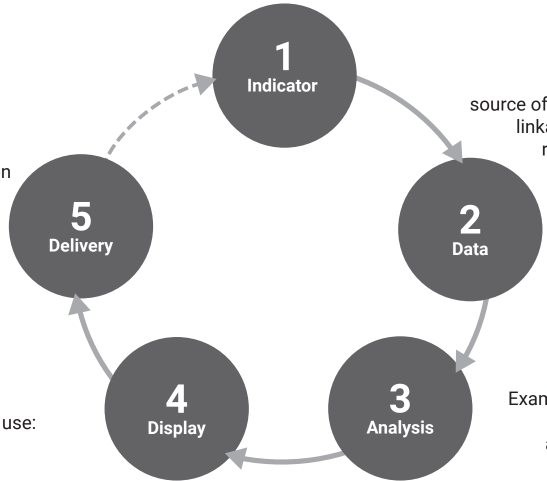
Considerations for the use of healthcare performance indicators

We recognise that depending on the purpose of use, each user has different information needs. The type of indicator (eg, process, structure outcome), sources of data (eg, administrative, clinical, survey data), timeliness (eg, weekly, quarterly, annually) or type of analysis (eg, benchmarking, time trend, international comparison), are among some of these differences.

Given this variability, there are a range of both practical and methodological considerations that may potentially affect the use of healthcare performance indicators. These considerations cannot be reduced solely to the analysis of indicators. For example, if an indicator is well-defined, collected and analysed but is not presented optimally, what it signals may not be clear to the intended user for decision-making purposes. In other instances, it may be the data itself that is the main issue, because it cannot be linked, is of poor quality or incomplete. We have clustered five key factors and potentially relevant considerations depending on the intended purpose of use of an indicator that have been highlighted in the literature and by the first round of panelists.

1. Based on your use of healthcare performance indicators, what are your critical needs across the indicator cycle shown in figure A3? That is, for each stage in the cycle as shown, what would make the ideal conditions for your purposes?
2. Which stage in your opinion is most important for the actionability of an indicator?
3. Is the information currently used by your organisation or practice useful for your purposes? That is, are you able to make decisions and learn from the information? How could it be better?
4. In your opinion, what are the main obstacles users face to make healthcare performance data actionable?

Figure A3 Use cycle of healthcare performance indicators



Selection of health care performance indicators

Examples of variability by use: quality domain pursued; type of measure; target population; appraisal of quality; defined risk adjustments; etc.

Data infrastructure for collecting and storing data

Examples of variability by use: source of data; system of identification; linkability; data collection method; representativeness of data; etc.

Methods for analysis

Examples of variability by use: type of analysis; aggregation of indicators; time interval; application of risk adjustments; discriminative power; reference group; etc.

Data presentation and display

Examples of variability by use: relevant chart options; lag time of reporting; format of reporting; data visualization; use of dashboards; customization of display; etc.

Activation of results for decision-making

Examples of variability by use: mandate or authority to make changes; trust in previous stages; competencies for interpretation of results; available time to interpret and act; etc.

Appendix 3: Panelists

EXPERT PANELISTS				USER PANELISTS			
#	Expertise (key words)	Literature consulted	Country	#	Organisation type	Level	Country
1	Quality of care	[1-6]	Australia	1	Standards	Macro	United States
2	Performance measurement	[7-10]	United States	2	Governmental	Macro	Belgium
3	Performance measurement	[11-16]	Germany	3	Research/academia	Micro	United Kingdom
4	Quality of care	[1,2,5,6,17]	Australia	4	Standards	Meso	Canada
5	Governance	[18-20]	Canada	5	Governmental	Macro	Ireland
6	Performance measurement	[21-23]	Denmark	6	Governmental	Macro	Canada
7	Data/information	[24-26]	Netherlands	7	Health services	Meso	Germany
8	Management	[27-29]	Italy	8	Improvement	Macro	United States
9	Data/information systems	[30-32]	Canada	9	Governmental	Macro	Canada
10	Performance measurement	[33-36]	United Kingdom	10	Health services	Micro	Netherlands
11	Management	[37-39]	Netherlands	11	Research/academia	Meso	Netherlands
12	Quality of care	[40-42]	United States	12	Health services	Meso	United States
13	Performance measurement	[33,35,36,43]	United Kingdom	13	Standards	Meso	Netherlands
14	Governance	[44-46]	Denmark	14	Health services	Micro	Netherlands
15	Governance	[23,47,48]	Canada	15	Improvement	Macro	Netherlands
16	Data/information systems	[49-51]	Netherlands	16	Governmental	Macro	Canada

Appendix 3 references

1. Braithwaite J, Hibbert P, Blakely B, Plumb J, Hannaford N, Long JC, et al. Health system frameworks and performance indicators in eight countries: A comparative international analysis. SAGE Open Med. 2017;5:2050312116686516.
2. Braithwaite J, Hibbert PD, Jaffe A, White L, Cowell CT, Harris MF, et al. Quality of health care for children in Australia, 2012-2013. JAMA. 2018;319(11):1113–24.
3. Mannion R, Braithwaite J. Unintended consequences of performance measurement in healthcare: 20 salutary lessons from the English National Health Service. Intern Med J. 2012;42(5):569–74.
4. Mumford V, Greenfield D, Hogden A, Debono D, Forde K, Westbrook J, et al. Development and application of an indicator assessment tool for measuring health services accreditation programs. BMC Res Notes. 2015;8:363.
5. Hibbert PD, Wiles LK, Cameron ID, Kitson A, Reed RL, Georgiou A, et al. CareTrack Aged: the appropriateness of care delivered to Australians living in residential aged care facilities: a study protocol. BMJ Open. 2019;9(6):e030988.
6. Runciman WB, Hunt TD, Hannaford NA, Hibbert PD, Westbrook JI, Coiera EW, et al. CareTrack: assessing the appropriateness of health care delivery in Australia. Med J Aust. 2012;197(2):100-5.
7. Damberg CL, Sorbero ME, Lovejoy SL, Lauderdale K, Wertheimer S, Smith A, et al. An evaluation of the use of performance measures in health care. Rand health quarterly. 2012;1(4).
8. Damberg CL, Baker DW. Improving the quality of quality measurement. J Gen Intern Med. 2016;31 Suppl 1(Suppl 1):8–9.
9. Friedberg MW, Damberg CL. A five-point checklist to help performance reports incentivize improvement and effectively guide patients. Health Aff. 2012;31(3):612–8.
10. Parast L, Doyle B, Damberg CL, Shetty K, Ganz DA, Wenger NS, et al. Challenges in assessing the process–outcome link in practice. J Gen Intern Med. 2015;30(3):359–64.
11. Shaw C, Groene O, Berger E. Chapter 8: External institutional strategies: accreditation, certification, supervision. In: Busse R, Klazinga N, Panteli D, Quentin W, editors. Improving healthcare quality in Europe: characteristics, effectiveness and implementation of different strategies. Copenhagen: WHO Regional Office for Europe; 2019.
12. Groene O. Improving the capacity for learning and improvement in health care. Int J Qual Health Care. 2018;30(3):159–60.
13. Groene O, Sunol R. Patient involvement in quality management: rationale and current status. J Health Organ Manag. 2015;29(5):556–69.
14. Taylor A, Neuburger J, Walker K, Cromwell D, Groene O. How is feedback from national clinical audits used? Views from English National Health Service trust audit leads. J Health Serv Res Policy. 2016;21(2):91–100.
15. Wagner C, Groene O, Thompson CA, Dersarkissian M, Klazinga NS, Arah OA, et al. DUQuE quality management measures: associations between quality management at hospital and pathway levels. Int J Qual Health Care. 2014;26(Suppl 1):66–73.

16. Hilarion P, Suñol R, Groene O, Vallejo P, Herrera E, Saura RM. Making performance indicators work: the experience of using consensus indicators for external assessment of health and social services at regional level in Spain. Health Policy. 2009;90(1):94–103.
17. Hibbert Pea. Performance indicators used internationally to report publicly on healthcare organisations and local health systems. South Wales: Australian Institute of Health Innovation: University of New South Wales; 2013.
18. Lavis JN. Finding and using research evidence: Summary sheet. Hamilton, Canada: McMaster Health Forum; 2019.
19. Fretheim A, Oxman AD, Lavis JN, Lewin S. SUPPORT Tools for Evidence-informed Policymaking in health 18: Planning monitoring and evaluation of policies. Health Res Policy Syst. 2009;7(1):S18.
20. Lavis JN, Hammill AC. Governance arrangements. In Lavis JN, ed. Ontario's health system: Key insights for engaged citizens, professionals and policymakers. Hamilton: McMaster Health Forum; 2016.
21. Mainz J. Defining and classifying clinical indicators for quality improvement. Int J Qual Health Care. 2003;15(6):523–30.
22. Mainz J. Developing evidence-based clinical indicators: a state of the art methods primer. Int J Qual Health Care. 2003;15(suppl_1):i5–11.
23. Carinci F, Van Gool K, Mainz J, Veillard J, Pichora EC, Januel JM, et al. Towards actionable international comparisons of health system performance: expert revision of the OECD framework and quality indicators. Int J Qual Health Care. 2015;27(2):137–46.
24. Medlock S, Wyatt JC. Health behaviour theory in health informatics: support for positive change. Stud Health Technol Inform. 2019;263:146–58.
25. Medlock S, Eslami S, Askari M, Arts DL, van de Glind EM, Brouwer HJ, et al. For which clinical rules do doctors want decision support, and why? A survey of Dutch general practitioners. Health Informatics J. 2019;25(3):1076–90.
26. Askari M, Wierenga PC, Eslami S, Medlock S, De Rooij SE, Abu-Hanna A. Studies pertaining to the ACOVE quality criteria: a systematic review. Int J Qual Health Care. 2012;24(1):80–7.
27. Nuti S. Let's play the patients music: A new generation of performance measurement systems in healthcare. Management Decision. 2018;56(10):2252–72.
28. Nuti S, De Rosis S, Bonciani M, Murante AM. Rethinking healthcare performance evaluation systems towards the people-centredness approach: their pathways, their experience, their evaluation. Healthc Pap. 2017;17(2):56–64.
29. Nuti S, Bini B, Ruggieri TG, Piaggesi A, Ricci L. Bridging the gap between theory and practice in integrated care: the case of the diabetic foot pathway in Tuscany. Int J Integr Care. 2016;16(2).
30. OECD. Health in the 21st Century: putting data to work for stronger health systems. Paris: OECD; 2019.
31. OECD. Health data governance: privacy, monitoring and research. Paris: OECD; 2015.
32. OECD. Strengthening health information infrastructure for health care quality governance: good practices, new opportunities and data privacy challenges Paris: OECD; 2013.

33. Smith P, Mossialos E, Papanicolas I. Performance measurement for health system improvement: eperiences, challenges and prospects. Copenhagen: WHO Regional Office for Europe; 2008.

34. Papanicolas I, Jha AK. Challenges in international comparison of health care systems. JAMA. 2017;318(6):515–6.

35. Smith P, Mossialos E, Papanicolas I, Leatherman S. Principles of performance measurement In: Smith P, Mossialos E, Papanicolas I, Leatherman S, editors. Performance measurement for health system improvement Cambridge: Cambridge University Press; 2009.

36. Papanicolas I, Smith PC. Health system performance comparison: An agenda for policy, information and research Maidenhead: McGraw-Hill; 2013.

37. Rotar AM, van den Berg MJ, Kringos DS, Klazinga NS. Reporting and use of the OECD Health Care Quality Indicators at national and regional level in 15 countries. Int J Qual Health Care. 2016;28(3):398–404.

38. Rotar AM, van den Berg MJ, Klazinga NS. An expert-based mapping of healthcare system strategies to support rational drug prescribing in primary care across 13 European countries. Health Res Policy Syst. 2020;18(1):102.

39. Rotar AM, Botje D, Klazinga NS, Lombarts KM, Groene O, Sunol R, et al. The involvement of medical doctors in hospital governance and implications for quality management: a quick scan in 19 and an in depth study in 7 OECD countries. BMC Health Serv Res. 2016;16(Suppl 2):160.

40. Van der Wees PJ, Nijhuis-van der Sanden MWG, van Ginneken E, Ayanian JZ, Schneider EC, Westert GP. Governing healthcare through performance measurement in Massachusetts and the Netherlands. Health Policy. 2014;116(1):18–26.

41. Van Der Wees PJ, Nijhuis-Van Der Sanden MWG, Ayanian JZ, Black N, Westert GP, Schneider EC. Integrating the use of patient-reported outcomes for both clinical practice and performance measurement: Views of experts from 3 Countries. Milbank Q. 2014;92(4):754–75.

42. Geissler KH, Friedberg MW, SteelFisher GK, Schneider EC. Motivators and barriers to using patient experience reports for performance improvement. Med Care Res Rev. 2013;70(6):621–35.

43. Smith PC, Anell A, Busse R, Crivelli L, Healy J, Lindahl AK, et al. Leadership and governance in seven developed health systems. Health Policy. 2012;106(1):37–49.

44. Barbazza E, Tello J. A review of health governance: Definitions, dimensions and tools to govern. Health Policy. 2014;116:1–11.

45. Tello JE, Barbazza E, Waddell K. Review of 128 quality of care mechanisms: A framework and mapping for health system stewards. Health Policy. 2020;124(1):12–24.

46. Tello J, Baez-Camargo C. Strengthening health system accountability: a WHO European Region multi-country study. Copenhagen: WHO Regional Office for Europe; 2015.

47. Veillard JH, Brown AD, Baris E, Permanand G, Klazinga NS. Health system stewardship of National Health Ministries in the WHO European region: concepts, functions and assessment framework. Health Policy. 2011;103(2-3):191–9.

48. Veillard J, Champagne F, Klazinga N, Kazandjian V, Arah OA, Guisset AL. A performance assessment framework for hospitals: the WHO regional office for Europe PATH project. Int J Qual Health Care. 2005;17(6):487–96.

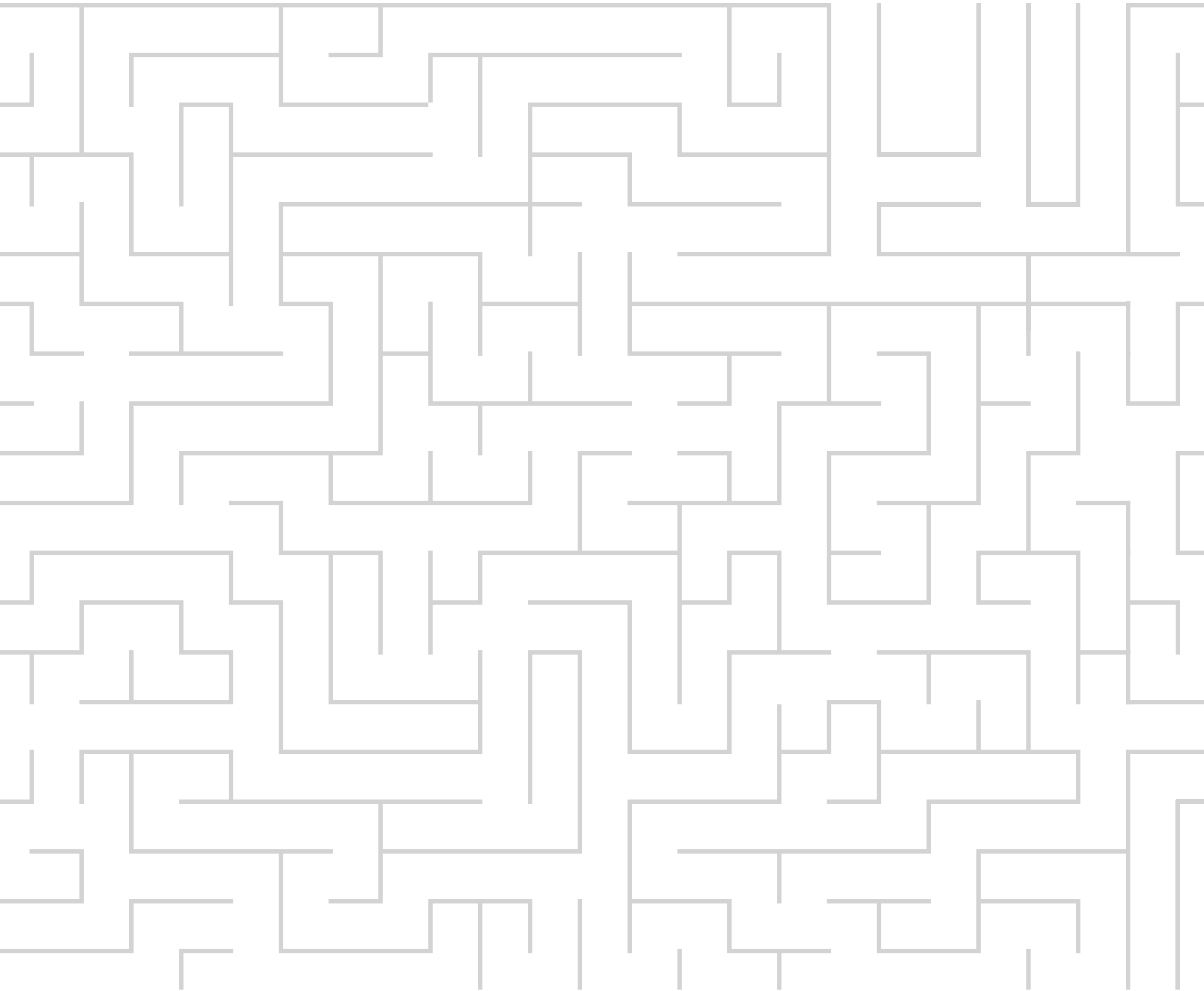
49. Verheij RA, Curcin V, Delaney B, McGilchrist MM. Possible sources of bias in primary care electronic health record data use and reuse. J Med Internet Res. 2018;20(5).

50. Verheij R, Witvliet C, Jansen T, Hooiveld M, Hilten O van. Reuse of routine care data for policy and science: how things can be improved [Dutch]. Utrecht: Nivel; 2019.

51. van der Bij S, de Hoon S, Nielen M, de Jong A, de Boer D, Verheij R. Routine recorded care data as a source of quality information [Dutch]. Utrecht: Nivel; 2016.

Part II

Exploring actionability applied to primary health care

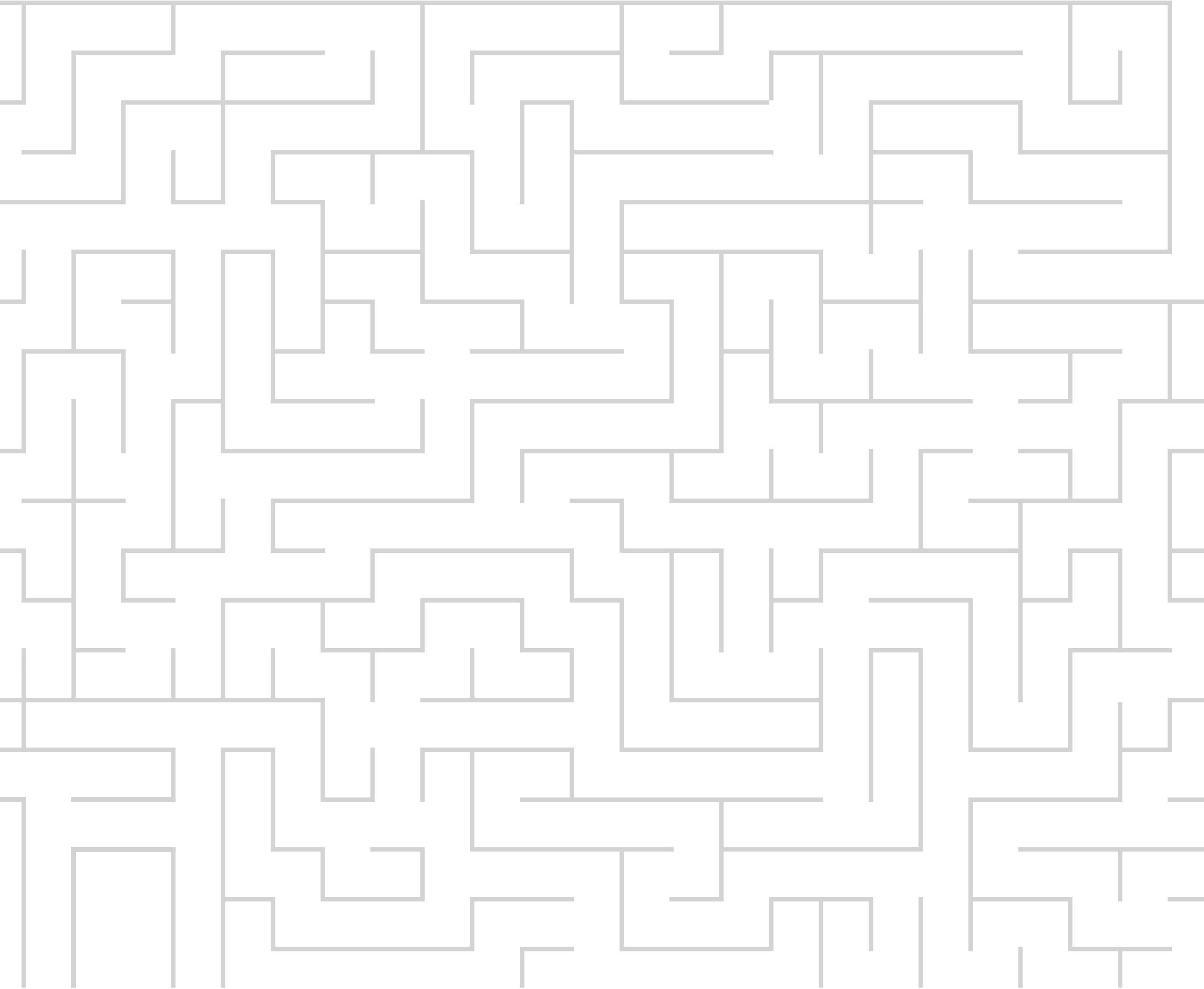


Chapter 2

Creating performance intelligence for primary health care strengthening in Europe

This chapter was published as:

Barbazza E, Kringos D, Kruse I, Klazinga NS, Tello JE. Creating performance intelligence for primary health care strengthening in Europe. BMC Health Serv Res. 2019;19(1006).



Abstract

Background

Primary health care and its strengthening through performance measurement is essential for sustainably working towards universal health coverage. Existing performance frameworks and indicators to measure primary health care capture system functions like governance, financing and resourcing but to a lesser extent the function of services delivery and its heterogeneous nature. Moreover, most frameworks have weak links with routine information systems and national health priorities, especially in the context of high- and middle-income countries. This paper presents the development of a tool that responds to this context with the aim to create primary health care performance intelligence for the 53 countries of the WHO European Region.

Methods

The work builds-off of an existing systematic review on primary care and draws on priorities of current European health policies and available (inter)national information systems. Its development included: (i) reviewing and classifying features of primary care; (ii) constructing a set of tracer conditions; and (iii) mapping existing indicators in the framework resulting from (i). The analysis was validated through a series of reviews: in-person meetings with country-nominated focal points and primary care experts; at-distance expert reviews; and, preliminary testing with country informants.

Results

The resulting framework applies a *performance* continuum in the classical approach of structures- processes-outcomes spanning 6 domains – primary care structures, model of primary care, care contact, primary care outputs, health system outcomes, and health outcomes – that are further classified by 26 subdomains and 63 features of primary care. A *care* continuum was developed using a set of 12 tracer conditions. A total of 139 indicators were mapped to the classification, each with an identified data source to safeguard measurability. Individual indicator passports and a glossary of terms were developed to support the standardization of the findings.

Conclusion

The resulting framework and suite of indicators, coined the Primary Health Care Impact, Performance and Capacity Tool (PHC-IMPACT), has the potential to be applied in Europe, closing the gap on existing data collection, analysis and use of performance intelligence for decision-making towards primary health care strengthening.

Background

Four decades following the adoption of the Declaration of Alma-Ata, the evidence base for primary health care (PHC) as the most inclusive, effective and efficient approach to make progress towards universal health coverage (UHC) and enhance population health [1-4] has solidified a PHC approach as the ambition of countries worldwide [5]. In spite of progress made to strengthen PHC, in 2019 the global health community is confronted with the work still to be done. From a European perspective this includes widening inequities and gender differences for noncommunicable disease (NCD) outcomes, the substantial burden of mental illness, rapid population ageing and the global threat of antimicrobial resistance [6-8]. The region also faces persisting quality deficiencies, increasing vulnerable groups, and impoverishing levels of out-of-pocket payments [7,9,10].

With the 2030 Sustainable Development Goals (SDGs) on the horizon there is renewed impetus and political commitment for PHC strengthening as an accelerator towards UHC [5]. For this, measuring the performance of primary care services has a fundamental role.

A PHC approach from a services delivery perspective can be characterized as primary care: the continuum of first contact promotive, preventive, diagnostic, curative, rehabilitative and palliative care services delivered across the life-course [5]. How countries select, design, organize, manage and improve their primary care services is heterogeneous. As a result, there is considerable diversity in the scope of primary care services, types and profiles of health professionals like nurses, general practitioners, social workers, public health professionals, narrow specialists, paediatricians or occupational therapists, and settings of care like single offices of general practitioners, group practices, multi-profile teams or polyclinics.

Without primary care performance measurement sensitive to these differences, countries often lack the necessary information to monitor and evaluate their options for improvement. Despite the numerous initiatives to strengthen primary care measurement [11-15], the lack of comparable data on primary care in Europe continues to limit performance intelligence for decision-making. Of the factors contributing to this we highlight three.

First, there is no single approach to provide basic, up-to-date information on the organization and delivery of primary care. This is in contrast to internationally comparable information on financial resources (eg, System of Health Accounts) or professional classifications (eg, International Labour Standards) that define a more standardized approach. Importantly, even these standards face constraints to capture primary care, such as for making international comparisons on its costs and workforce. The challenge of comparability is especially relevant in the context of the WHO European Region as member countries range from western, eastern and southern Europe, the Baltic countries, central Asia and the Caucasus.

Second, frameworks defined for global use are strained to measure variations for health outcomes that matter most to European countries. The World Health Organization's (WHO) global UHC service coverage index illustrates this point. According to 2017 reporting, nearly 40% of European countries had an average coverage score of 77 or more on the index; the highest globally [16]. However, the inclusion of tracer conditions and services like malaria and sanitation limits the sensitivity of the index to high- and middle-income countries. Global frameworks are also strained to capture European policy priorities, like the importance the region's member countries have weighted to people-centred services [17] and measurement of patient experiences [18,19].

Third, most primary care frameworks and performance assessments have weak links with routine information systems and national health priorities [20]. This is despite the wide uptake of electronic information systems and health records in primary care across Europe [21,22]. It means primary care monitoring efforts have yet to fully leverage and integrate existing data infrastructure to best support evidence-informed decision-making [23,24].

This paper describes the development of a new tool for monitoring PHC performance across the 53 member countries of the WHO European Region. Our research was guided by the aim to create robust performance intelligence in Europe that captures the ability of primary care to respond to population health needs. Specifically, this work responds to the policy commitment of the WHO European Region member countries enacted in 2016, calling for intensified regional monitoring on health services delivery [25], and is supplementary to global monitoring efforts, like monitoring UHC [16] and foreseen monitoring framework for the implementation of the Astana Declaration [5].

Methods

The following details the processes we undertook between mid-2016 and 2018 in a three-staged approach: first, reviewing and classifying features of primary care, second, constructing a set of tracer conditions and third, mapping existing indicators in the framework devised in the first stage.

Targeted literature review of features of primary care

As a starting point, we reviewed the literature for characteristics of primary care in existing frameworks, tools and surveys. We took as a basis a study by Kringos et al. (2010) being the most comprehensive review on the core dimensions of primary care to-date [26]. To update the review, we extracted priority areas and strategies of a contemporary European policy: the WHO European Framework for Action on Integrated Health Services Delivery [25]. The policy was developed and endorsed by countries and aligns with current European policies [18,27] making it highly attuned to policy priorities in the region.

A literature review search strategy was developed to target recently published scientific and grey literature on frameworks and tools for health services delivery in general, and primary care in particular [28]. We conducted initial searches between October 2016 and May 2017 using PubMed to identify scientific literature published since 2010. We brought the existing systematic review up-to-date by searching new key terms including: avoidable hospitalization; chronic disease management; community-based care; drugs and medical devices; financial incentives; information systems; integrated care; job satisfaction; patient-centredness; patients with complex needs; population health management; responsible use of medicines; role of nurses; shared care plans; task-shifting; technology assisted care; unmet need; waste and appropriateness of care; and workload.

We hand-searched websites and databases of key international actors active in monitoring PHC, namely WHO using WHOLIS, the World Bank, Organisation for Economic Co-operation and Development (OECD) and European Commission and collated sources already known to the authors. Reference lists of relevant work identified were also reviewed and titles were searched in a snowballing approach. With the exception of global frameworks and a recent PHC initiative for low- and middle-income countries [13], work from the European context was prioritized.

Two authors (EB,DK) completed the initial document review. For each framework identified, the features of primary care, their respective classification and key definitions were extracted and logged in an Excel spreadsheet. The authors jointly carried out an analysis of the review findings to identify crosscutting themes.

Review of tracer conditions

To tailor the framework to the European context, we used the method of tracer conditions [29], like applied to monitoring UHC globally [16,30]. Tracer conditions have been used in health services research on the premise that a carefully selected set of health problems makes it possible to profile the strengths and weakness of services delivery and health systems [31]. On this basis, we sought to construct a set of tracer conditions to inform the selection of indicators that – when analysed together – could serve to gauge the ability of primary care to respond to a range of health needs individually and concurrently as multimorbidities, while also measuring across population groups and life stages.

The selection of tracer conditions prioritized the following: relevance to the burden of disease in Europe; responsiveness to the strength of primary care; and representativeness of primary care's functions. The final selection also gave consideration to the measurability of conditions and the parsimony of the set, weighing together the balanced representation of different target populations and life stages, gender importance and types of services. The overall manageability of the set was also prioritized for the selection of a core group of tracers that could serve the purpose of scoping the tool to high-priority health improvement areas.

Current global and European health policies were reviewed by two authors (EB,IK) as a proxy for priority health improvement areas. To prioritize conditions amendable to primary care, European lists of ambulatory care sensitive conditions were consulted [32], together with priority conditions included in an earlier study on the strength of primary care in Europe [12]. To achieve a comprehensive and holistic view to primary care, the type of condition (eg, acute, chronic), relation to the life-course, gender importance and function of primary care (eg, prevention, detection, treatment, management) were also considered. For each possible tracer condition, findings for the criteria considered were recorded.

Identifying existing indicators

To identify existing, internationally standardized indicators, we searched by features of the framework resulting from the first stage, in databases of international organizations (WHO, OECD, European Commission) and topic-specific databases of research consortiums eg, cancer, medicines and tuberculosis. We reviewed existing global and European surveys related to health services delivery, patient-reported experience and outcome measures or conditions amendable to the strength of primary care. Standardized country reports by international organizations were also reviewed through searches on their respective websites. Indicators from the initial literature review and health strategies used to select tracer conditions were also extracted.

To select indicators for the framework, we prioritized the following:

- measurability through an existing or feasible data source;
- available internationally standardized indicators and survey questions;
- relevance to the European context;
- balanced coverage across the framework and its classification; and,
- balanced representation of perspectives eg, patients, practitioners, policy-makers.

We prioritized the first criterion on data availability in our selection to align to information systems and make use of the vast amount of available data, also minimizing the burden of new data collection. We undertook a detailed process of identifying sources by drawing on an existing study on health information systems [22]. We further expanded upon this to scan the availability of health services delivery data across Europe. The findings from this scan have been published elsewhere [21] and were used to ensure existing data sources are drawn from. Alternative sources where applicable, such as national documents (eg, health policies, directives or prikaz, guidelines) or key informants, were also considered as part of asserting the measurability of indicators to merit their selection.

Indicators were mapped to the classification resulting from stage one. For the purposes of this mapping, indicator passports were developed to clearly define the scope and measurement of each individual indicator. The indicator passports draw from the literature reviewed and existing international standards where available to detail the following: alignment to the framework (domain, subdomain, feature), indicator/question title, indicator/question definition, numerator/denominator or answer choices, unit of measurement, rationale, relevant definitions, disaggregation, known limitations and possible data sources. A glossary of terms accompanies the indicator passports with emphasis put to capturing different terminology used in the European countries. The terms and definitions draw from existing international classifications including the International Classification for Health Accounts, International Standard Classification of Occupations and International Standard Classification of Education.

Validation of the framework, tracers and indicators

Country-nominated focal points representing ministries of health, health insurance funds, centres on health services or similar from 30 countries assessed face and content validity of the framework and selection of tracer conditions at a meeting in June 2017 [33]. The set of tracer conditions was also presented and validated with country representatives. They were asked to consider the relevance and comprehensiveness of the framework and tracer conditions in relation to their systems. In the same period, the framework was presented to members of WHO's European Primary Health Care Advisory Group – a group of appointed experts to support the continued advancement of PHC [34]. All comments and discussion points were recorded and adjustments to features were made for a revised version of the framework that was then applied for the mapping and selection of indicators.

To review the indicators identified, we engaged more than 40 experts between November 2017 and June 2018. Reviewers spanned three profiles: (i) staff of WHO; (ii) experts in relevant fields from academia, think tanks and international organizations; and (iii) representatives of professional and patient associations, as well as practising clinicians.

Attention was put to ensure that reviewers were representative of countries across the region and included a range of language skills – with approximately one quarter (23%) being native Russian-speakers – and gender balance (49% females, 51% males). Nearly half of reviewers (42%) were trained medical doctors. Reviewers also included information specialists on European and central Asian countries.

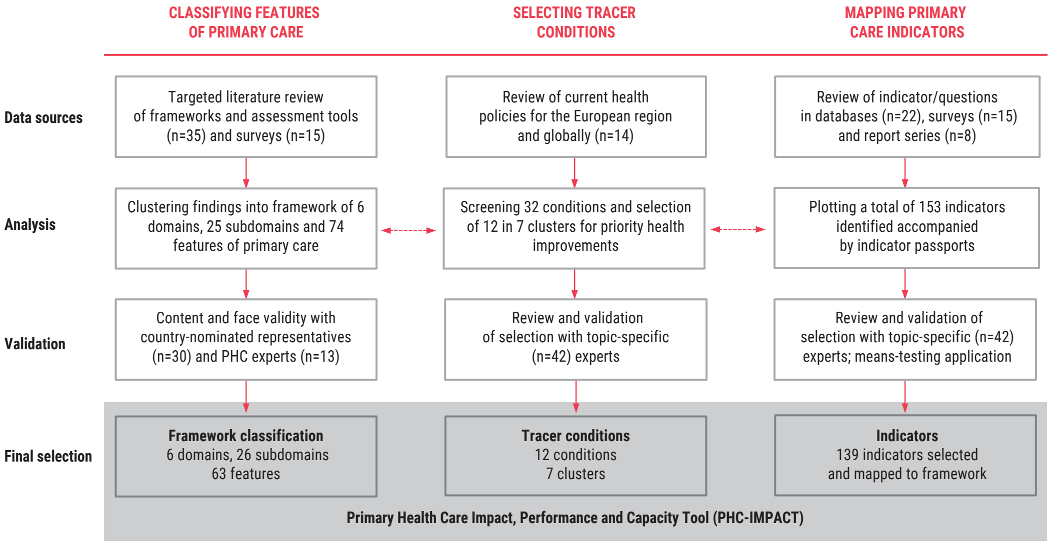
Each reviewer received a written request for their feedback on a subset of indicators. Reviewers were provided the indicator passport, background on the framework and selection criteria. They were asked to score the indicator's overall quality, provide comments or amendments and/or suggest an alternative indicator or source. One author (IK) consolidated the feedback from all reviewers. Indicators that were rated of poor quality, too vague or not meaningful for analysis were removed. For others, comments were used to revise the indicator passports. Comments included important feedback for updating indicators to current international standards as well as making explicit the limitations of indicators where known and for identifying alternative sources of data if available.

Further to technical reviews, we also conducted a preliminary test of the framework and indicators as an initial validation of its use in practice. The indicators were translated to Russian and applied in Kazakhstan on the basis of testing their applicability in the context of a Russian-speaking country and the characteristics and cultural nuances of health systems in central Asia and Caucasus countries. This process extended from December 2017 to June 2018 and included a series of workshops with national centres responsible for data collection. Further revisions were incorporated into the indicator passports and the glossary of terms.

Findings

The findings across the three stages of our research process are summarized in Figure 1 and described to follow. Supplementary files of the literature reviewed, selection of tracers, individual indicator passports and glossary of key terms is available electronically [35].

Fig. 1 Summary of findings



	CLASSIFYING FEATURES OF PRIMARY CARE	SELECTING TRACER CONDITIONS	MAPPING PRIMARY CARE INDICATORS
Data sources	Targeted literature review of frameworks and assessment tools (n=35) and surveys (n=15)	Review of current health policies for the European region and globally (n=14)	Review of indicator/questions in databases (n=22), surveys (n=15) and report series (n=8)
Analysis	Clustering findings into framework of 6 domains, 25 subdomains and 74 features of primary care	Screening 32 conditions and selection of 12 in 7 clusters for priority health improvements	Plotting a total of 153 indicators identified accompanied by indicator passports
Validation	Content and face validity with country-nominated representatives (n=30) and PHC experts (n=13)	Review and validation of selection with topic-specific (n=42) experts	Review and validation of selection with topic-specific (n=42) experts; means-testing application
Final selection	**Framework classification** 6 domains, 26 subdomains 63 features	**Tracer conditions** 12 conditions 7 clusters	**Indicators** 139 indicators selected and mapped to framework

Primary Health Care Impact, Performance and Capacity Tool (PHC-IMPACT)

Classifying features of primary care

We found a total of 50 different frameworks, assessment tools and survey instruments, recorded in Appendix 1 [35]. From the literature reviewed, we identified approximately 50 domains and 100 features of primary care. We further analysed these findings to identify crosscutting themes and to cluster related features. We noted several areas of clear consensus in the literature. For example, the contribution of primary care to first contact access, comprehensive services and continuity and coordination of care is recognized across frameworks [12,14,33,36].

We developed a hierarchy for the classification of findings, adopting the classical framework of Donabedian's structure-process-outcome logic model [37]. These components were classified and sequenced as the capacity, performance, and impact of primary care. We defined a taxonomy to describe these components from broad to specific as domains, subdomains, and features [35].

Under *primary care capacity*, we put attention to disaggregate the unique yet often overlooked resource needs of primary care, including the primary care workforce, medicines, diagnostics, facility infrastructure, and information system. We were also attentive to differentiate the system's capacity, as the enabling *system structures* underpinning primary care, from the function of services delivery. We classified this as the *model of care*: the result of deliberate decisions taken that determine the contents, design, organization, management and quality improvement elements of services delivery.

This classification is a point of departure from existing frameworks. It captures the less prevalent 'software' of primary care's capacity [13], such as managerial autonomy for determining staffing, budgeting and strategic planning in primary care facilities, prescribing authority of general practitioners to initiate or refill prescriptions and the existence and scale of quality improvement mechanisms, like practice audits, patient complaint systems or peer review teams. The taxonomy around the selection of services spans from identifying needs, to the selection of preventive care, diagnostic procedures, treatment and disease management services as well as services for supporting self-management. The model of care also bridges between the system on one side, and the provision of services and perspective of patients, on the other.

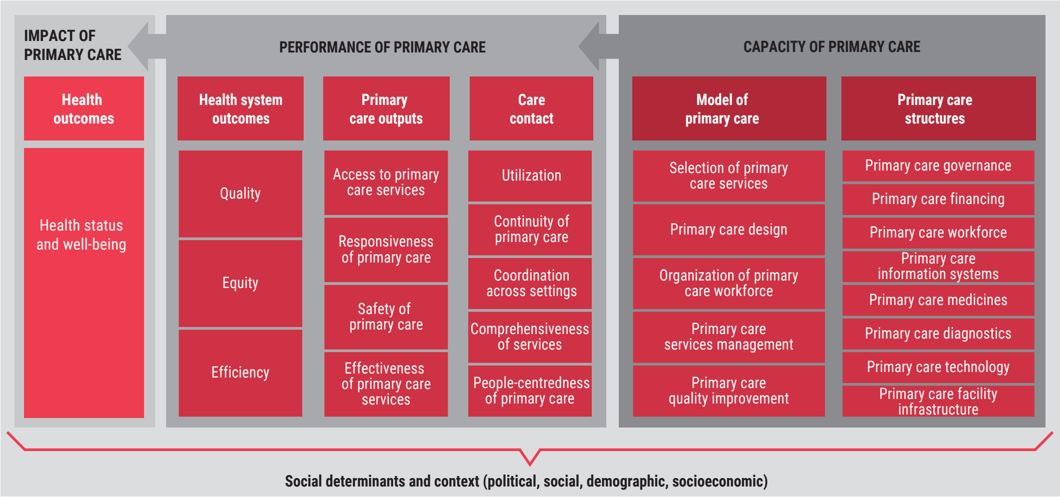
This domain, at the intersection with the *performance of primary care*, is captured as *care contact*. It is novel in distinguishing the 'structural' from its implications on performance. For example, we find skill-mix and multidisciplinary teams an agreed upon feature of primary care [12,14,33,38,39]. However, it has typically been classified as a feature of coordination. We argue the setup and structure of teams captures how providers are organized and their resulting level of interaction and joint-work rather as a measure of coordination.

Importantly, while in the reviewed literature there was clear consensus on the policy importance of capturing the perspective of patients, to a lesser extent had this priority area been translated into monitoring frameworks. The domain of *care contact* collocates patient experience as a core feature of overall primary care performance and is found an important distinction from earlier classifications.

In line with existing system frameworks, *outputs* via services delivery (access, responsiveness, safety, effectiveness) and *health system outcomes* (quality, equity, efficiency) were classified from a services delivery perspective, linking to the final component of *impact* on health outcomes (health status and well-being). Importantly, in distinguishing between *outputs* from *outcomes*, we recognize that suboptimal outcomes can be attributed to features of the health system beyond the scope of primary care services and have labelled it as such. Figure 2 illustrates the resulting framework. Like other frameworks, we acknowledge that primary care performance lies within larger socio-political contexts, though these factors are outside the scope of health systems [12,19,36].

Adopting the approach of people-centred systems, the framework begins with health outcomes. In this way, health outcomes are the lens through which capacity and performance are monitored. By cascading the framework's domains, features and subdomains as shown, the taxonomy applies system thinking principles to associate connections between capacity, performance and impact. Importantly, as the field of systems thinking has revealed, changes to systems can have unpredictable and multi-direction results [40].

Fig. 2 Monitoring framework



Selecting tracer conditions

Fourteen disease-specific strategies actively being implemented in Europe and globally were identified and reviewed (Appendix 2). We screened 32 conditions, identified first and foremost as priority health improvement areas in Europe and selected a set of 12 grouped in 7 clusters based on our selection criteria. These conditions span: reproductive, maternal, neonatal and child health; communicable diseases; cardiovascular diseases; diabetes; respiratory diseases; cancer; and mental health (Table 1).

The selection process included a review within and across clustered to assess the conditions in combination in order to gauge the balance across the criteria applied and the manageability of the set. Guided by our primary aim to select a core set of tracers for profiling primary care, we prioritized one or two conditions per cluster, with one exception (cancer). In a last stage, we also considered the measurability of conditions in primary care [21], resulting in the exclusion of those specific to ageing, like dementia. Nonetheless, ensuring the representativeness of varied population groups and life stages was among the core selection criteria applied. For example, a range of primary care services for older adults are included such as, influenza vaccines (prevention), colorectal cancer (detection, management) and cardiovascular diseases (prevention, detection, treatment, management).

Table 1 Selected tracer conditions

CLUSTER	CONDITION OR SERVICES	CLASSIFICATION	TARGET POPULATION/ LIFE-STAGE[1]	GENDER IMPORTANCE	TYPE OF SERVICE[2]
1 Reproductive, maternal, neonatal and child health	post-natal care	service	infant; adolescents; adults	women and infants	T, M
2 Communicable	influenza	vaccine-preventable	children older adults	both	P
	tuberculosis	chronic	all	both	P, D, T, M
3 Cardiovascular diseases	hypertension	chronic	adults; older adults	both	P, D, T, M
	heart disease	chronic	adults; older adults	both	P, D, T, M
4 Diabetes	diabetes type II	chronic	adults; older adults	both	P, D, T, M
5 Respiratory	chronic obstructive pulmonary disease	chronic	adults; older adults	both	P, D, T, M
	asthma	chronic	childhood – onwards	both	P, D, T, M
6 Cancer	breast	chronic	adults	women	D, M
	cervical	vaccine-preventable	adolescents	women	P, D, M
	colorectal	chronic	older adults	men	D, M
7 Mental health	depression	chronic	adolescents – onwards	both	P, D, T, M

[1] Life-stage translated to age ranges: infant (0 to 1 year); children (1 to 10 years); adolescent (11 to 19 years); adults (20 to 59 years); older adults (60+ years)

[2] Type of service – *P* prevention; *D* detection; *T* treatment; *M* management

Mapping primary care indicators

More than 20 international databases were reviewed to extract existing and reported on indicators. Fifteen global and European surveys were also reviewed on topics including medicines and e-health, patient experience, primary care doctors, and on tracer conditions like influenza and NCDs. An additional 8 standardized country reports were identified eg, Health Systems in Transition series, OECD country reviews and WHO country assessments.

From this, we consolidated a total 243 indicators/questions. We plotted the indicators in our classification of subdomains/features. When mapped, we found the largest number of indicators for the structure domain (health workforce, financing) and health impact (morbidity, mortality), consistent with their wide use in health system performance frameworks [20]. The model of care domain was the least populated from this initial mapping and further targeted reviews were conducted to identify indicators for its features. In a final stage of development, we reassessed the initial classification with the indicators identified for refinements at the feature-level. Following this, three features remained without assigned indicators: acceptability, equity, and responsiveness.

We applied the tracer conditions to scope the selection and explicitly link indicators across the framework using theory of change principles as described [41]. In doing so, health outcomes are preceded by related performance and capacity indicators. For example, impact indicators on diabetes link to preceding diabetes-related performance indicators eg, hospitalizations, managed insulin-levels, and capacity indicators eg, prevention services for diabetes, existence of patient registries. Indicators that measured conditions outside the scope of the selected tracer conditions were excluded. A balance in the number of indicators for each tracer condition was also sought. We retained relevant disaggregations, such as public-private mix and rural-urban status for analysis purposes. The full set of indicator passports is available electronically in Appendix 3 and related glossary of terms in Appendix 4 [35].

Final selection and new tool

We consolidated our findings in a tool we refer to as the Primary Health Care Impact, Performance and Capacity Tool (PHC-IMPACT). The tool includes a total of 139 indicators mapped to a detailed framework in a hierarchy of domains (6), subdomains (26), and features (63) as summarized in Table 2 and expanded in Table 3.

Table 2 Overview of final framework and suite of indicators

	SUBTOTALS ACROSS DOMAINS						**TOTALS**
DOMAINS	Health outcomes	Health system outcomes	Primary care outputs	Care contact	Model of primary care	Primary care structures	6
Subdomains	1	3	4	5	5	8	26
Features	2	4	6	11	21	19	63
Indicators	7	8	13	29	40	42	139

The measurability of each indicator has been safeguarded through an extensive process of identifying a possible source for each. More than half (61%) of the indicators can be sourced from more than one type of data source, increasing the potential measurability across countries. The range of possible data sources include: national and international databases (43 indicators); existing surveys (11 indicators); policies (27 indicators) and reports (10 indicators); and key informants (62 indicators) (Table 3).

Table 3 Overview of framework for monitoring the impact, performance and capacity of PHC, indicators and data sources

DOMAIN	SUBDOMAIN	FEATURE	INDICATOR TITLE	EXPECTED DATA SOURCES
Primary care structures	Primary care governance (GOV)	GOV1. Primary care priorities	Primary care strategy	policy; key informant
		GOV2. Accountability arrangements	Primary care mandate	key informant
			Primary care resources	key informant
			Public health services mandate	report; key informant
		GOV3. Stakeholder participation and engagement	Roles of professional associations of generalist medical practitioners	key informant
			Roles of professional associations of nurses and midwives in primary care	key informant
			Roles of patient and/or consumer groups	report; survey; key informant
		GOV4. Quality assurance mechanisms	Quality assurance of health professionals	policy; key informant
			Quality assurance of facilities	policy; key informant
			Development of primary care clinical practice guidelines	policy; survey; key informant
			Patient rights and choice	policy; report; key informant
	Primary care financing (FIN)	FIN1. Primary care expenditure	Total primary health care expenditure as a share of total health expenditure	database
			Domestic primary health care expenditure	database
			Capital and recurrent expenditure arrangements	key informant
		FIN2. Payment methods in primary care	Provider payments	report; survey; key informant
			Employment status and remuneration of generalist medical practitioners	survey; report; key informant
			Pay-for-performance	survey; key informant
			Support for caregivers/family carers	report; key informant
		Benefit package	Services included in the health benefit package	report; survey; key informant

DOMAIN	SUBDOMAIN	FEATURE	INDICATOR TITLE	EXPECTED DATA SOURCES
Primary care structures	Primary care workforce (WRK)	WRK1. Primary care workforce planning	Type of primary care health professionals	policy; key informant
			Scope of practice for primary care health professionals	policy; key informant
			Incentives for recruitment and retention in underserved areas	policy; key informant
			Retraining programme for specialist medical practitioners/narrow specialists	key informant; database
			Workforce registry with information on primary care professionals	survey; key informant
		WRK2. Financial status of general practitioners	Relative financial status of generalist medical practitioners	database
		WRK3. Primary care workforce availability	Age distribution of generalist medical practitioners	database
		WRK4. Academic status of primary care	General practice/family medicine undergraduate/bachelor education	key informant
			General practice/family medicine postgraduate education	key informant
			General practice/family medicine postgraduate clinical practice	key informant
			General practice/family medicine specialization among medical students	database
			Nurses working in primary care undergraduate/bachelor and postgraduate education	key informant
			Professional journal on general practice/family medicine	key informant
	Primary care information system (INF)	INF1. Data capture	Electronic health records system	survey; key informant
			Electronic health record system linked to clinical systems	survey; key informant
		INF2. Aggregation of data	Patient registries	survey; key informant
		INF3. Patient platforms	Use of mHealth in primary care	survey; key informant
	Primary care medicines (MED)	MED1. Availability of medicines	Reimbursement eligibility scheme for outpatient medicines	policy; survey; key informant
			Availability of essential medicines for primary care	survey; database; expert consensus
	Primary care diagnostics (DGN)	DGN1. Laboratory	Availability of laboratory tests in primary care	survey; database; expert consensus
		DGN2. Imaging	Availability of diagnostic imaging in primary care	survey; database; expert consensus
	Primary care technologies (TCH)	TCH1. Basic technology	Availability of equipment in primary care	survey; database; expert consensus
	Primary care facility infrastructure (STR)	STR1. Amenities	General service readiness at facility-level	key informant

DOMAIN	SUBDOMAIN	FEATURE	INDICATOR TITLE	EXPECTED DATA SOURCES
Model of primary care	Primary care selection of services (SEL)	SEL1. Identifying needs	Population stratification	key informant
		SEL2. Preventive care	Counselling services	key informant
			Population based screening	key informant
			Individual risk assessments/stratification	key informant
			Vaccination services	survey; report; key informant
		SEL3. Diagnostic procedures	Diagnostic exams	key informant
			Final diagnosis in primary care	key informant
		SEL4. Treatment	Prescribing authority of generalist medical practitioners	policy; report; key informant
		SEL5. Management of diseases	Follow-up services in primary care	key informant
			Other services	key informant
		SEL6. Patient engagement	Self-management and health literacy in primary care	key informant
	Primary care design (DES)	DES1. Referral system	Gatekeeping system	survey; report; key informant
			Referral protocol from primary care to higher levels of care	policy; survey; key informant
			Reply and discharge protocol from higher levels of care to primary care	policy; key informant
		DES2. Care pathways	Shared care pathways	report; policy; key informant
		DES3. Flexible access modes	Different access modes	survey; expert consensus
		DES4. Shared care plans	Developing shared care plans	survey; expert consensus
Model of primary care	Primary care workforce organization (ORG)	ORG1. Practice population	Choice of generalist medical practitioner	survey; report; key informant
			Patient list system	policy; report; key informant
			Primary care health professionals' density	database; report
			Caseload of generalist medical practitioner	database; survey
		ORG2. Out-of-hours care	Opening hours in primary care	report; policy; key informant
			Out-of-hours in primary care	survey; key informant
		ORG3. Primary care teams	Types of primary care facilities	policy; key informant
			Shared practices in primary care	policy; report; database
			Coordination within primary care	policy; survey; report; expert consensus
			Existence of care coordinator	policy; survey; report; expert consensus
		ORG4. Collaboration of primary care with other professionals	Cooperation with specialist medical practitioners	survey; expert consensus
			Coordination across sectors	policy; survey; report; expert consensus

DOMAIN	SUBDOMAIN	FEATURE	INDICATOR TITLE	EXPECTED DATA SOURCES
Model of primary care	Primary care services management (MAN)	MAN1. Primary care staffing	Autonomy in staffing of medical staff	key informant
		MAN2. Managing primary care facilities	Degree of autonomy in budgeting	key informant
			Health care technology management	survey; key informant
		MAN3. Strategic planning	Population health management	key informant
	Primary care quality improvement (IMP)	IMP1. National or regional primary care performance assessment	Accountability for performance	policy; survey; report; key informant
			Patient experience measures	policy; survey; report; key informant
			Job satisfaction	survey; key informant
		IMP2. Practice-level quality improvement mechanisms	Quality of care processes	policy; report; key informant
			Safety incidents reporting	policy; report; key informant
		IMP3. External accountability for quality of care	External accountability for quality of care delivered by generalist medical practitioners	key informant
		IMP4. Continuous professional development	Continuous professional development opportunities	database; expert consensus
Care contact	Utilization (UTL)	UTL1. Consultation rate	Overall utilization of primary care services	database; survey
		UTL2. Preventive care and diagnostic services	Influenza vaccination coverage	database; report; expert consensus
			HPV vaccination coverage	database; survey; expert consensus
			Diabetic education	database; survey; expert consensus
			Counselling services for tobacco cessation	survey
			National cancer screening programmes targeting the general population	database; survey; expert consensus
			Individual risk assessments	database; expert consensus
			Tuberculosis preventive care and diagnostic services	database
			WHO recommended rapid test as the initial diagnostic test for tuberculosis	database

DOMAIN	SUBDOMAIN	FEATURE	INDICATOR TITLE	EXPECTED DATA SOURCES
Care contact	Continuity of primary care (CON)	CON1. Treatment	Hypertension treatment coverage	database; survey; expert consensus
			Tuberculosis treatment coverage	database
			Depression treatment coverage	database; expert consensus
		CON2. Follow-up care	Hypertension follow-up	database; survey; expert consensus
			Diabetes monitoring	database; expert consensus
			Chronic obstructive pulmonary disease follow-up	database; expert consensus
			Post-natal care	database; expert consensus
			Depression treatment follow-up	database; expert consensus
		CON3. Longitudinal continuity of care	Stability of patient–generalist medical practitioner relationship	survey
		CON4. Informational continuity of care	Medical record keeping	survey; expert consensus
			Incoming clinical information procedures	survey; expert consensus
			Generalist–specialist medical practitioner communication	survey; expert consensus
			Generalist medical practitioner-social services	survey; expert consensus
	Coordination of care across settings (COR)	COR1. Transition management	Referral feedback to primary care	survey; expert consensus
	Comprehensiveness of primary care (COP)	COP1. Resolution capacity of generalist medical practitioner	General medical practitioner consultations without referral	database; expert consensus
	People-centredness of primary care (PCC)	PCC1. Patient experience	Patient satisfaction	report; survey
		PCC2. Shared decision-making	Care and treatment shared decision-making	database; survey; report
		PCC3. Patient engagement	Patient reporting opportunity to ask questions	database; survey; report
			Patient reporting enough time with doctor	database; survey; report
			Patient reporting easy to understand explanations	database; survey; report
Primary care outputs	Access to primary care services (ACC)	ACC1. Availability and affordability of primary care services	Same day appointments	survey
			Waiting time for appointment	survey; report
			Access barriers due to treatment costs	database; survey; report
			Access to medicines	database
		ACC2. Acceptability	Patient reported acceptability of primary care services	survey

DOMAIN	SUBDOMAIN	FEATURE	INDICATOR TITLE	EXPECTED DATA SOURCES
Primary care outputs	Responsiveness of primary care (RES)	RES1. Resolving capacity of primary care	Composite measure	database; survey; report; key informant
	Safety of primary care (SAF)	SAF1. Medical errors	Correct diagnosis	reports; expert consensus
			Incident reporting	reports; expert consensus
		SAF2. Medicine safety	Overall volume of antibiotics prescribed	database
			Medication review	survey; expert consensus
	Effectiveness of primary care services (EFF)	EFF1. Effective management and control of diseases	Control of blood pressure among people treated for hypertension	database; expert consensus
			Control of blood glucose among people treated for diabetes	database; expert consensus
			Tuberculosis detection and treatment	database
			Cancer survival rates	database
Health system outcomes	Quality (QLY)	QLY1. Quality of care for chronic conditions	Hospital admissions for chronic conditions	database
			Avoidable complications	database
			Notified tuberculosis cases lost to follow-up	report
			Stage at diagnosis for cancer	database
		QLY2. Prescribing in primary care	Secondary prevention/high-risk control	survey; expert consensus
			Tuberculosis and rifampicin/multidrug resistant tuberculosis treatment in primary care	database
			Access to palliative care	report; database
	Equity (EQT)	EQT1. Equitable delivery of primary care services	Composite measure	database; survey; report; key informant
	Efficiency (EFC)	EFC1. Unnecessary procedures	Unnecessary duplication of medical tests	survey; expert consensus
Health outcomes	Health status and well-being (HSW)	HSW1. Burden of disease and risk factors	Risk factors – smoking	database
			Risk factors – alcohol	database
			Risk factors – overweight and obesity	database
			Morbidity	database; survey
			Disability adjusted life years	database
		HSW2. Mortality	Standardized death rates	database
			Premature mortality	database

Discussion

Creating performance intelligence with PHC-IMPACT

This research set out with the aim to create robust performance intelligence for PHC strengthening in Europe. Through the three-staged research process described, the tool has been tailored for a classification, set of tracer conditions and selection of indicators that are sensitive to primary care, policy priorities and information systems in Europe.

The broad suite of indicators is intentional in order to allow the possible tailoring of the indicators, functioning as a menu of options to be selected on the basis of a country's policy priorities. The customization of the tool is among its core advantages and an important feature to increase the tool's responsiveness within and transferability across countries. Other unique features are found to include the following: diversified data sources accommodate a range of perspectives for a more holistic view to primary care; the translation and means testing of the tool in Russian attempts to redress context-specific classification challenges unique to the membership of the WHO European Region; the cascading of the taxonomy developed facilitates varied entry points to analysis and a uniquely detailed approach to capture the model of primary care; and, the indicator passports and glossary of key terms developed are a practical resources for data collection.

Prior to the use of the tool, a review of the indicators for further tailoring to the context of a specific country should be conducted. The selection of tracer conditions should also be reviewed, with the possibility to adjust this list given a country's health priorities. This process of customizing the tool's suite of indicators should rely on the meaningful engagement of key stakeholders for the full benefits of co-designing with the intended users.

Addressing classification limitations

The relevance of existing indicators for use in monitoring primary care was a significant limitation. For example, nurses in primary care are not defined in existing databases, surveys or reporting, ultimately limiting the extent to which the number, profile, role and performance of nurses in primary care can be assessed. We have attempted to redress these limitations with adjustments to standard indicators using existing definitions and classifications to improve their sensitivity to primary care. In particular, we have harmonized the varied terminology for the primary care workforce, types of facilities and levels of education that have previously limited the relevance of frameworks and tools across Europe. The glossary of terms developed supports the classification defined [35].

We also found metrics for equity and responsiveness to be limited. A similar finding was reported in a recent review on health system performance assessment frameworks [20]. We recognize the need to operationalize both in a more comprehensive manner, suggesting the use of composite indicators and highlight acceptability as a feature in need of further development. The disaggregation of indicators existing in international databases was retained where possible and includes gender, age, socioeconomic status and rural–urban classifications. These variables are found especially relevant for the analysis of equity. An approach that links the relevant indicators and disaggregations is suggested for a more holistic appraisal of equity considerations.

The tool is found novel in its attempt to capture the capacity of primary care beyond system structures, with indicators like prescribing authority to assess the ability of general medical practitioners to issue initial prescriptions and/or refills for treatment and the autonomy of managers on planning, staffing and budgeting. These features of the model of care, together with the domain on care contact, are found important specifications for depicting primary care that allow for further analysis and comparisons across countries.

To further improve the sensitivity of the tool, answer choices where applicable were disaggregated to capture responses as *country-wide*, *in some regions* or *pilot status*.

Aligning to information systems and other sources of data for applying PHC-IMPACT

Collecting data should rely as much as possible on existing international databases, surveys and country reporting. The development of an electronic data processing system is already being explored to build linkages to existing databases and create a common living platform for interactive analysis. For other indicators, there is untapped potential to uptake data from national information systems, in particular on hospitalizations for ambulatory sensitive conditions where reporting for many non-OECD, non-EU countries of Europe is out-dated. For these countries, strengthening linkages with national systems should be prioritized.

An electronic questionnaire is being built to serve as a data collection tool for qualitative indicators. Where key informants are a data source, we suggest diversified informants to capture varied profiles (policy, managerial, clinical) for accurate responses on the tool's range of topics. By soliciting a range of informants with complementary knowledge, this approach also facilitates multi-stakeholder engagement while ultimately yielding more objective and reliable results.

A modular approach could also be taken to data collection for a focus on topics like mental health, maternal and child health, and out-of-hours services based on a country's priorities. While the tool has prioritized available data, the extent to which indicators are measurable across countries varies making some features more ambitious and future-oriented in some contexts. In instances where preferred databases or survey sources are not available, and the indicator cannot be answered by one informant, we suggest a pragmatic approach is taken using the method of expert consensus. This method is applicable for one quarter (27%) of the total indicator set. Drawing from established group-based methods, a Delphi technique followed by a consensus workshop could be used to generate estimates. The highly structured method preserves anonymity while capturing a range of perspectives. This data could support meaningful analytics as countries aspire to and work in parallel on advancing the use and alignment of data in their national information systems. Lessons on expert consensus methods in health services research could be explored for use here [42-45].

Policy relevance and research implications

PHC-IMPACT has been designed with view to the information needs of decision-makers in the WHO European Region both for international monitoring and country-specific priority-setting. The merit of a regional approach to monitoring has already been advocated for SDG 3 in the scope of financial protection [46]. We have excluded conditions or services considered a basic expectation or fundamental to primary care, such as family planning and childhood vaccination. The exclusion of these services is a prioritization of the tool's sensitivity to disaggregate performance in high- and middle-income countries rather than a statement of their importance. Moreover, disease- or service-specific monitoring tools and instruments are in use for this purpose.

The comprehensiveness of the tool's taxonomy brings depth to the analysis for country-specific use. It is seen as a vehicle for identifying priority areas for improvement, while also shedding light on the information landscape and overall availability of data and actors involved. For analysis purposes, the tool facilitates linkages along different continuums: a clinical continuum, linking prevention, diagnosis, treatment and disease management for tracer conditions; a performance continuum in the classical structure-process-outcome sequence; and a continuum of stakeholders cascading the delivery of services from the micro-level (health professionals, patients), to meso- (managers, regional health authorities) and macro-level (policy-makers, health insurers). These relations between indicators have strong analytical potential to improve the coherence of PHC strengthening and signalling of policy opportunities to accelerate performance gains.

For example, the availability and provision of services in primary care can be assessed across to the care continuum to gauge the extent to which the full continuum of services are available and if not, where gaps in services provision lie (i.e. lack of risk assessment services for cardiovascular diseases or mental health; limited role of primary care in follow-up for tuberculosis. This analysis draws on the indicators related to the selection of services. In a similar approach, the role of different primary care practitioners can be profiled, clustering the provision of services by general medical practitioners, nurses, or specialists working in primary care, among others. This analysis has the potential to shed light on the different roles and scope or practice of primary care practitioners, including important insights into the potential for general medical practitioners to confirm an initial diagnosis or role nurses in risk assessment or follow-up services in primary care. Other thematic clusters of indicators could aggregate indicators by policy-relevant themes such as patient engagement, out-of-hours primary care, integrated health and social care, prescribing practices in primary care, among others still.

The tool should be treated as a living resource to be adjusted and improved upon as new types and sources of data become available. This includes the continuous improvement and development of indicators that are defined according to global standards such as total primary health care expenditure and the UHC services coverage index. It requires piloting beyond the initial country-validation described to test its approach and robustness for country-specific, cross-country comparisons and use overtime. Ultimately, despite its attempt to be comprehensive, not all complexities can be accounted for.

Further to piloting PHC-IMPACT, areas for continued development include: developing composite indicators for features like equity and responsiveness and priority policy areas like scope of practice; selecting a core set of indicators for use in dashboards for the purposes of international benchmarking; improving metrics for hard-to-measure topics, like medicines, primary care workforce and acceptability; exploring methods of expert consensus; and intensifying data collection from existing sources and for newer indicators like patient reported experience measures in primary care. Patient experiences measures are found an important area for further research and development to allow cross-country comparisons with the necessary adjustments for their wider use in eastern European and central Asian countries. Tools developed in the scope of the Patient-Reported Indicators Survey (PaRIS) Initiative of the OECD are one platform that could be coordinated with and tools adapted from for use in the context of countries across the European Region [47].

Conclusion

Performance intelligence on the ability of primary care to respond to health needs is vital for systems to evolve rather than react to health needs and make sustainable progress towards UHC targets. This paper presents a tool for creating performance intelligence sensitive to the WHO European Region. The tool addresses limitations of existing classifications to better capture primary care, improve linkages with (inter)national information systems, and ensure specificity to high- and middle-income countries. The framework and suite of indicators consolidated have promising analytical power that merits further development through its application.

Abbreviations

NCDs: noncommunicable diseases; OECD: Organisation for Economic Co-operation and Development; PHC: primary health care; PHC-IMPACT: Primary Health Care Impact, Performance and Capacity Tool; SDGs: Sustainable Development Goals; UHC: universal health coverage; WHO: World Health Organization.

Acknowledgements

We thank Enrique Loyola, Ivo Rakovic, Michael van den Berg, Zhamin Yelgezekova, the Ministry of Health of Kazakhstan, technical reviewers, staff of the WHO European Centre for Primary Health Care, WHO European network of Integrated Health Services Delivery Focal Points, members of the Primary Health Care Advisory Group.

References

1. Ghebreyesus TA, et al. Primary health care for the 21st century, universal health coverage, and the Sustainable Development Goals. Lancet. 2018;392(10156):1371–2.
2. Balabanova D, et al. Good health at low cost 25 years on: lessons for the future of health systems strengthening. Lancet. 2013;381(9883):2118–33.
3. Kringos D, et al. The strength of primary care in Europe: an international comparative study. Br J Gen Pract. 2013;63(616):e742–50.
4. Pavlic DR, et al. Strength of primary care service delivery: a comparative study of European countries, Australia, New Zealand, and Canada. Prim Health Care Res Dev. 2018;19(3):277–87.
5. Declaration of Astana. In The Global Conference on Primary Health Care. Astana, Kazakhstan; 2018.
6. OECD. Health at a glance: Europe 2018. Paris: OECD; 2018.
7. WHO Regional Office for Europe. European Health Report 2018 – more than numbers – evidence for all. Copenhagen: WHO Regional Office for Europe; 2018.
8. European Centre for Disease Prevention and Control. Surveillance of antimicrobial resistance in Europe - Annual report of the European Antimicrobial Resistance Surveillance Network (EARS-NET). Stockholm: ECDC; 2018.
9. National Academies of Sciences. Crossing the global quality chasm: improving health care worldwide. Washington, D.C: National Academies of Sciences, Endineering and Medicine; 2018.
10. Cylus J, Thomson S, Evetovits T. Catastrophic health spending in Europe: equity and policy implications of different calculation methods. Bull World Health Organ. 2018;96(4):599–609.
11. Schafer WL, et al. QUALICOPC, a multi-country study evaluating quality, costs and equity in primary care. BMC Fam Pract. 2011;12:115.

12. Kringos DS, et al. The European primary care monitor: structure, process and outcome indicators. BMC Fam Pract. 2010;11:81.
13. Veillard J, et al. Better measurement for performance improvement in low- and middle-income countries: the primary health care performance initiative (PHCPI) experience of conceptual framework development and indicator selection. Milbank Q. 2017;95(4):836–83.
14. WHO Regional Office for Europe. Primary care evaluation tool. Copenhagen: WHO Regional Office for Europe; 2010.
15. The Commonwealth Fund. 2015 Commonwealth Fund international survey of primary care physicians in 10 nations. Washington, DC: The Commonwealth Fund; 2015.
16. WHO and World Bank. Tracking universal health coverage: 2017 global monitoring report Geneva: World Health Organization and the World Bank; 2017.
17. Santana M-J, et al. Measuring patient-centred system performance: a scoping review of patient-centred care quality indicators. BMJ Open. 2019;9(1):e023596.
18. WHO Regional Office for Europe. Health 2020: A European policy framework supporting action across government and society for health and well-being. Copenhagen: WHO Regional Office for Europe; 2013.
19. WHO Regional Office for Europe. Priorities for health systems strengthening in the European Region 2015–2020. Walking the talk on people centredness. Copenhagen: WHO Regional Office for Europe; 2015.
20. Kekri O, Macarayan E, Klazinga N. Health system performance assessment in the WHO European Region: which domains and indicators have been used by Member States for its measurement? In WHO Health Evidence Network Synthesis Report 55. Copenhagen: WHO Regional Office for Europe; 2018.
21. WHO Regional Office for Europe. Availability of national health services delivery data across the WHO European Region: scanning survey results. Copenhagen: WHO Regional Office for Europe; 2018.
22. OECD. Strengthening health information infrastructure for health care quality governance. In OECD Health Policy Studies. Paris: OECD; 2013.
23. World Health Assembly. Digital health - draft resolution proposed by Algeria, Australia, Brazil, Estonia, Ethiopia, Germany, India, Indonesia, Israel, Italy, Luxembourg, Mauritius, Morocco, Panama, Philippines and South Africa. Geneva: World Health Organization; 2018.
24. WHO Regional Office for Europe. Towards a roadmap for the digitalization of national health systems in Europe. Copenhagen: WHO Regional Office for Europe; 2018.
25. WHO Regional Office for Europe. Strengthening people-centred health systems in the WHO European Region: framework for action on integrated health services delivery in Regional Committee for Europe 66th Session. Copenhagen: WHO Regional Office for Europe; 2016.
26. Kringos DS, et al. The breadth of primary care: a systematic literature review of its core dimensions. BMC Health Serv Res. 2010;10:65.
27. United Nations. Transforming our world: the 2030 Agenda for Sustainable Development in Seventieth session Agenda items 15 and 116. New York: United Nations; 2015.
28. Grant M, Booth A. A typology of reviews: an analysis of 14 review types and associated methodologies. Health Info Libr J. 2009;26:91–108.

29. Kessner D, Kalk C, Singer J. Assessing health quality: the case for tracers. N Engl J Med 1973;288.

30. Boerma T, et al. Monitoring intervention coverage in the context of universal health coverage. PLoS Med. 2014;11(9).

31. Nolte E, Bain C, McKee M. Population health in peformance measurement for health system improvement. Copenhagen: WHO Regional Office for Europe; 2009.

32. WHO Regional Office for Europe. Assessing health services delivery performance with hospitalizations for ambulatory care sensitive conditions. Copenhagen: WHO Regional Office for Europe; 2016.

33. Shi L, Starfield B, Xu J. Validating the adult primary care assessment tool. J Fam Pract. 2001;50(2):161–4.

34. WHO Regional Office for Europe. Primary health care advisory group first meeting report. Copenhagen: WHO Regional Office for Europe; 2017.

35. Barbazza E, et al, Supplementary files: creating performance intelligence for primary health care strengthening in Europe. 2019: https://figshare.com/s/28a9bc80dc03c37dfd75.

36. Primary Health Care Performance Initiative. Primary health care performance initiative: methodology note. Washington, DC: PHCPI; 2015.

37. Donabedian A. The definition of quality and approaches to its assessment. Explorations in quality assessment and monitoring, 1980.

38. Pan American Health Organization. Integrated health service delivery networks: concepts, policy options and a road map for implementation in the Americas. Washington, DC; 2011.

39. World Health Organization. Framework on integrated, people-cenred health services. Geneva: World Health Organization; 2016.

40. Adam T, de Savigny D. Systems thinking for strengthening health systems in LMICs: need for a paradigm shift. Health Policy Plan. 2012;27(suppl_4):iv1–3.

41. Seidman G. Does SDG 3 have an adequate theory of change for improving health systems performance? J Glob Health. 2017;7(1):010302.

42. Aljamal MS, Ashcroft D, Tully MP. Development of indicators to assess the quality of medicines reconciliation at hospital admission: an e-Delphi study. Int J Pharm Pract. 2016;24(3):209–16.

43. Aronson BD, Janke KK, Traynor AP. Investigating student pharmacist perceptions of professional engagement using a modified Delphi process. Am J Pharm Edu. 2012;76(7):125.

44. Campbell SM, Cantrill JA. Consensus methods in prescribing research. J Clin Pharm Ther. 2001;26(1):5–14.

45. Black N, et al. Consensus development methods: a review of best practice in creating clinical guidelines. J Health Serv Res Policy. 1999;4(4):236–48.

46. Yerramilli P, Fernandez O, Thomson S. Financial protection in Europe: a systematic review of the literature and mapping of data availability. Health Policy. 2018;122(5):493–508.

47. OECD. Patient-reported indicators survey. Paris: OECD; 2017.

48. Allemani C, et al. Global surveillance of trends in cancer survival 2000–14 (CONCORD-3): analysis of individual records for 37 513 025 patients diagnosed with one of 18 cancers from 322 population-based registries in 71 countries. Lancet. 2018;391(10125):1023–75.

Supplementary appendices

Available here: https://figshare.com/s/28a9bc80dc03c37dfd75.

Appendix 1: Literature reviewed

Description: An overview of the frameworks and assessment tools, surveys, databases and health and development strategies reviewed in the initial literature review.

Appendix 2: Tracer conditions

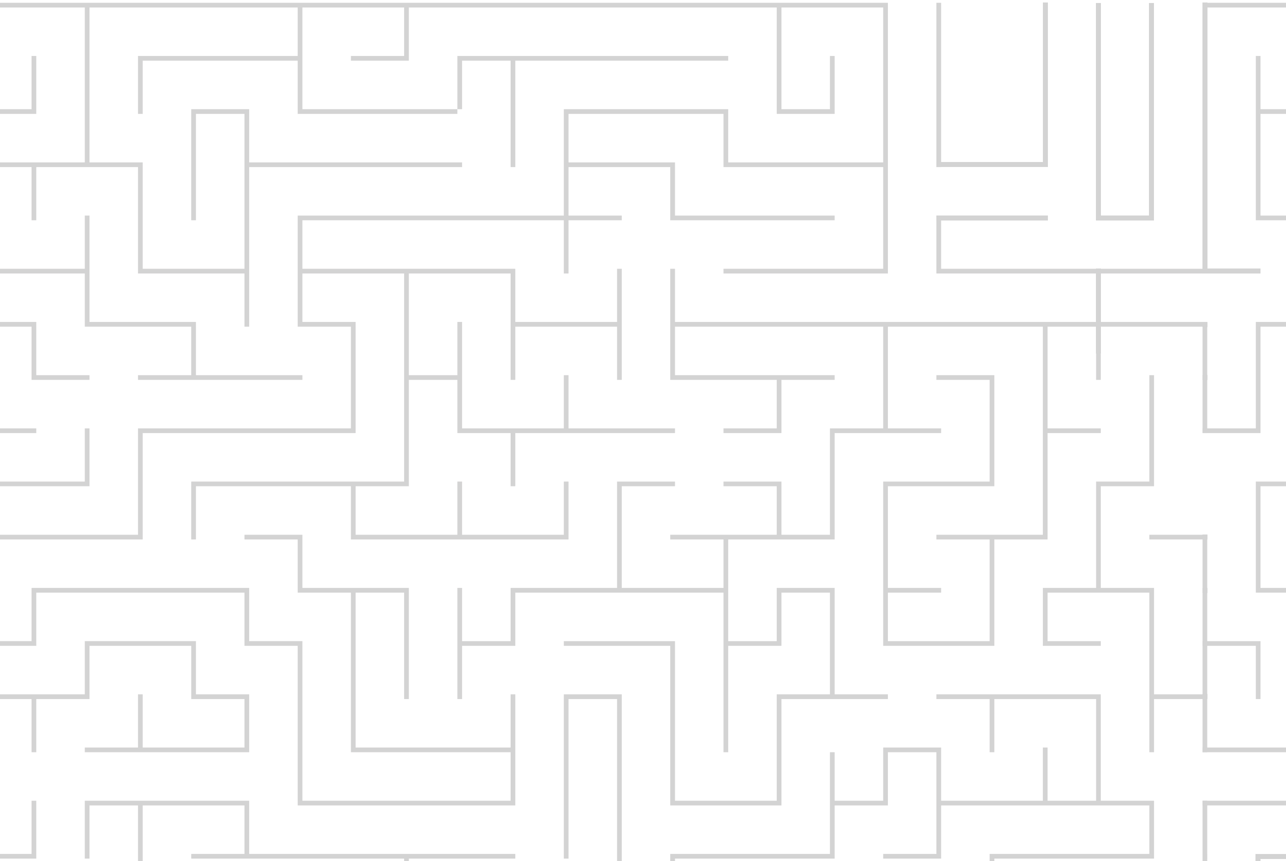
Description: A mapping of the criteria applied to refine the selection of tracer conditions to a core set of 7 clusters and 12 conditions. The final selection was made taking into account three considerations: (i) priority health improvement areas in Europe; (ii) relevance of conditions to the strength of primary health care; and (iii) a balanced range of primary health care services across the life-course.

Appendix 3: Indicator passports

Description: The final set of indicator passports containing the following details by indicator: framework alignment; indicator/question title; indicator/question definition or question; numerator/denominator or answer; unit of measurement; rationale; preferred data sources; disaggregation; and limitations.

Appendix 4: Glossary of terms

Description: A glossary of terms defining underlined words in Supplementary file 3 –Indicator passports, according to existing international classifications and definitions where available and/or identified sources. The glossary is organized in three sections, alphabetical order by section: health workforce; settings of health services delivery; and other, general terms.

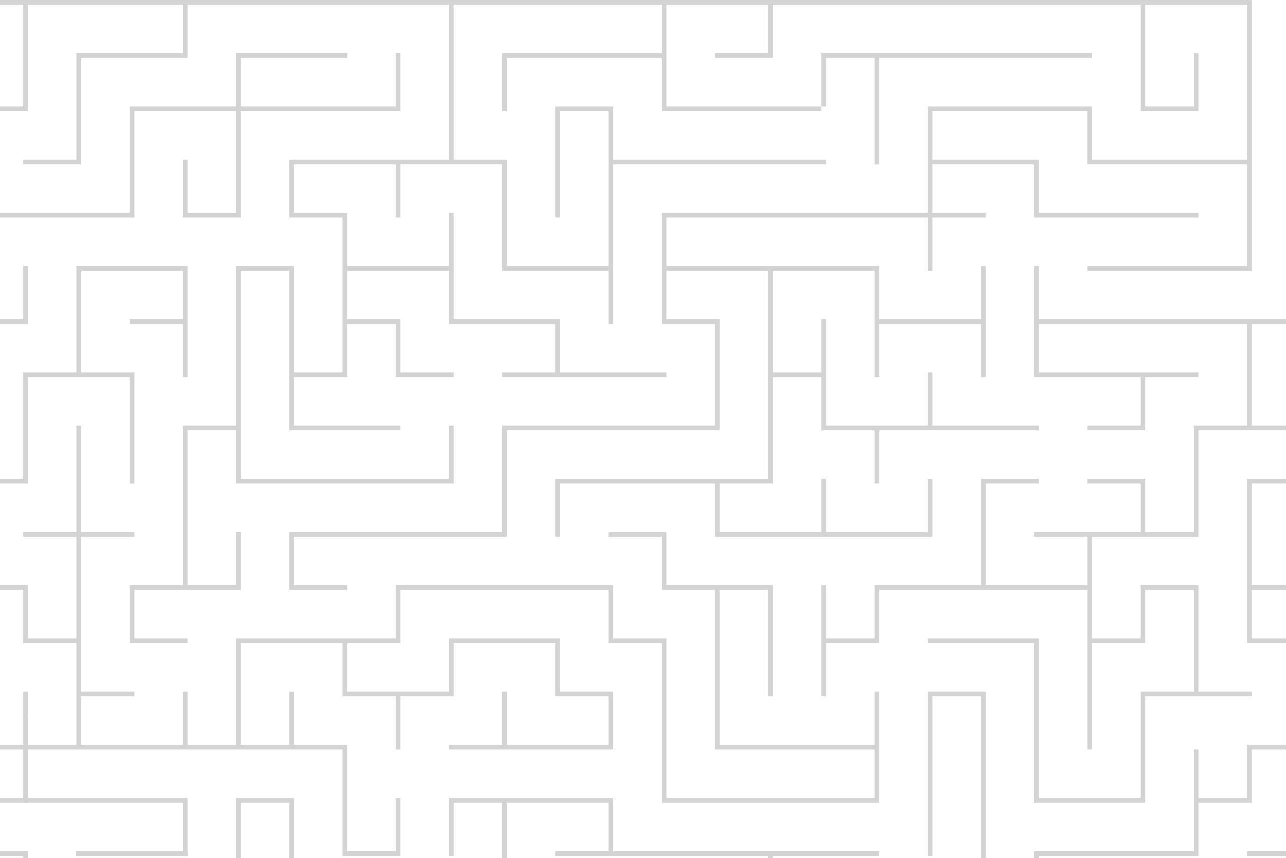


Chapter 3

The current and potential uses of Electronic Medical Record (EMR) data for primary health care performance measurement in the Canadian context

This chapter was published as:

Barbazza E, Allin S, Byrnes M, Foebel AD, Khan T, Sidhom P, Klazinga NS, Kringos DS. The current and potential uses of Electronic Medical Record (EMR) data for primary health care performance measurement in the Canadian context: a qualitative analysis. BMC Health Serv Res. 2021;21(820).



Abstract

Background

Electronic Medical Records (EMRs) are a rich data source to measure and improve quality of care. As Canadian primary health care (PHC) EMRs mature, there is increasing potential use of EMR data for performance measurement. This study identifies and describes current uses of EMR data for performance measurement and considerations to further its potential in the Canadian context.

Methods

We applied a qualitative case study design and descriptive assessment in three phases, consulting multiple data sources including scientific and grey literature, system leaders (*n*=41), and clinician/researchers (*n*=20). Phases included a multimethod approach to identify initiatives using EMR data for performance measurement across Canadian jurisdictions; in-depth review of current initiatives identified from a healthcare performance intelligence lens; and triangulation and thematic analysis across data sources to explore considerations for advancing performance measurement uses of EMR data in the Canadian context.

Results

Six initiatives of EMR data use for performance measurement were identified: one multi-jurisdictional; five jurisdiction-specific in the provinces of British Columbia, Manitoba and Ontario. EMR data uses were predominately for micro-level PHC physician and team performance improvement, with some use for meso-level organization/network-wide improvement. Indicator sets varied in number, though shared emphasis on chronic disease management and prevention/screening and to a lesser extent medication management. Key considerations for governing, resourcing and implementing EMR data for performance measurement were identified.

Conclusion

The extent of EMR data use for performance measurement varies across Canada. To further its potential, pan-Canadian data and privacy standards, performance intelligence competencies and renewed core PHC indicators should be prioritized. Experiences across countries, coupled with increasing momentum for performance measurement using real-world data, should be leveraged to avoid unnecessarily slow progress in Canada and abroad.

Background

The evidence base for primary health care (PHC) as an accelerator towards universal health coverage and enhanced population health has sustained a PHC approach to services delivery as the ambition of countries worldwide for decades [1-5]. Measuring the performance of health services has a fundamental role to play in assuring quality of care and achieving improvements [6]. By definition, performance measurement "seeks to monitor, evaluate and communicate the extent to which various aspects of the health system meet key objectives" [7]. The resulting performance intelligence has important uses that extend across the micro-meso-macro contexts of health systems. These uses include, for example, improving the management of a practice panel by individual physicians or PHC teams at the micro-level, assuring care standards are adhered to across networks or community health centres at the meso-level, or identifying gaps in care for population subgroups to inform strategic priorities at the macro-level [6,8,9].

Electronic medical records (EMRs) are an important data source for clinical care but also for secondary uses, including performance measurement. The rich patient-level data generated in EMRs has a number of advantages relative to other PHC data sources, such as administrative data or surveys. This includes its granularity, especially for diagnosis and intervention-related information [10,11], and its potential to link with other data sets, such as hospital discharge data. The timeliness of EMR data is also a key advantage, with increasing potential for near–real-time data extraction. The value of its timeliness has been demonstrated in the context of the COVID-19 pandemic. For example, countries with advanced secondary uses of EMR data, such as the Netherlands [12] and United Kingdom [13], have leveraged EMRs as a source for measuring the spread of community infection and its impact on population health and health services.

Despite the advantages of EMR data, realizing its full potential for performance measurement uses across health systems faces a number of challenges. This includes the quality and utility of its hybrid structured, semi-structured and unstructured data [8,14]. Other challenges across countries have traditionally included the low penetration of EMRs, insufficient analytical capacity to make use of the data, and inconsistent use of minimum or standard data elements [14,15].

In the Canadian context, each of the 13 provinces/territories have followed their own approach to EMR implementation since the early 2000s [16]. The differing paths taken and level of prioritization for EMR content standards, have resulted in varied EMR systems across the country. The ensuing patchwork of EMRs [16], persistent variability in EMR adoption rates, and ultimately, limitations in data quality and comparability, have each in part contributed to the slowed use of EMR data for performance measurement [17-19].

Nonetheless, the PHC EMR environment in Canada is changing. In 2019, 86% on average of participating Canadian family physicians to the Commonwealth Fund International Health Policy survey reported using EMRs in their practice [20]. This figure, while still below the Commonwealth average (93%) [20], has more than doubled in the past decade, up from 37% in 2009 [21], and 73% in 2015 [22]. The development of pan-Canadian EMR content standards and minimum data set [23,24], and assessments of EMR benefits [25], are signs of continued progress and sustained momentum [19]. As the adoption and sophistication of EMR systems advances, the lament of limited, quality EMR data has been described as a deficit that has continued to shrink [26,27].

In this study, we set out to systematically identify and describe the current uses of EMR data for performance measurement in Canada. We additionally aimed to explore challenges to be overcome for furthering the potential uses of EMR data for PHC performance measurement. To do so, we explored the following three questions in the Canadian context: Where is EMR data currently used as a source for performance measurement? What are the purposes of use and indicators sourced from EMR data for the initiatives identified? And, what are key considerations to furthering the use of EMR data for PHC performance measurement?

Methods

Design

We employed a qualitative case study design and descriptive assessment in three phases (Fig. 1) [28]. Reporting is in accordance with the Standards for Reporting Qualitative Research [29]. First, we consulted multiple data sources, including system leaders and researcher/clinicians across Canadian jurisdictions, to systematically identify use cases (initiatives) of EMR data for performance measurement. Second, where identified, these initiatives were studied in-depth from a health care performance intelligence lens according to an existing characterization of *fit for purpose* and *fit for use* healthcare performance indicators [9]. Third, to explore the further potential uses of EMR data in the Canadian context, we triangulated and analyzed data collected in a deductive and inductive approach using thematic analysis [30-32].

The first author is a doctoral student in healthcare performance intelligence focusing on the actionability of healthcare performance data. The multidisciplinary study team consisted of experts with complementary research, policy and subject matter expertise in the Canadian context.

We defined initiatives of EMR data for performance measurement as established processes to extract, analyze, and display (report) EMR data for quality of care-related decision-making [7,9]. No restrictions were placed on the primary decision-making context (eg, micro-, meso-, macro-level uses) or type of organization responsible for the initiative's development (eg, government agency, professional association, research network). In line with our aim to describe the context and processes of initiatives in practice, we excluded initiatives in the initial stages of development (pre-implementation), though included initiatives that had ended within the past year.

Fig. 1 Overview of study phases

Phases	Aims	Steps
Phase one	Identifying use cases of EMR data for performance measurement	1.1. Searching scientific and grey literature. 1.2. Mapping key policy stakeholders and research networks. 1.3. Consulting jurisdiction-appointed PHC advisors (n=13). 1.4. Interviewing system leaders (n=41) and clinician/researchers (n=20).
Phase two	Describing initiatives identified	2.1. Analyzing interview questions (section 2) with initiative-affiliated experts (n=11). 2.2. Reviewing initiative-specific reporting and indicator sets. 2.3. Validating analysis with initiative-affiliated experts (n=11).
Phase three	Exploring considerations to further uses of EMR data	3.1. Analyzing interview questions (section 3) with system leaders (n=41) and clinician/researchers (n=20). 3.2. Validating findings with initiative-affiliated experts (n=11).

Setting

In Canada, the 13 provincial and territorial governments steward PHC services for their populations [33]. This autonomy accounts in part for the variation across jurisdictions with regards to how a PHC approach is defined, including its delivery as primary care services, organization of practices (eg, solo physician, group or multi-profile practices) [20] and payment of providers (eg, fee-for-service, salaried, capitation, blended models) [34]. There is similar heterogeneity in how jurisdictions approach performance measurement and improvement: some with dedicated agencies (quality councils), and others assigning this role to a ministry department or regional health authority and/or professional associations [35-37]. These differences also extend to measurement itself, with jurisdiction-defined performance frameworks and indicator sets.

To facilitate jurisdiction-led PHC performance measurement and to encourage meaningful comparisons within and across jurisdictions, a core set of pan-Canadian PHC indicators was first developed in 2006 and updated in 2012 [38,39]. At the outset, administrative and survey data were suggested data sources. In the 2012 update, the primary care EMR system was added as a possible source for a subset of indicators. The use and sources of these indicators is ultimately to the discretion of each jurisdiction.

Phase one: identifying use cases of EMR data for performance measurement

In the absence of an up-to-date overview of EMR data as a source for performance measurement in Canada, we first explored uses and sources of PHC performance measurement across jurisdictions. We took as a basis a related environmental scan conducted by the Canadian Institute for Health Information (CIHI) (CIHI, unpublished data, 2016). From this, an initial listing of initiatives was developed. We used multiple methods to systematically update this list.

First, the scientific and grey literature on PHC performance measurement in Canada was searched. Searches were conducted using PubMed in late-2019 using the following key terms in varied combinations: EMR; performance measurement; PHC; Canada. Reference lists of relevant literature were reviewed in a snowballing approach.

Second, we identified and mapped more than 80 key policy stakeholders and research networks related to PHC performance measurement and/or improvement by jurisdiction (Appendix 1). Websites of identified organizations were searched manually for relevant reporting or activities. French-language websites were reviewed using online translations.

Third, an existing CIHI network of jurisdiction-appointed PHC advisors (*n*=13)—comprising executives in roles related to PHC from provincial/territorial ministries of health—was convened virtually in February 2020 to validate the completeness of the actors and mapping of initiatives, and to solicit insights on other emerging efforts. Recommendations for jurisdiction-specific experts to consult were also sought. All comments and discussion points were documented, and members were followed-up with by email.

Lastly, we directly consulted with experts across jurisdictions for their firsthand insights into their respective contexts. Two profiles of experts in each jurisdiction were pursued: (i) system leaders affiliated to provincial/territorial ministries of health, health authorities, quality councils, professional associations and/or other key stakeholders; and (ii) researchers affiliated to academia, research networks and/or practicing clinicians. The large number of experts was deemed necessary given the exploratory aims of the study.

Individuals were identified by drawing on contact and membership lists of webpages consulted, authorship of literature reviewed, expertise of the study team and advisors met with, as well as a snowballing of recommendations. We contacted 91 experts via email in English or French, providing an overview of the study and in total, 61 experts were consulted: 41 system leaders and 20 clinician/researchers. See Appendix 3 for an overview of experts by jurisdiction. We requested to engage each in one-on-one discussions, rather than written responses, for rich individual exchanges and practical insights into reasons contributing to contexts where EMR data was not leveraged as a source for performance measurement (research question 3). See Appendix 2 [40] for further details on the topics and approach taken.

Data was collected over a three-month period (January–March 2020). This phase was considered complete when at least one of the target two profiles of experts was consulted from each jurisdiction. Non-participants (n=30) were nearly equal-thirds unreachable, unavailable or referred to an alternate contact. The target two perspectives (system leaders and clinician/researchers) were met in 8 of 13 jurisdictions. In one instance (Yukon), researchers working elsewhere but with experience working in the jurisdiction were consulted in lieu of available informants. All discussions took place in English and were conducted by the first author joined by one team member (SA, MB, TK), primarily for consultations conducted with two or more informants. In three instances, information was collected via email exchanges only.

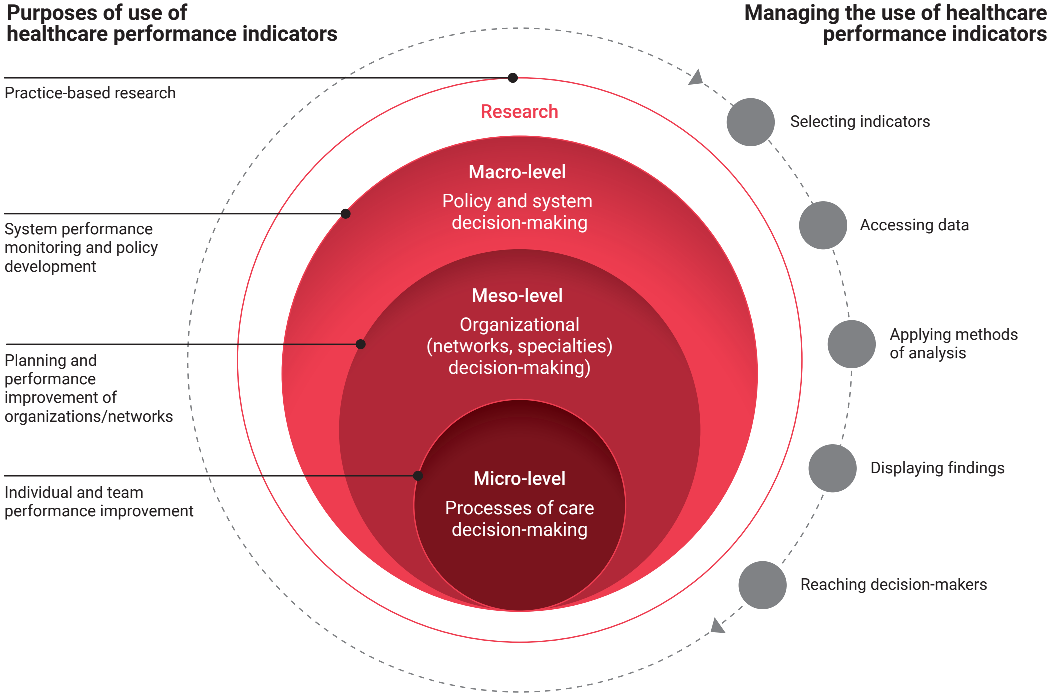
Phase two: describing initiatives identified

We developed a description of the initiatives identified from a healthcare performance intelligence perspective in the approach visualized in Fig. 2. Creating healthcare performance intelligence accounts for the varied steps to convert data to indicators, information to knowledge, and use of this knowledge as action in decision-making [40]. To be actionable, data should be both fit for purpose and use [9]. We applied these constructs to describe each initiative by their intended purpose and management in practice.

Specifically, we differentiated the *uses* of EMR data for performance measurement beyond their common aim of informing quality of care-related decision-making. These *uses* were distinguished according to an existing multi-level characterization as improving individual or team performance (micro-level); planning and performance improvement of organizations/networks (meso-level); system performance monitoring and policy development (macro-level); and cross-cutting uses for practice-based research [9,41]. To depict the handling of data in practice, we applied the conceptualization of an indicator's use cycle, extending from the selection of indicators to processes for accessing the data, analyzing and displaying results and reaching the target decision-makers.

We used multiple data sources to describe the initiatives identified. This included supplementary questions during semi-structured interviews with the aforementioned experts directly involved in these initiatives (Appendix 2, Sec. 2). Records of the interviews were prepared as detailed summaries. We triangulated data sources to prepare a description of the cases in the approach described (Fig. 2). The experts consulted from each initiative were returned the analyzed findings to review its completion and accuracy. Two follow-up discussions were organized and other written feedback was incorporated into the description of each case.

Fig. 2 Conceptualization of purposes of use and fitness for use considerations applied to describe initiatives



Phase three: exploring considerations to further uses of EMR data

As a final phase, we explored the underlying main challenges to further the use of EMR data as a source for performance measurement in the Canadian context. Thematic analysis was used to analyze the collected data of the first two phases [32]. Data analysis was performed manually in a deductive and inductive approach [31,32]. The deductive analysis was guided by the considerations explored related to the management of healthcare performance indicators (selecting indicators, accessing data, applying methods of analysis, displaying findings and reaching decision-makers) [9]. We also applied the main categories of contextual considerations previously found to influence an indicator's use defined as information infrastructure, governance, workforce capacity, and culture [9]. Additional themes and naming subcategories emerged in an inductive approach. The initial coding and clustering of themes was conducted by the first author and reviewed by the study team.

A preliminary analysis of the study findings was presented at a public webinar in April 2020. All experts contributing to the earlier phases of the study were personally invited to attend the event. The event was attended by approximately 100 participants. As such, the presentation of preliminary findings gave an opportunity for member checking. The final clustering of main challenges was also reviewed by the experts of the six initiatives consulted to review the results of phase two.

Ethics

The research adheres to the Dutch ethics guidelines stated in “Medical Research Act with People (Wet medisch-wetenschappelijk onderzoek met mensen (WMO)) [Dutch], in BWBR0009408, W.a.S. Ministry of Health, Editor. 1998: Hague, Netherlands” [42], for which verbal consent was deemed adequate by the authors as no human data was retained. To ensure informed voluntary participation, experts contributing to this study provided written agreement to participate during the recruitment stage.

Results

Identified initiatives of PHC performance measurement using EMR data

Across the jurisdictions, we identified six initiatives—one multi-jurisdictional and five jurisdiction-specific (British Columbia, Manitoba, Ontario)—where EMR data is used as a source for measuring PHC performance. Table 1 describes the six initiatives. The actors underpinning each vary, ranging from ministries of health, to membership-based networks, to actors with a mandate focused on EMR data use. Funding is predominately from the respective ministries or grant-specific. Importantly, the underpinning payment model for affiliated practices varies across initiatives, ranging fee-for-service, capitated and salaried practices. The initiatives range from well-established, having been in place for more than five years, to more recent like *Health Data Coalition’s (HDC) Discover* and *OntarioMD’s Insights4Care*. In June 2020, all initiatives were being implemented aside from Association of Family Health Teams of Ontario’s *(AFHTO) Data2Decisions (D2D)* which was time-bound and ran between 2014 and 2019, though its resources remain in the public domain [27].

Further to these established initiatives, a number of pilot or emerging examples of EMR data use were identified. These include: the Quebec-based initiative *Le Collectif pour les Meilleures Pratiques et l’Amélioration des Soins et Services+* (CoMPAS+, the Collective for Best practices and Improvement of Care and Services) exploring EMR data as a source for practice feedback [43,44]; the *Community Information Integration* initiative in Alberta, working to centrally store EMR data for quality improvement and system planning [45]; and in Saskatchewan, the *Chronic Disease Management Quality Improvement Program* using EMR data together with paper-based records for issuing quality improvement payments [46]. We also identified a number of research-focused initiatives including the multi-jurisdictional project *SPIDER* [47], and Quebec-based initiative *PULSAR* [48]. The experts also described a number of ad hoc, physician-driven initiatives that have emerged organically as physicians champion the use of their EMRs (eg, [49]).

Description of six initiatives

For the purpose of this study, the six initiatives of EMR data for performance measurement were explored further (Table 1). Overall, measurement was found geared towards the micro-level context to improve the performance of individual physicians or teams. Two initiatives, *D2D* and the *Business Intelligence Reporting Tool (BIRT)* additionally target the meso-level context, using EMR-sourced indicators for planning and improvement of community health centres and family health teams/organizations. Similarly, *HDC Discover* and *Insights4Care* are also expanding to meso-level uses for communities and integrated health teams, respectively. No macro-level uses of EMR data were identified.

Each initiative has developed processes to extract, anonymize and centrally-store EMR data for affiliated practices, with the exception of *Insights4Care* which queries data directly from patient files. The frequency and automatization of data extraction processes vary, with more manual efforts in some instances, such as *D2D*'s approach requiring data uploading to a secure platform on a 6-month cycle. This is in contrast to *BIRT* and *Insights4Care* which extract data from the EMRs daily.

With regards to the analysis of data, the initiatives were found to share a common approach to report indicators over time and using breakdowns that range for comparisons between practices, organizations and/or the province. The initiatives vary in the frequency of data updating, from daily, to quarterly to every 6-months. In all instances, the detailed analyzed data is not publicly reported and rather, is presented in secure online dashboards or portals, aside from in Manitoba where feedback is provided as offline reports. Informants across the initiatives emphasized the support of hands-on data quality improvement specialists, though the approach and availability of such resources ranged from at-distance (eg, in Manitoba), to partnership-driven (eg, *HDC Discover*), to practice-affiliated data and improvement specialists (eg, *D2D, BIRT, Insights4Care*).

Some user feedback and evaluations on the impact of initiatives have been conducted, like in the case of the *Canadian Primary Care Sentinel Surveillance Network (CPCSSN)* and its *Data Presentation Tool* [50-52], the pilot phase of *Insights4Care* [53], and *AFHTO's D2D* [54-56]. Assessing the impact of each initiative was beyond the scope and aims of this study.

Table 1 Overview of EMR data for PHC performance measurement by initiative

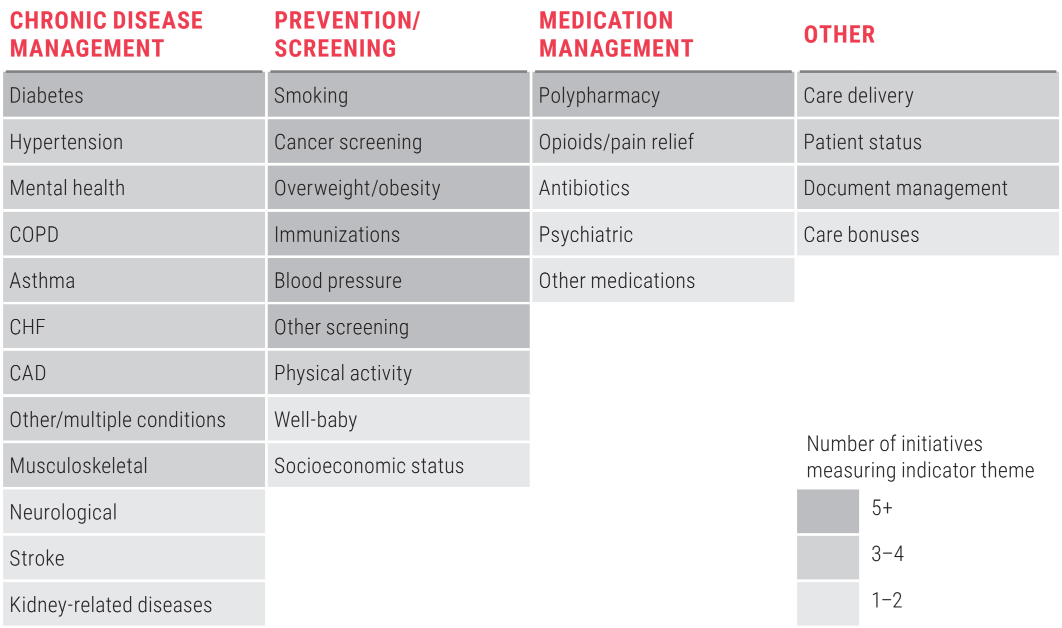
CONSIDERATIONS	CPCSSN	HDC DISCOVER	MANITOBA PCQI	INSIGHTS 4CARE	D2D	BIRT
Context						
Jurisdiction	Multiple	British Columbia	Manitoba	Ontario	Ontario	Ontario
Actor	CPCSSN	Health Data Coalition	Manitoba Health	OntarioMD	AFHTO	The Alliance
Funder	Public Health Agency of Canada	General Practice Services Committee	Manitoba Health	Ontario Ministry of Health	Ontario Ministry of Health	Multiple sources; not-for-profit
Duration of initiative	> 5 years	< 5 years	> 5 years	< 5 years	5 years (ended 2019)	> 5 years
Purposes of use						
Target context	Cross-cutting	Micro	Micro	Micro	Micro/Meso	Micro/Meso
Primary use	Practice-based research	Individual performance improvement; community improvement	Team performance improvement	Individual performance improvement	Planning and improvement of FHT/team	Planning and improvement of CHC/team
Target users (practice type)	Individual physicians; practice-based researchers	Individual physicians/ NPs (solo/ group practices)	Home clinic teams (group practices)	Individual physicians, NPs and practice staff (solo/group practices)	Individual physicians, teams, executives (FHTs)	Individual physician/ NPs, executives (CHCs)
Managerial considerations						
Number of indicators	NA[a]	184	44	64	17	40+
EMR vendors	Spans across multiple vendors	OSCAR MOIS Telus Health Intrahealth	Spans across multiple vendors	Telus Health OSCAR	Across yet mainly: Telus Health Accuro OSCAR	Telus Health NOD Purkinje
Analysis frequency	6-month	Quarterly	Quarterly	Daily	6-month	Daily
Feedback format	Portal dashboard	Portal dashboard	Report	EMR-based dashboard	Portal dashboard	Dashboard and report
Public reporting	No	No	No	No	Yes (summaries)	Yes (annual report)
User support	Local-network led	Collaboration with practice support program	At-distance support of department at Manitoba Health	Practice Enhancement Consultants	Network of QIDSS	CHC-based data coordinators; region-al decision support
Evaluations of initiative	Multiple studies; user feedback	User feedback	Ad hoc	Proof of concept evaluation	Project evaluation	Ad hoc

Abbreviations: AFHTO Association of Family Health Teams, The Alliance The Alliance for Healthier Communities, BIRT Business Intelligence Reporting Tool, CHCs community health centres, CPCSSN Canadian Primary Care Sentinel Surveillance Network, D2D Data2Decisions, FHTs family health teams, HDC Discover Health Data Coalition Discover, Manitoba PCQI Manitoba Primary Care Quality Indicators, QIDSS Quality Improvement Decision Support Specialists.

[a] As a surveillance database, varied data elements are collected and can be reported on by CPCSSN.

We explored the common themes—as the focus of indicators—being measured across the initiatives. Figure 3 summarizes recurrent themes in four main clusters: chronic disease management, prevention/screening, medication management and other measures. See Appendix 4 for a detailed mapping of the frequency of themes by initiative. The most common themes were related to prevention/screening including smoking, cancer screenings, obesity, immunizations and blood pressure. Screening by socioeconomic risk factors, such as food and housing insecurity, was uniquely captured by one initiative (*BIRT*). EMR data was frequently used by the initiatives to measure chronic disease management, in particular diabetes as well as cardiovascular diseases, mental health and respiratory diseases. Measurement related to prescribing was less common beyond polypharmacy patients. Indicators related to care delivery, such as follow-up after hospitalization, hospital admissions for ambulatory care sensitive conditions or emergency department visits, were reported with medium frequency.

Fig. 3 Common indicator themes across EMR-sourced indicators by initiative



CHRONIC DISEASE MANAGEMENT	PREVENTION/ SCREENING	MEDICATION MANAGEMENT	OTHER
Diabetes	Smoking	Polypharmacy	Care delivery
Hypertension	Cancer screening	Opioids/pain relief	Patient status
Mental health	Overweight/obesity	Antibiotics	Document management
COPD	Immunizations	Psychiatric	Care bonuses
Asthma	Blood pressure	Other medications	
CHF	Other screening		
CAD	Physical activity		
Other/multiple conditions	Well-baby		
Musculoskeletal	Socioeconomic status		
Neurological			
Stroke			
Kidney-related diseases			

Number of initiatives measuring indicator theme
▓ 5+
▒ 3–4
░ 1–2

Abbreviations: COPD chronic obstructive pulmonary disease, CHF congestive heart failure, CAD coronary artery disease.

Key considerations to extend EMR data use

Canadian jurisdictions are at varied stages of development to use their EMRs, from early EMR adoption to improving and extending its use like in the initiatives identified. Despite these differences, our analysis across data sources and jurisdictions found commonalities in challenges to further the use of EMR data. Specific challenges emerged related to governance, contextual and implementation fitness for use considerations (Table 2). The identified initiatives, while few in total, offer some local solutions based on the experiences of these efforts to-date. For example, among the main contextual challenges are those related to the time and resources demanded to improve the quality of data due to lack of common regulations and data standards. The initiatives studied offer different approaches to address this, from increased attention and prioritization of data standards to hands-on support in-practice.

Table 2 Summary of common considerations for increasing EMR data use for performance measurement in the Canadian context

CONSIDERATION	MAIN CHALLENGE	LESSONS FROM INITIATIVES
Governance		
Vision and political will	Gaining momentum to establish privacy and technology regulations and prioritize use of data due to lack of high-level commitment.	Build indicators into new PT-initiatives, strategies or reforms; define clear roles and uses of data from the outset.
Privacy and data sharing regulations	Clarifying the relationship between patients, physicians and vendors regarding data ownership versus custodianship.	Engage across stakeholders from the outset including data users; improve utilisation of existing standards.
Aligned financing structures	Ensuring PHC workforce will be paid for their time due to different payment models in primary care.	Embed measurement and improvement into payment system for fee-for-service PHC physicians; consider incentives (financial and non-financial) for salaried physicians.
Contextual		
Information system infrastructure	Lagging saturation of EMRs due to time and resource burden of negotiating with vendors and standardizing the information architecture.	Leverage developed tools from vendors for use in other contexts to accelerate progress; prioritize standardization from the outset.
Data quality	Investing considerable time and resources to improve the quality of data due to lack of common regulations specifying data standards.	Standardize what, how and where information is to be recorded in patient records; increase use and adherence to standards through trainings.
Workforce capacity	Ensuring PHC professionals appreciate the importance for high quality data capture and its use due to lack of training in population health and quality improvement.	Define and invest in data literacy as a PHC professional competency; ensure all levels are equipped with performance intelligence competencies.
Professional culture	Changing behavior and professional culture due to misaligned accountability, concerns of trust, time span needed for behavior change and critical mass of users.	Engage champions to demonstrate data use in practice; integrate data use into accountability arrangements.
Implementation		
Selecting indicators	Selecting meaningful indicators due to unclear purposes of use, undefined priority indicators, challenges to capture multi-professional teamwork.	Ensure the intended use of data is clear from the outset; standardize core indicators; continuously review indicator sets with end-users.

CONSIDERATION	MAIN CHALLENGE	LESSONS FROM INITIATIVES
Accessing data	Configuring across EMR vendors to gain access to data due to varied vendors with unharmonized standards and lack of regulations for EMR vendors.	Standardize workflows for data entry; support PHC professionals through initial and continuous training.
Displaying findings	Designing a simple, user-friendly display of findings due to differing uses and lack of prioritization of outputs.	Ensure outputs of data are intuitive, easy to navigate and improved upon with feedback from users over time.
Reaching decision-makers	Using data in practice due to time constraints, users' uncertainty of interpretation and lack of familiarity with tools.	Provide hands-on coaching; embed use within quality management cycles; engage improvement facilitators for change management support.

Discussion

With this study, we set out to explore the current and potential use of EMR data for PHC performance measurement in the Canadian context. We aimed to capture the state-of-the-art of EMR data use as well as to gain practical insights for furthering its potential. To do so, we consulted both the literature and firsthand insights of system leaders, clinicians and researchers. We observe the following main findings.

First, while jurisdictions remain at varied stages [16], recognition of the importance and potential secondary uses of EMR data is common. Nonetheless, while nearly 15 years since the initial launch of a pan-Canadian PHC indicator set and almost a decade since its updating to include EMRs as a possible source, EMR data is used in only a handful of initiatives for performance measurement. Instead, a number of other data sources for PHC performance measurement continue to be relied on. This is predominately physician billing or other administrative sources such as census, laboratory and registry data and survey data. This finding is in line with recent international studies, signalling electronic health systems are yet to be leveraged to their full potential [14,57]. These sources are in use for macro-level measurement across jurisdictions, be it in ad hoc reports, programme-specific monitoring and annual health system performance measurement, and at the micro-level as panel reports like in Alberta, Ontario, and Saskatchewan. It means, EMR data as a source for performance measurement is only a fraction of the total activity.

Where EMR data is in use, this is predominately geared towards performance measurement in the context of the micro-level, for use by individual clinicians and their teams. The EMR-based initiatives also equip affiliated physicians, their practices and networks with comparable data to generate research. EMR data for executives to manage and improve organizations is less established, though its potential is demonstrated by *BIRT* and *D2D*. Uses of EMR data for system performance improvement are not yet leveraged. This is despite its advantages, especially when linked with other data sets, to assess performance, identify problems such as unwarranted variation, and enable smarter resource allocation [14, 58]. Further to diversifying the performance measurement uses of EMR data, we note patients and the public are not among EMR data users at present, as the reporting across initiatives is not publicly available, nor is consistent patient access to their EMRs common practice.

The six different initiatives making use of EMR data for measurement and improvement demonstrate there is not a singular approach to do so. The initiatives vary in their contexts, including the target PHC practice model and affiliated EMR vendors, but also in their approaches to extract, standardize and return analyzed information to their users. In terms of the EMR-sourced indicators by each initiative, the range of indicators extend beyond the original 2012 pan-Canadian indicator set [38, 39], in particular with regards to chronic disease management and prescribing. Ways to update and broaden a pan-Canadian set of indicators that can potentially be sourced from EMR data should be explored together with continued investment in minimum data standards.

New initiatives in the past five years like *HDC Discover* and *Insights4Care,* as well as greater EMR coverage across jurisdictions, suggest the possibility for a quickening pace of change. The pan-Canadian nature of EMR vendors may facilitate the adoption of existing tools in other jurisdictions. Moreover, the COVID-19 pandemic has underscored the importance of timely, aggregated data for the system to monitor cases [40] as well as the potential use of EMR data in PHC to observe sudden changes in visits and to proactively reach patients [59].

To dramatically accelerate the use of EMR data will require more assertive action. The lessons for enabling EMR data use described by initiatives attest to the valuable experience and expertise that lies within the system and can be leveraged (Table 2), like advancing privacy and data sharing agreements.

The recurrent themes call for: defining a clear vision together with key stakeholders and focusing on the standardization of EMR data at the pan-Canadian level, as has been underscored elsewhere [15,35,60-62]; advancing beyond EMR adoption where still needed and investing in workforce competencies at all levels for the professionalization of performance measurement; and, considering updating the core set of pan-Canadian PHC indicators to fully account for the potential of EMR data as a source. Further research should test empirically the impact of EMR data for different decision-making uses. The implementation of EMR-sourced performance measurement and quality improvement should also leverage the insights of relevant international examples like the United Kingdom [63] and the Netherlands [64]. In particular, the further exchange of good practices around the handling of privacy and data sharing agreements and data capture in EMRs of virtual care services, mental health and addiction encounters, and socioeconomic status, appear needed.

Strengths and limitations

To our knowledge, this is the first study to systematically explore and describe examples of EMR data use for performance measurement in the Canadian context from a health care performance intelligence perspective. The study was enriched by the wide-reaching engagement of experts across Canadian jurisdictions and of different profiles (stakeholders and clinician/researchers). Additionally, given the acceleration of electronic health information system improvements brought on by the COVID-19 pandemic, our findings are of particular relevance to ensure sustained, system-wide improvements are pursued.

Findings of this study should be understood in the context of three primary limitations. First, the target diversity in perspectives of informants was not met in all jurisdictions. While significant efforts were made for consistency in representation, the availability of informants, range of stakeholders and presence of research networks ultimately varies considerably by jurisdiction. The impact of this limitation was mitigated through the triangulation of existing sources and expert advice. Second, the process of classifying indicators involved a degree of subjectivity as our definition was broad and for this reason, we limited comparisons to indicator titles. Third, the analysis of key considerations was conducted by independent thematic coding. To limit the risk of overlooked considerations while also mindful of the burden the COVID-19 pandemic has placed on informants, a subset of the original informants reviewed these results.

Conclusion

Performance measurement is integral to PHC improvement. In this study, we explored the use of EMR data for measurement and improvement in the Canadian context. As an evolving field, with continuous improvements in the maturity of EMRs across the country, we engaged informants of varied perspectives to systematically explore the extent of current use but also the potential use based on firsthand insights and experiences. The six initiatives identified, in general, share a common focus on practice, micro-level performance measurement and improvement. They also provide a range of insights into approaches to extract and display data, as well as the types of indicators analyzed using EMR data at present. These firsthand experiences, coupled with the momentum for digitalization in PHC brought on by 2020, should be leveraged to avoid unnecessarily slow progress and ensure the potential uses of EMR data across Canada and beyond, are realized.

Abbreviations

AFHTO: Association of Family Health Teams of Ontario; BIRT: Business Intelligence Reporting Tool; CPCSSN: Canadian Primary Care Sentinel Surveillance Network; D2D: Data2Decisions; EMRs: Electronic Medical Records; HDC: Health Data Coalition; PHC: primary health care.

Acknowledgements

We acknowledge the contributions and are grateful for and to the following: the time and expertise of key informants, CIHI's Jurisdictional Advisory Group members and observers, and Client Affairs Managers; the additional support to review by Kavita Mehta and Sandeep Gill (Association of Family Health Teams of Ontario), Jennifer Rayner (Alliance for Healthier Communities), John Queenan (Canadian Primary Care Sentinel Surveillance Network), Simon Lang and Darren Larsen (OntarioMD), Donna Bell and Siddhesh Talpade (Manitoba Health) and Kim Morrison (Shared Health Manitoba), William Clifford and Gordon McNeil (Health Data Coalition); the guidance of HealthPros consortium members Gregory Marchildon (University of Toronto) and Kathleen Morris (CIHI); logistical support of Jennifer Trebell (CIHI) and Monika Roerig (University of Toronto); reviews by HealthPros Fellows; draft documents that served as a basis for this study prepared by CIHI's PHCiTeam; and the support of the Amsterdam Public Health research institute Quality of Care research programme for visiting researchers.

References

1. Balabanova D, Mills A, Conteh L, Akkazieva B, Banteyerga H, Dash U, et al. Good health at low cost 25 years on: lessons for the future of health systems strengthening. Lancet. 2013;381(9883):2118–33.
2. Ghebreyesus TA, Fore H, Birtanov Y, Jakab Z. Primary health care for the 21st century, universal health coverage, and the Sustainable Development Goals. Lancet. 2018;392(10156):1371–2.
3. Kringos D, Boerma W, van der Zee J, Groenewegan P. Europe's strong primary care systems are linked to better population health but also to higher health spending. Health Affairs. 2013;32(4):686–94.
4. Pavlic DR, Sever M, Klemenc-Ketis Z, Svab I, Vainieri M, Seghieri C, et al. Strength of primary care service delivery: a comparative study of European countries, Australia, New Zealand, and Canada. Prim Health Care Res Dev. 2018;19(3):277–87.
5. The Lancet. The Astana Declaration: the future of primary health care? The Lancet. 2018;392(10156):1369.

6. Smith P, Mossialos E, Papanicolas I. Performance measurement for health system improvement: eperiences, challenges and prospects. Copenhagen: WHO Regional Office for Europe; 2008.
7. Smith P, Mossialos E, Papanicolas I, Leatherman S. Part 1: Principles of performance measurement. In: Smith P, Mossialos E, Papanicolas I, Leatherman S, editors. Performance measurement for health system improvement: experiences, challenges and prospects. Copenahgen: WHO Regional Office for Europe; 2008.
8. Birtwhistle R, Williamson T. Primary care electronic medical records: a new data source for research in Canada. CMAJ. 2015;187(4):239–40.
9. Barbazza E, Klazinga N, Kringos D. Exploring the actionability of health care performance indicators for quality of care: a qualitative analysis of the literature, expert opinion and user experience. BMJ Qual Saf. 2021;30:1010–20.
10. Cebul R. Using electronic medical records to measure and improve performance. Trans Am Clin Climatol Assoc. 2008;119:65–76.
11. Williamson T, Lamber-Lanning A, Martin K, Leggett J, Morkem R, Khan S, et al. Primary health care intelligence: 2013 progress report of the Canadian Primary Care Sentinel Surveillance Network (CPCSSN). 2013.
12. Nivel. Corona Alert 2021. Available from: https://www.nivel.nl/nl/corona-actueel.
13. de Lusignan S, Liyanage H, McGagh D, Jani BD, Bauwens J, Byford R, et al. COVID-19 surveillance in a primary care sentinel network: in-pandemic development of an application ontology. JMIR Public Health Surveill. 2020;6(4):e21434-e.
14. OECD. Health in the 21st Century: putting data to work for stronger health systems. Paris: OECD; 2019.
15. Oderkirk J. Readiness of electronic health record systems to contribute to national health information and research. Paris: OECD; 2017.
16. Chang F, Gupta N. Progress in electronic medical record adoption in Canada. Canadian Family Physician. 2015;61(12):1076–84.
17. Huang MZ, Gibson CJ, Terry AL. Measuring electronic health record use in primary care: a scoping review. Appl Clin Inform. 2018;9(1):15–33.
18. OECD. Health data governance: privacy, monitoring and research – policy brief. Paris: OECD; 2015.
19. Terry A, Stewart M, Fortin M, Wong S, Kennedy M, Burge F, et al. Gaps in primary healthcare electronic medical record research and knowledge: findings of a pan-Canadian study. Healthc Policy. 2014;10(1):46–59.
20. CIHI. How Canada compares: results from the Commonwealth Fund’s 2019 international health policy survey of primary care physicians. Ottawa: Canadian Institute for Health Information; 2020.
21. CMWF. Commonwealth Fund international health policy survey of primary care physicians. New York: The Commonwealth Fund; 2009.
22. Canadian Institute for Health Information. How Canada compares: results from the Commonwealth Fund 2015 international health policy survey of primary care physicians. Ottawa: CIHI; 2016.

23. CIHI. Pan-Canadian primary health care electronic medical record content standard, Version 3.0 – Clinician-Friendly Pick-List Guide. Ottawa: Canadian Institute for Health Information; 2014.

24. CIHI. Pan-Canadian primary health care emr minimum data set for performance measurement: Version 1.0. Ottawa: Canadian Institute for Health Information; 2020.

25. PwC. Canada Health Infoway: the emerging benefits of electronic medical records use in community-based care. Toronto: Canada Health Infoway; 2013.

26. Jones M, Koziel C, Larsen D, Berry P, Kubatka-Willms E. Progress in the enhanced use of electronic medical records: data from the Ontario experience. JMIR Med Inform. 2017;5(1):e5–e.

27. MacKinnon S. QIDS-ESSENTIAL: The making and meaning of the quality improvement decision support program. Toronto: Association of Family Health Teams of Ontario; 2019.

28. Baxter P, Jack S. Qualitative case study methodlogy: study design and implementation for novice researchers. TQR. 2008;13(4):544–59.

29. O'Brien BC, Harris IB, Beckman TJ, Reed DA, Cook DA. Standards for reporting qualitative research: a synthesis of recommendations. Acad Med. 2014;89(9):1245–51.

30. Vogl S, Schmidt E, Zartler U. Triangulating perspectives: ontology and epistemology in the analysis of qualitative multiple perspective interviews. Int J Soc Res Methodol. 2019;22(6):611–24.

31. King N. Using templates in the thematic analysis of text. Essential Guide to Qualitative Methods in Organizational Research. Sage; 2004.

32. Braun V, Clarke V. Using thematic analysis in psychology. Qual Res Psychol. 2006;3(2):77–101.

33. Marchildon G, Allin S, Merkur S. Provision of services Canada: Health System Review 2020. Health Systems in Transition. Copenhagen: WHO Regional Office for Europe; 2020.

34. Peckham A, Ho J, Marchildon G. Policy innovations in primary care across Canada. Toronto: North American Observatory on Health Systems and Policies; 2018.

35. Johnston S, Hogel M. A decade lost: primary healthcare performance reporting across Canada under the action plan for health system renewal. Healthc Policy. 2016;11(4):95–110.

36. Office of the Auditor General of Ontario. Chapter 3: Section 3.03 Health Quality Ontario 2018. In: Annual report 2018: volume 1 [Internet]. Toronto: Office of the Auditor General of Ontario. Available from: https://www.auditor.on.ca/en/content/annualreports/arreports/en18/2018AR_v1_en_web.pdf.

37. Milligan C, Peckham A, Marchildon G. Healthcare Quality Councils: a pan-Canadian scan. Toronto: North American Observatory on Health Systems and Policies; 2018.

38. CIHI. Pan-Canadian primary health care indicators: pan-Canadian primary health care indicator development project, report 1. Ottawa: Canadian Institute for Health Information; 2006.

39. CIHI. Pan-Canadian primary health care indicator update report Ottawa: Canadian Institute for Health Information; 2012.

40. Kringos D, Carinci F, Barbazza E, Bos V, Gilmore K, Groene O, et al. Managing COVID-19 within and across health systems: why we need performance intelligence to coordinate a global response. Health Res Policy Syst. 2020;18(80).

41. Plochg T, Klazinga NS. Community-based integrated care: myth or must? Int J Qual Health Care. 2002;14(2):91–101.

42. Medical Research Act with People (Wet medisch-wetenschappelijk onderzoek met mensen (WMO)) [Dutch], (1998).

43. INESSS. Collectif pour les Meilleures Pratiques et l'Amélioration des Soins et Services+ (CoMPAS+) [Collective for best practices and the improvement of care and services+]. 2019. Available from: https://www.inesss.qc.ca/en/projects/compas.html.

44. Vachon B, Gaboury I, Menear M, Pomey M-P, Roy D, Houle L, et al. Evaluating implementation and impact of a provincial quality improvement collaborative for the management of chronic diseases in primary care: the COMPAS+ study protocol. BMC Fam Pract. 2020;21(1):3.

45. Alberta Netcare. CII/CPAR – Technology for integration and continuity: general and frequently asked questions. Edmonton: Alberta Netcare; 2018.

46. Saskatchewan Medical Association. Chronic disease management: frequently asked questions 2014. Available from: https://www.sma.sk.ca/resources/41/cdm-qip-frequently-asked-questions.html.

47. Greiver M, Dahrouge S, O'Brien P, Manca D, Lussier MT, Wang J, et al. Improving care for elderly patients living with polypharmacy: protocol for a pragmatic cluster randomized trial in community-based primary care practices in Canada. Implement Sci. 2019;14(1):55.

48. PULSAR. PULSAR 2020. Available from: https://pulsar.ca/en/discover-pulsar?lang=en.

49. Greiver M. Dr Greiver's EMR: Blogspot; 2010. Available from: http://drgreiver.blogspot.com/.

50. Queenan J, Taylor M, Drummond N, Griever M, Manca D, Lussier M, et al. The improvement, implementation and evaluation of the canadian primary care sentinel surveillance network data presentation tool (CPCSSN-DPT). Colorado: North American Primary Care Research Group (NAPCRG); 2016.

51. Queenan J, Taylor M, Drummond N, Griever M, Manca D, Lussier M, et al. The early adoption of the Canadian Primary Care Sentinel Surveillance Network Data Presentation Tool in primary care clinics. Montreal: North American Primary Care Research Group; 2017.

52. Queenan J, Taylor M, Drummond N, Griever M, Manca D, Lussier M, et al. Evaluating the implementation of the canadian primary care sentinel surveillance network data presentation tool (CPCSSN-DPT). Chicago: North American Primary Care Research Group (NAPCRG); 2018.

53. OntarioMD. EMR quality dashboard proof of concept: phase 2 report. Toronto: OntarioMD; 2019.

54. Mulder C. Changing primary care performance measurement by getting started. Liverpool University of Liverpool; 2018.

55. Wagner D, Durbin J, Barnsley J, Ivers N. Beyond quality improvement: exploring why primary care teams engage in a voluntary audit and feedback program. BMC Health Serv Res. 2017;17(1):803.

56. Wagner D, Durbin J, Barnsley J, Ivers N. Measurement without management: qualitative evaluation of a voluntary audit & feedback intervention for primary care teams. BMC Health Serv Res. 2019;19(1):419.

57. OECD. Using routinely collected data to inform pharmaceutical policies. Paris: OECD; 2019.

58. Vuik S, Mayer E, Darzi A. Patient segmentation analysis offers significant benefits for integrated care and support. Health Aff. 2016;35(5):769–75.

59. Bhatti S, Commisso E, Rayner J. A rapid primary healthcare response to COVID-19: An equity-based and systems-thinking approach to care ensuring that no one is left behind. Healthc Q. 2020;23(3):29–33.

60. CIHI. Forging the path: toward a shared standard for EMR data - highlights and recommendations from CIHI's primary care forum. Ottawa: Canadian Institute for Health Information; 2019.

61. Keshavjee K, Williamson T, Martin K, Truant R, Aliarzadeh B, Ghany A, et al. Getting to usable EMR data. Canadian family physician. Medecin de famille canadien. 2014;60(4):392.

62. Greiver M, Keshavjee K, Jackson D, Forst B, Martin K, Aliarzadeh B. Sentinel feedback: path to meaningful use of EMRs. Canadian family physician Medecin de famille Canadien. 2012;58(10):1168-e612.

63. Royal College of General Pracitioners. RCGP Research and Surveillance Centre; 2020. Available from: https://www.rcgp.org.uk/clinical-and-research/our-programmes/research-and-surveillance-centre.aspx.

64. Nivel. Nivel Primary Care Database; 2020. Available from: https://www.nivel.nl/en/nivel-primary-care-database.

Supplementary appendices

Appendix 1: Mapping of PHC actors

Appendix 2: Expert interview guide

Appendix 3: Characteristics of experts consulted

Appendix 4: Detailed mapping of indicator themes by initiative

Appendix 1: Mapping of PHC actors

JURISDICTION	TYPE	ACTOR (ABBREVIATED NAME)*
Newfoundland and Labrador	Policy/ stakeholders	Newfoundland & Labrador Department of Health and Community Services*
		Eastern Health*
		eDocsNL
	Research networks	Primary Healthcare Research and Integration to Improve Health System Efficiency (PRIIME)*
		Atlantic Practice Based Research Network (APBRN)
Prince Edward Island	Policy/ stakeholders	Health PEI*
	Research networks	Maritime Family Practice Research Network (MaRNet)
		The Prince Edward Island Primary and Integrated Health Care Innovation Network (PIHcIN)
Nova Scotia	Policy/ stakeholders	Department of Health and Wellness*
		Nova Scotia Health Authority*
	Research networks	Nova Scotia Primary and Integrated Health Care Innovations Network
		Maritime Family Practice Research Network (MaRNet)
New Brunswick	Policy/ stakeholders	New Brunswick Department of Health*
		New Brunswick Health Council
	Research networks	New Brunswick SPOR Network: Primary and Integrated Community Care
		Maritime Family Practice Research Network (MaRNet)
Quebec	Policy/ stakeholders	Ministère de la Santé et des Services sociaux – Ministry of Health and Social Services*
		Institut national d'excellence en santé et en services sociaux (INESSS) – National Institute of Excellence in Health and Social Services*
	Research networks	Reseau de recherche en soins primaires de l'Université de Montréal (RRSPUM) – University of Montreal Primary Care Research Network
		Réseau-1 Québec – Quebec Knowledge Network in Integrated Primary Health Care
		Pulsar*
		Groupe de recherche interdisciplinaire en informatique de la santé (GRIIS) – Interdisciplinary Research Group in Health Informatics*
Ontario	Policy/ stakeholders	Ministry of Health and Long-Term Care
		Ontario Health (Health Quality Ontario)*
		Alliance for Healthier Communities (the Alliance)*
		Association of Family Health Teams of Ontario (AFHTO)*
		OntarioMD*
		Institute for Clinical Excellence (ICES)*
	Research networks	eHealth Centre for Excellence
		University of Toronto Practice Based Research Network (UTOPIAN)*
		Deliver Primary Healthcare Information Project (DELPHI)*
		The Eastern Ontario Network Practice-Based Research Network (EON)
		McMaster University Sentinel and Information Collaborative (MUSIC)
		Better Access and Care for Complex Needs (BEACCON)

JURISDICTION	TYPE	ACTOR (ABBREVIATED NAME)*
Manitoba	Policy/ stakeholders	Manitoba Health, Seniors and Active Living*
		Shared Health Manitoba*
	Research networks	Manitoba Primary Care Research Network (MaPCReN)*
		The Manitoba SPOR Primary and Integrated Health Care Innovation Network (MPN)
		Manitoba Centre for Health Policy*
Saskatchewan	Policy/ stakeholders	Ministry of Health*
		Health Quality Council of Saskatchewan (HQC)*
		Saskatchewan Medical Association (SMA)
		eHealth Saskatchewan
Alberta	Policy/ stakeholders	Alberta Health*
		Alberta Health Services*
		Health Quality Council of Alberta (HQCA)*
		Alberta Netcare
		Physician Learning Program
		Alberta Medical Association (AMA)
	Research networks	Southern Alberta Primary Care Research Network (SAPCReN)*
		Northern Alberta Primary Care Research Network (AFPRN)
		The Alberta SPOR Primary and Integrated Health Care Innovation Network
British Columbia	Policy/ stakeholders	Ministry of Health
		Provincial Health Services Authority (PHSA)
		Doctors of BC
		Health Data Coalition (HDC)*
		Northern Health
		General Practice Services Committee (GPSC)
		BC Patient Safety and Quality Council
	Research networks	British Columbia Primary Care Research Network (BC-PCReN), University of British Columbia (BC-CPCSSN and SPOR PIHCIN)*
		eHealth Observatory, University of Victoria
Yukon	Policy/ Stakeholders	Yukon Health and Social Services
		1Health
Northwest Territories	Policy/ stakeholders	Department of Health and Social Services
		Northwest Territories Health and Social Services Authority
	Research networks	Institute for Circumpolar Health Research*
		Development of a Northern-Based SPOR Network in Primary and Integrated Health Care Innovations
Nunavut	Policy/ Stakeholders	Nunavut Department of Health*
	Research networks	Qaujigiartiit Health Research Centre*

JURISDICTION	TYPE	ACTOR (ABBREVIATED NAME)*
Pan-Canadian	Policy/ stakeholders	Health Canada
		Canadian Institute for Health Information*
		College of Family Physicians of Canada
		Canada Health Infoway
		Canadian Medical Association
		Canadian Partnership Against Cancer*
		Digital Health Canada
		Canadian Nurses Association
	Research networks	Canadian Primary Care Sentinel Surveillance Network (CPCSSN)*
		Strategy for Patient Oriented Research (SPOR) Primary and Integrated Health Care Innovations Network (PIHCIN)*

*Denotes actors from which an informant was directly engaged.

Appendix 2: Expert interview guide

Information letter (adapted to exclude identifiers)

Background to the study

Primary health care (PHC) and its strengthening through performance measurement is essential for sustainably working towards improved health outcomes. In Canada, a core set of PHC indicators with this aim and for use at the system- and practice-level across jurisdictions was first introduced in 2006 and has continued to be refined over time.

Since the initial release of PHC indicators for pan-Canadian use, the PHC Electronic Health Record (EMR) system has been recognized as an important data source. However, realizing the full potential of EMR data has been constrained by factors such as the quality and utility of largely unstructured data as well as the varied uptake of EMR systems across the country. As the adoption and sophistication of EMR systems advances, the extent to which PHC indicators are or could be sourced from EMR data has also improved.

While illustrative examples of EMR data use for performance measurement are known – such as in British Columbia, Manitoba and Ontario – an up-to-date overview of PHC indicators in use is needed as this context continues to evolve. An overview on the use and sourcing of PHC indicators is a relevant input for the continued updating of a pan-Canadian set. Moreover, exploring the contextual factors that influence the use of EMR data in the cases identified may offer insights into enabling system conditions and organizational factors.

Aim of study

This study aims to investigate the use of PHC indicators sourced from EMR data across jurisdictions in Canada in order to explore the current and potential use of EMR data and enabling contextual factors.

Scope and guiding questions

To scope our investigation, we have put focus on the use of PHC indicators drawing from routine administrative data or EMR systems. *Indicators* are defined as a quantitative measure that provides information about a performance dimension (eg, quality, effectiveness, safety, people-centredness, etc.) of PHC. *Use* is defined as the selection, sourcing, analysis and dissemination of indicators for the purpose of performance measurement at the macro (policy), meso (organization/institution or network) or micro (practice) level. The study is guided by the following key questions.

1. **Reviewing the current use of EMR and/or other routine data sources such as administrative data for PHC indicators across jurisdictions**. Where is PHC EMR data or other routine data sources such as administrative data currently used as a source for PHC performance indicators across Canadian jurisdictions?
2. **Exploring the technical specifications of EMR-sourced indicators and context of their use**. Where PHC EMR data are in use, how are the indicators defined and standardized? How can the use of these indicators be further described with regards to their analysis, display and delivery to the target end-user?
3. **Analyzing the organizational factors enabling the use of EMR data for PHC indicators**. Where PHC EMR data are in use, how can the development of the EMR data system be described? What is the organizational context and model of primary care in which the data is being used?

Approach to study

The study is designed around two phases. The first sets out to identify where EMR data or other routine administrative sources are in use for PHC performance measurement at the system (macro), network (meso) or practice (micro) level across Canadian jurisdictions. This phase builds upon recent internal scans conducted by the Primary Health Care Information team of the Canadian Institute for Health Information (CIHI) and will be conducted through a systematic review of organizational websites. A series of key informant and stakeholder interviews will also be organized to gain further insights into ongoing activities across jurisdictions.

A second phase aims to explore in-depth the location-specific uses of EMR-sourced indicators. In this phase, the specific purposes of use and technical specifications for indicators will be studied through semi-structured interviews and document reviews. The context will also be explored with regards to the organization of the EMR data system and model of PHC in place.

Dissemination and policy implications of results

It is the intention of the study team to submit the findings for peer-reviewed publication. Key Informants will be noted in the acknowledgements unless requested otherwise. The study's findings are expected to offer insights for the continued updating of a pan-Canadian set of PHC indicators by way of signalling high-frequency indicators or themes in use. Moreover, as the study endeavours to explore contextual factors that influence the use of PHC EMR data, the findings may offer insights into the EMR data system and organization of PHC enabling the uptake and use of EMR data. These findings may carry international relevance, offering insights to the strategic development of PHC and information systems that are also in alignment with a country's model of care and the information needs of practitioners, managers and system decision-makers.

Key considerations

- Does your organization currently use EMR data or routine administrative data sources for PHC performance measurement? Is this defined in a framework or indicator set? Which PHC indicators does this include?
- What is the intended purpose of the indicator? (eg, system planning, practice-level performance improvement)? How is the data being analyzed and disseminated? Who is the target end-user?
- Are you aware of any existing studies or reports or can suggest contacts that should be consulted in the scope of this work?

Detailed semi-structured interview questions

1. Purposes of use of PHC performance indicators (all experts)

- **Current uses**. How does your organization currently use PHC performance indicators? Eg, research, micro-level clinical practice improvement, meso-level organization or network planning, macro-level system monitoring?
- **Sources**. What are the current sources of data for the uses described? Specifically, which if any are sourced from EMR data?
- **Actors**. What actors do you work with directly in the scope of measuring PHC performance?
- **Planned uses**. What, if any, initiatives are currently in development using EMR data as a source for performance measurement?

2. Description of current EMR-data uses (only where applicable)

- **Overview of use**. Can you briefly describe the development of your organization's current EMR data use overtime in terms of main milestones? How would you describe your current stage of use? Who are the target end-users (eg, type of practices, physicians, total range of users engaged)?
- **Indicators**. What are the specific indicator themes being reported on? Are the technical specifications defined and if so, can these be shared? How have these changed overtime?
- **Data sources**. How is the EMR data being extracted? How does this extraction work across vendors? At what time-interval is data extracted? Where is the data stored? Is data anonymized?
- **Analysis**. How is the data currently analyzed (eg, benchmarking, time trends, composite measures)? What comparators are used?
- **Display**. How is the data disseminated? What is the format of reporting (print, electronic, web-based)? What is the lag time if any in presenting analyzed data?
- **Delivery**. How do the findings reach the intended user? What is the reporting cycle? What resources are available to support end-users?
- **Impact evaluation**. Have studies on use and impact been conducted? What are the key findings where available? If anecdotally available, what are the lessons learned?

3. Barriers or enablers of use (all experts)

- **Opportunities for improvement**. In your opinion, how can your current uses of EMR data for performance measurement be improved upon?
- **Barriers**. In your opinion, what are the main obstacles or challenges faced by your organization or jurisdiction-at-large to make EMR data more actionable? In general, what are the obstacles to optimizing the use of EMR data for PHC performance measurement?
- **Enablers**. In your opinion, what are some of the factors that have contributed to achievements to-date?

Other: Relevant reporting and additional informants

- **Available reporting**. Are you aware of any existing studies or reports that are publicly available and/or can be shared in the scope of this work?
- **Additional informants**. Can you suggest a colleague, expert in your jurisdiction (specific stakeholder or clinician/research profile as needed) or network that you think should be met with in the scope of this work?

Appendix 3: Characteristics of experts consulted

	PERSPECTIVE		TOTAL INFORMANTS N=61 (N=44[a])	
CHARACTERISTICS	Policy-maker/ stakeholder	Researcher/ clinician	n (sub-total)	% (total informants)
Jurisdictions				
Newfoundland and Labrador	3	1	4	7
Prince Edward Island	1	0	1	2
Nova Scotia	2	0	2	3
New Brunswick	4	0	5	8
Quebec	3*	2	5	8
Ontario	7	8	15	25
Manitoba	3	1	4	7
Saskatchewan	5	0	5	8
Alberta	5	2*	7	11
British Columbia	1	1	2	3
Yukon	0	0	0	0
Northwest Territories	0	2	3	5
Nunavut	1	1*	2	3
Pan-Canadian	6	2	8	13
Gender				
Female	24	8	32	52
Male	17	12	29	48
Perspectives				
Policy-maker/stakeholder	-	-	41	67
Researcher/clinician	-	-	20	33

Notes: [a]In total 44 meetings were held. Nine interviews were conducted with two-person (or more) are counted as only one participant (meeting). * indicates correspondence in written format only (n=9).

Appendix 4: Detailed mapping of indicator themes by initiative

	INITIATIVES/ORGANIZATIONS						
INDICATOR THEMES	CIHI	CPCSSN	HDC Discover	Manitoba PCQI	Insights 4Care	D2D	BIRT
Total indicators[a]	18	NA[b]	184	44	64	17	40+
Type							
Process	16		162	44	57	14	39
Outcome	2		22	–	7	3	3
Scope							
Generic	10		115	15	41	11	34
Disease-specific	8		31	29	23	6	8
Function							
Prevention/screening	10		29	16	16	5	6
Prescribing	3		62	–	18	1	4
Disease management	6		33	28	16	6	5
Surveillance	–		22	–	4	–	1+
Other	–		38	–	10	5	26
Prevention/screening							
Well-baby	1	–	–	–	1	–	–
Blood pressure/CVD	1		1	3	1	1	1
Cancer screening	3		3	3	6	–	3
Other screening	–		9	4	–	1	6
Immunizations	3		2	3	6	2	1
Overweight/obesity	1		6	1	1	–	1
Physical activity	–		4	1	–	–	1
Smoking	1		4	1	1	1	1
SES	–	–	–	–	–	–	3

INDICATOR THEMES	INITIATIVES/ORGANIZATIONS						
	CIHI	CPCSSN	HDC Discover	Manitoba PCQI	Insights 4Care	D2D	BIRT
Chronic disease management							
Asthma	–	▨	2	1	–	–	1
AMI/stroke	1	–	–	–	–	1	–
CAD	2	▨	–	5	3	–	1
CHF	–	–	4	5	–	–	1
COPD	–	▨	4	4	4	–	–
Diabetes	1	▨	7	7	8	4	2
Hypertension	2	▨	2	5	4	–	1
Kidney-related diseases	–	▨	4	–		–	–
Mental health	2	▨	2	–	1	3	1
Neurological	–	▨	–	–	–	1	–
Musculoskeletal	–	▨	1	1	–	–	–
Other/multi-conditions	–	▨	7	–	–	1	1
Prescribing							
Antibiotics	–	▨	22	–	1	–	–
Opioids/pain relief	–	▨	21	–	5	–	3
Psychiatric	–	▨	4	–	4	–	–
Other medications	–	▨	11	–	7	–	–
Polypharmacy	–	▨	4	–	1	1	1
Other							
Care delivery	–	▨	–	–	1	1	22
Patient status	–	▨	–	–	1	2	3
Care bonuses	–	–	–	–	5	–	–
Document management	–	▨	38	–	3	2	–

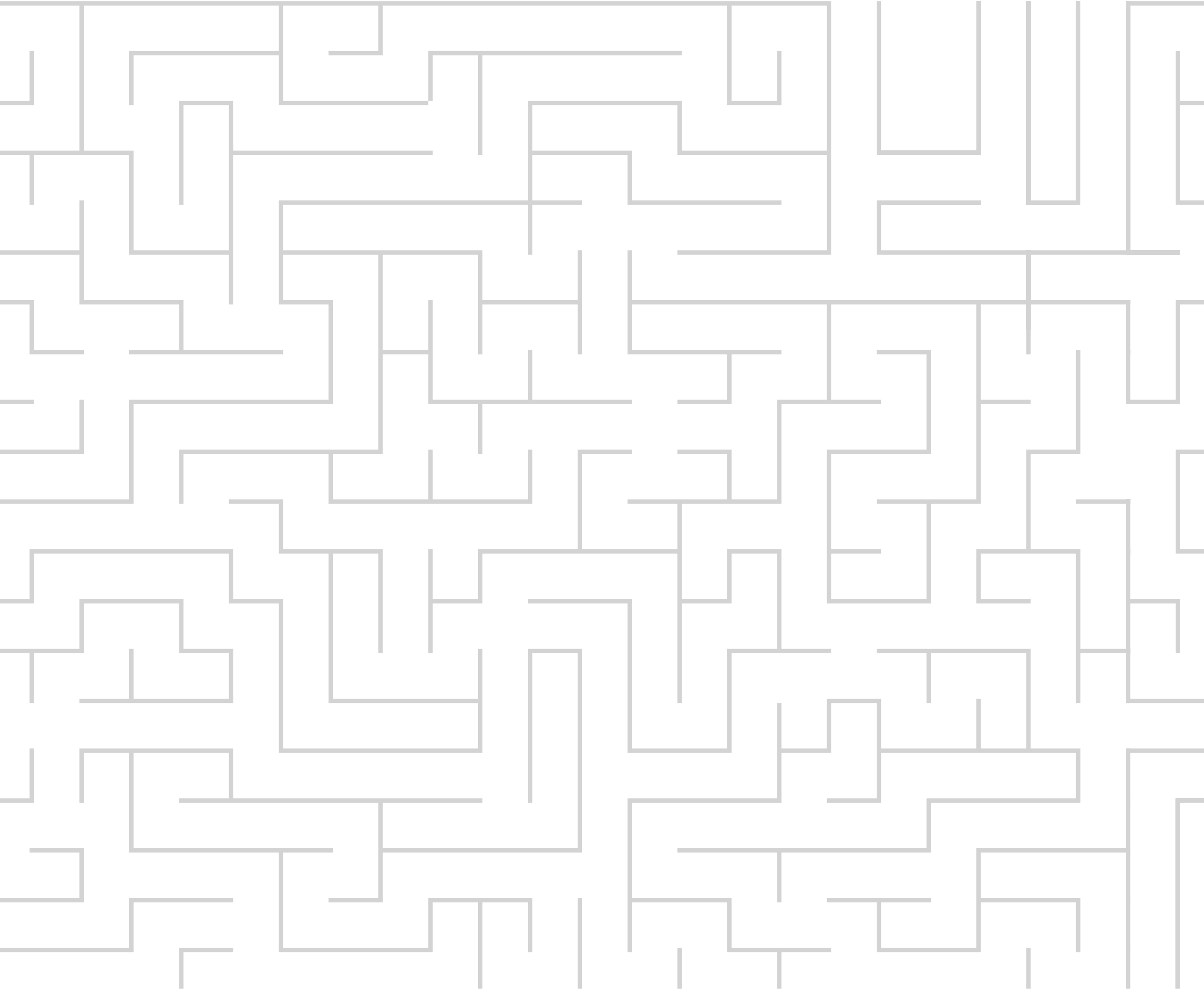
Notes:

[a] This total is representative of the EMR-sourced indicators in each set and therefore, not necessarily the total indicators. Importantly, many of these indicator sets continue to be iterated. The total and themes of indicators is according to the versions available on the date reviewed. Refer to references for specific version number and date.

[b] As a surveillance database, the shading refers to the data elements available in CPCSSN.

– none specified. CAD: coronary artery disease; CDM: chronic disease management; CHF: coronary heart failure; COPD: chronic obstructive pulmonary disease.

Sources: (Association of Family Health Teams of Ontario 2017; CIHI 2012; Health Data Coalition 2020; Manitoba Health 2019; OntarioMD 2020).

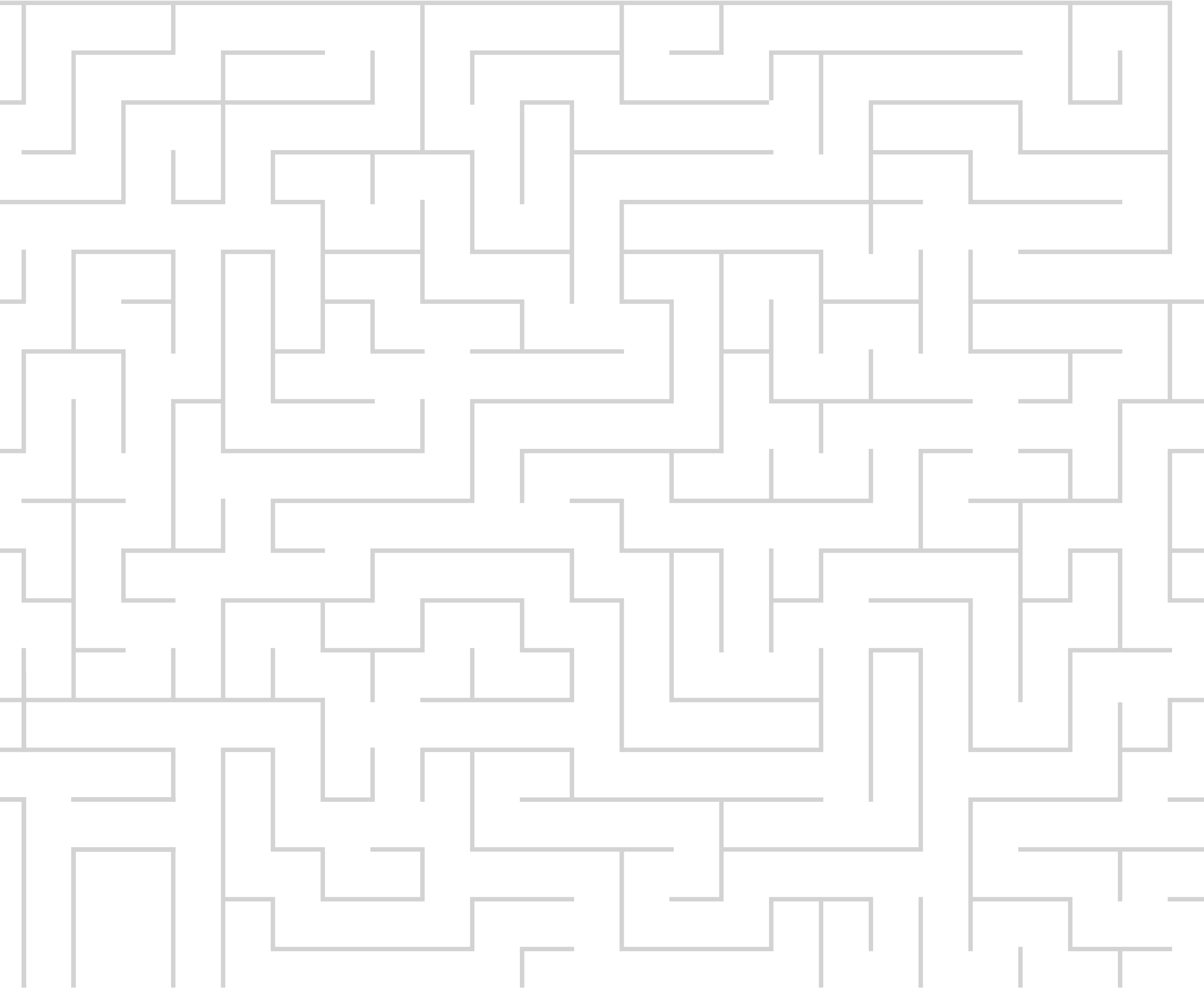


Chapter 4

Optimising the secondary use of primary care prescribing data to improve quality of care in the Dutch context

This chapter was published as:

Barbazza E, Verheij R, Ramerman L, Klazinga N, Kringos D. Optimising the secondary use of primary care prescribing data to improve quality of care: a qualitative analysis. BMJ Open. 2022;12(7):e062349.



Abstract

Objectives

To explore available data sources, secondary uses, and key considerations for optimising the actionability of primary care prescribing data to improve quality of care in the Dutch context.

Design

An exploratory qualitative study was undertaken based on semi-structured interviews. We anchored our investigation around three tracer prescription types: antibiotics; benzodiazepines; and opioids. Descriptive and explanatory themes were derived from interview data using thematic analysis.

Setting

Stakeholders were sampled from across the micro (clinical), meso (organisational), and macro (policy) contexts of the Dutch primary care system.

Participants

The study involved 28 informants representing general practitioners (GPs), community pharmacists, regional chronic care networks (care groups), academia and research institutes, insurers, professional associations, electronic health record (EHR) vendors, and national authorities.

Results

In the Netherlands, three main sources of data for improving prescribing in primary care are in use: clinical data in the EHRs of GP practices; pharmacy data in community pharmacy databases; and claims data of insurers. While the secondary use of pharmacy and claims data is well-established across levels, the use of these data together with EHR data is limited. Important differences in the types of prescribing information needed by micro-meso-macro context are found, though the extent to which current indicators address these varies by prescription type. Five main themes were identified as areas for optimising data use: (1) measuring what matters, (2) increasing data linkages, (3) improving data quality, (4) facilitating data sharing, and (5) optimising fit for use analysis.

Conclusions

To make primary care prescribing data useful for improving quality, consolidated patient-specific data on the indication for a prescription and dispensed medicine, over time, is needed. In the Netherlands, the selection of indicators requires further prioritisation to better signal the appropriateness and long-term use of prescription drugs. Prioritising data linkages is critical towards more actionable use.

Introduction

Improving prescribing practices has received increasing policy attention globally. This prioritisation follows concerning trends, including rising levels of antimicrobial resistance [1,2], an epidemic of opioid use [3-5], and the increasing misuse of benzodiazepines [6-8]. In the Dutch context—like other gatekeeping models of primary care—general practitioners (GPs) function as the first-line for patient management and entry-point to secondary healthcare services. In effect, GPs together with community-based pharmacists are central to services including the issuing and refilling of outpatient prescription medicines [9]. Measuring the performance of services provided by GPs and community pharmacists (both key primary care providers) is fundamental to improve quality [10]. Hence, the use of quality indicators, as a measurement tool to quantify quality, is of critical importance [11-13].

In the Netherlands, the far-reaching digitalisation of patient data and physician prescribing has long been recognised as a powerful resource for improving quality [14-16]. All GP practices (approximately 5,000) record data in electronic health records (EHRs) supplied by ten main EHR vendor brands on the market [16]. Since 2014, primary care prescriptions are issued electronically for dispensing medicines at one of approximately 2,000 community pharmacies across the country [16]. The resulting electronic primary care prescribing data has secondary uses that extend across the micro (clinical care), meso (organisations and networks), and macro (policy) context of the Dutch healthcare system [17].

However, as health services research has increasingly called attention to, the availability of data alone does not guarantee its *use* for quality of care-related decision-making [18,19]. The information produced should also be actionable [20]. The movement towards learning healthcare systems further attests to the critical role of actionable data as an integral part of healthcare delivery processes [21,22]. In primary care, given the critical potential of prescription data to indicate, for instance, inappropriate prescriptions, overprescribing, addiction issues, or antimicrobial resistance trends, it is essential to ensure healthcare systems are optimally using available prescription data for learning and decision-making purposes towards quality improvement in practice.

In the data-rich context of the Netherlands, activity around the use of healthcare data is high: survey data finds Dutch GPs regularly receive as many as ten different feedback reports [23]. This volume of activity has called into question the extent to which performance indicators are actually used for improvement purposes. Research on the secondary uses of healthcare data has been conducted in the context of Dutch hospitals [24], out-of-hours care [25], and integrated care networks [26]. In the absence of an overview of routine primary care prescribing data sources, what and how available data is used for learning and improvement purposes across the healthcare system is unclear.

In this study, we set out to investigate the current secondary uses of primary care prescribing data for improving quality of care through the first-hand insights of stakeholders across the Dutch healthcare system. We also aimed to distil their views on opportunities to improve the use of prescribing data for quality of care-related decision-making. Importantly, the optimisation of secondary uses of primary care prescribing data is an intermediary step to improving care. Direct uses of prescribing data for patient care, such as for education purposes and shared decision-making, is also a key aspect to improve prescribing [27-29], however, these uses are outside the scope of this study. To anchor our investigation and generate concrete, practical examples of prescribing data uses, we focused on three commonly prescribed types of prescriptions: antibiotics; benzodiazepines; and opioids. The prescriptions are each of significant societal and public health importance [30,31] and vary in their etiological and therapeutic use (infection control, psychological disorders, and pain management, respectively). In combination, the selected prescription types can offer insights into the use of primary care prescribing data as a whole.

With this aim and focus, the study is guided by the following three questions: what are the available sources and characteristics of primary care prescribing data? How is this data currently used for improving quality of care? And, what are key considerations for optimising the secondary uses of primary care prescribing data?

Methods

Design

An exploratory qualitative study design was employed [32]. Reporting adheres to the Consolidated Criteria for Reporting Qualitative Research [33]. Semi-structured interviews with stakeholders ranging the clinical (micro), organisational (meso) and policy (macro) context of the Dutch healthcare system were conducted for rich individual exchanges and practical insights across the healthcare system [34]. The research team included experts on healthcare performance intelligence, primary care, health information systems, and the Dutch context. The primary researcher and interviewer is an experienced qualitative researcher and doctoral student on the actionability of healthcare performance indicators.

To operationalise the construct of actionable indicators, we drew from an existing definition depicting actionability as the two related constructs of *fitness for purpose*—information serving an intended decision-making function—and *fitness for use*—the ability to get the right information, into the right hands at the right time [20]. To explore fitness for purpose, the definition's differentiation of types of uses of indicators across healthcare systems was applied. This depiction of actionable indicators, together with our three main research questions, served as the framework for our interview guide. Specifically, the themes explored with informants included: sources of primary care prescribing data; current uses of prescribing data (anchored in the selected prescription types); and perceived actionability constraints (Appendix 1).

Sample and recruitment selection

We defined our target informants by Dutch stakeholders across the micro-meso-macro contexts of the healthcare system with first-hand use of primary care prescribing data for monitoring, assessing and/or improving quality. We identified more than 20 different stakeholders, ranging: government health agencies; associations, including patient and professional groups; regional care networks; health professionals; EHR suppliers; insurers; and researchers (Appendix 2). An initial listing was prepared based on reviews of key literature [16,35,36] and the expertise of the study team. The list was validated with an existing Dutch network (Data Expert Community), with representation of national stakeholders working in the field of healthcare data. Feedback from the network was solicited at an in-person meeting in November 2019 in Utrecht, the Netherlands.

We used multiple methods to reach prospective informants affiliated to the stakeholders identified. First, we reviewed the webpages of target stakeholders for contacts and membership lists. Second, the authorship of literature related to primary care and medicines in the Dutch context (eg, scientific articles, reports, evaluations, factsheets, presentations) was extracted. Third, the expertise of the study team and advice of external experts was solicited, and a snowballing approach was applied. In a similar way, some prospective participants served as contact mediating informants, suggesting alternative colleagues best suited for participating. Informants were invited to participate in the study via email by the authors (EB,RV,LR) and received a document detailing the background, aim, scope, and research questions.

Data collection

Interviews were conducted over a four-month period (November 2019 to February 2020). Interviews ranged 30–60 minutes in length. They were conducted both in-person and at-distance by phone, based on the proximity and preference of informants. In instances where informants requested to extend an invitation to colleagues, these interviews were conducted jointly. We also accommodated requests to answer questions in writing. With the agreement of informants, interviews were recorded and transcribed verbatim. Regular meetings with the full study team were organised to discuss the process and recurrent themes. The interviews were considered complete when the range of informants represented stakeholders spanning the micro-meso-macro levels of the healthcare system.

Data analysis

Thematic analysis was used to analyse interview data [37] in an Excel tool developed in the approach of Meyer and Avery [38]. The analysis process included familiarisation with the data, development of a coding framework, coding, mapping and interpretation of results. The coding framework was developed based on the items of the semi-structured interviews: purposes of use; actors; indicators; data sources; analysis; dissemination; barriers; and opportunities for improvement (Appendix 2). Additional themes were generated through open (unrestricted) coding in an inductive approach. The initial coding and clustering of themes was conducted by the primary researcher. To ensure validity of the findings, the results were regularly reviewed by the full study team. In reporting on the results by research question, verbatim quotes were extracted from the transcripts.

Ethics

The research protocol was developed in accordance with the ethical requirements of the primary research affiliation to Amsterdam University Medical Centers of the University of Amsterdam and relevant Dutch ethics guidelines [39]. To ensure informed voluntary participation, informants contributing to this study provided written informed consent to participate during the recruitment stage and restated their consent verbally at the start of interviews. All interview data has been anonymized. Confidentiality was assured by referring to informants by stakeholder type and an assigned number (eg, Health professional–1).

Patient and public involvement

The preliminary findings were shared at an international scientific conference in 2021. The interaction with participants provided a unique opportunity for critically reflecting on the findings.

Results

Characteristics of informants

In total, 53 informants were contacted of which 28 were interviewed representing 26 different stakeholders. Ten prospective informants referred to an alternative contact within their team or organisation. Non-participants were either unresponsive (n=12) or unavailable due to time constraints (n=3). In either instance (contact mediating informants or non-participants), no healthcare system level or type of stakeholder was overly non-responsive to participation. See Appendix 3 for a detailed breakdown.

Two interviews were conducted with two informants present. In two other instances, information was collected via email exchange only, at the preference of the informant. No repeat interviews were carried out. Some informants held multiple affiliations. Notably, three informants were both health professionals and affiliated to another stakeholder, as signalled by totals included in round brackets in Table 1. For the purposes of reporting, only one primary affiliation has been used (Table 1). See Appendix 3 also for a detailed overview of informant characteristics.

Table 1. Summary of informant characteristics

	TOTAL INFORMANTS N=28	
CHARACTERISTICS	n[a]	%
Healthcare system level (context)		
Micro (clinical)	1 (4)	4
Meso (organisational)	11	39
Macro (policy)	9	32
Cross-cutting (research, EHR supplier)	7	25
Type of stakeholder		
Association (patient, professional)	8	29
Care group (network)	2	7
Government health agency	9	32
Health professional	1 (4)	4
EHR supplier	4	14
Insurer	1	4
Research	3	11
Gender		
Female	8	29
Male	20	71

EHR: Electronic health record.
[a] Numbers in round brackets indicate the total number of informants when individuals with multiple affiliations are accounted for.

Sources and characteristics of primary care prescribing data

Three main sources of primary care prescribing data for secondary uses towards improving quality are in use in the Netherlands: clinical data in the EHRs of GP practices and dispensing data related to prescriptions dispensed in community pharmacy databases and claims for prescriptions of insurers.

Datasets which can be combined and supplemented with other information are available, specifically: the Institute for Drug Outcomes Research Database [39], Nivel Primary Care Database [15,35,40], and various research-specific datasets of academic networks of GPs (eg, Registration Network Groningen [41]). These datasets have the advantage of more complete information (diagnosis and dispensed medicines) though are limited to the voluntary participation GP practices. Other types of prescribing data though not specific to primary care include self-reported or physician-reported medicines' side effects [42] and in-patient prescribing in hospital databases.

Table 2 summarises these data sources, the nature of information and advantages, and limitations of each for secondary quality-related uses as described by informants. According to informants, not one data source is considered *complete*, as each has unique advantages, but also limitations as a potential source for quality-related decision-making. For example, clinical data in EHRs captures the diagnosis (indication) for a prescription, however, depending on the EHR system, it can lack details on the medicines retrieved and dispensed in community pharmacies. Conversely, administrative pharmacy data and insurance claims are rich in details of prescriptions dispensed and reimbursed, though lack clinical details found in EHRs, specifically associated laboratory results and a specific diagnosis. As informants described:

> The missed link between the diagnosis in the EHR and what is dispensed as the medication, leaves little insights into whether the prescription provided was the right one or necessary. (Health professional–2)
>
> From the pharmacist perspective, the absence of a link to a specific diagnosis means that interpreting values requires in most instances more analysis and reflection. (Association–13)

Table 2. Primary care prescribing data landscape in the Netherlands according to informants

DATA SOURCE	REPOSITORY	COVERAGE	NATURE OF INFORMATION	ADVANTAGES	LIMITATIONS
Clinical	EHRs	All GP practices	Prescription level data with patient ids including complete medical history, diagnosis, lab tests and prescribed medicines.	Includes indication for prescription. Possibility to link across databases using unique patient identifier. Possible to link with comorbidities.	Lacks data on prescriptions filled and dispensed by pharmacist. No central database. Varied recording of data across EHR suppliers.
Pharmacy dispensing data of community pharmacist	Foundation of Pharmaceutical Statistics	Across community pharmacies	Patient-level information on dispensed medicines in pharmacy system, medication including type, dosage, other medications.	Complete overview of dispensed medicines by community pharmacies.	Lacks data on diagnosis and lab results. Excludes: prescriptions issued but not retrieved; over-the-counter medicines; prescriptions issued and dispensed in hospitals.
Claims (pharmacy, services)	Drug Information Project (Dutch Health Care Institute)	Across community pharmacies	Information on prescription (eg, dosage, quantity dispensed), prescriber, dispensing pharmacy and price declared/ reimbursed filled by public pharmacies.	Data collected across all practices/public pharmacies.	Lacks data on diagnosis. Includes data only for reimbursed medicines and services.
Other reposit-ories	Nivel Primary Care Database (Nivel)	Affiliate GP practices from across the country[1]	Data on consultations, diagnosis, prescribed medicines, with the possibility to link other data sources for environmental characteristics, migration background, income, insurance claims, pharmacy data.	Possibility to combine and supplement EHR data with information about pharmaceutical care and secondary level care.	EHR data from affiliated practices only, though representation across the country (10% of the population).
	Pharmo Data Network (Pharmo)	Affiliate care groups2	Linked data from public pharmacy database, GP database, hospital pharmacy databases, clinical laboratories.	Possibility to link to EHR data to administrative insurance claims data and pharmacy data.	Data from affiliate care groups only.
	Academic GP network databases	Networks in catchment area of large university hospitals	Patient-level data including complete medical history, diagnosis, medications, etc. for affiliated practices.	Includes indication for prescription. Possibility to link across databases using unique patient identifier.	Limited to affiliate GP practices. Research-specific uses of data.
	Vektis database (Vektis)	Across health care insurers	Insurers claims database of all reimbursed services with data on physician services (eg, reason for visit) and procedures (eg, tests).	Completeness of database, with data spanning across the Dutch population and insurers.	Lacks data on diagnosis. Includes data only for reimbursed medicines and services.

Notes: EHR=electronic health record; GP=general practitioner; Nivel=Netherlands Institute for Health Services Research; Pharmo= Institute for Drug Outcomes Research Database.
[1]Approximately 500 GP practices, 1.7 million patients; [2]Approximately 13 care groups, 4 million patients.

Secondary uses of primary care prescribing data

The secondary uses and sources of primary care prescribing data are summarised to follow. See Appendix 1 for a detailed table. These descriptions are anchored in the illustrative prescription types applied. At the outset, the information needs by decision-making context and prescription type were described by informants (Table 3).

Table 3. Examples of information needs by type of prescription as described by informants

CONTEXT	ANTIBIOTICS	BENZODIAZEPINES	OPIOIDS
Macro (policy)	What is the overall volume of antibiotics prescribed annually?	How many elderly patients have a long-term benzodiazepine prescription?	What is the overall volume of opioids prescribed? How many are chronic opioid users?
Meso (organisational)	How does the volume of prescribing compare with previous years? (care groups)	How does the volume of prescribing compare with previous years and age groups?	How does the volume of prescribing compare with previous years and age groups?
Micro (clinical)	Have I prescribed antibiotics appropriately for infections?	How many of my patients have a long-term prescription? How many prescriptions were new versus refills?	How many of my patients have a long-term prescription? How many prescriptions were new versus refills?

Micro-level. Claims data of insurers is used to provide feedback on the quality of prescribing to GPs in a report called 'practice mirrors' introduced in 2018. These feedback reports detail the volume and costs of prescriptions and can signal GPs that overuse or underuse prescription medications. GPs participating to the Nivel, Pharmo or academic GP research network datasets receive additional feedback on their prescribing patterns.

Nearly all GPs in the Netherlands participate in pharmacotherapy audit groups (FTOs). FTOs are organised locally and are a practical mechanism for creating linkages between GPs and the pharmacists. As one informant described:

> From my experience as a GP, the FTO is a great mechanism for linking up the GP and the pharmacists as the pharmacist really is the one that has a lot of data on what medicines are being handed out. The pharmacist has a really powerful dataset but they do miss the facts about the patient's actual needs. The linkage [exchange] between a GP and the pharmacists data set happens only at the meeting [FTO] itself. (Health Professional–2)

Informants described the indicators reported at the micro-level vary for reasons primarily due to the type of data available to stakeholders, the priorities of practices and the relevance of existing indicators. On the latter, informants noted differences between feedback that may be useful for a pharmacist versus a GP. For example, from the perspective of pharmacists, the following was described regarding benzodiazepines over an extended period of time:

> There are some indicators to give feedback to pharmacists about whether they give long-term prescriptions to elderly people. But we do not use this as a quality indicator because the pharmacist's care is just a small amount of the care that is provided to patients using benzodiazepines…It depends [rather on] the work of the GPs. (Association–1)

In contrast, from the perspective of GPs, informants described structured feedback on antibiotics as limited by gaps in information, such as the absence of data on how long a patient actually took antibiotics.

Meso-level. Two main types of arrangements are in place for providing feedback at the meso-level. These include regional groups, specifically care groups, as geographically defined networks of healthcare providers which provide feedback to affiliated practices. Additionally, research and academic GP networks, such as the Nivel primary care database and GP practices organised around academic hospitals, also conduct research on specific indicators of interest to affiliated GPs.

Dutch professional associations for GPs (eg, National Association of GPs, Dutch GP Association) and pharmacists (eg, Royal Dutch Society for the Promotion of Pharmacy) provide feedback on prescribing for professional development purposes. In the sphere of community pharmacists, the number of medication reviews, participation in pharmacotherapy meetings (FTOs), as well as indicators related to dispensing amounts are regularly measured.

Uses of primary care prescribing data for monitoring purposes by meso-level organisations was described to typically include volume indicators related to the total prescriptions annually, compared to previous years and by age groups. Active monitoring of benzodiazepines at the meso-level was noted to have decreased following changes in reimbursement coverage from January 2009. As one informant explained:

> Around three quarters of prescriptions for benzodiazepines are not reimbursed and data [used] relies on the reimbursement claims. (Association–8)

Moreover, as another informant described with regards to monitoring the uses of prescribing data more locally (eg, by regions), overall activity is currently limited.

> The discussion on the use of prescriptions at the moment is taking place at the national-level and at the local level but not at the regional-level. This may and is likely to change in the coming years as care groups are more actively involved in the regional implementation of policies. (Association–15).

Macro-level. At the macro-level, pharmacy and claims data are used for strategy development, system performance measurement and quality assurance purposes. Indicators related to the tracer prescriptions are also reported for international comparisons (eg, total volume of antibiotics for systemic use, elderly patients with prescription of long-term benzodiazepines or related drugs and overall volume of opioids prescribed). A number of policy initiatives are in place to monitor antibiotic prescribing and opioids. However, with regards to benzodiazepines, informants described this as a less pertinent priority following the change in reimbursement resulting in an overall decreasing trend in the number of benzodiazepines prescribed.

Optimising the use of primary care prescribing data

Five main themes were identified as areas for optimising the use of primary care prescribing data: (1) measuring what matters, (2) increasing data linkages, (3) improving data quality, (4) facilitating data sharing, and (5) optimising fit for use analysis. Theme one pertains to methodological considerations about the indicators in use, while themes two, three and four relate to contextual considerations, specifically, the underlying information system and regulations. The last theme is found to reflect managerial considerations influencing an indicator's use in practice. The themes are described to follow.

Measuring what matters. "We have the data. We don't have the right indicator" (Health professional–2). Similar statements were made in reference to indicators currently in use, in particular at the micro-level. Specifically, the absence of indicators to monitor the stop date of prescriptions were noted, despite the relevance of this information to limit over–re-prescriptions. Information on the stop date for prescriptions was described of growing importance. Notably, as GPs increasingly work in teams and multiple practices, there is greater potential for re-prescribing to go unnoticed. Similarly, the absence of indicators that distinguish between new versus repeat refills, as well as indicators for monitoring "de-prescribing" were noted as an information gap, especially for measuring quality of chronic care services.

The lack of indicators to measure the appropriateness of prescriptions was also raised:

> Instead of receiving, 'this month you prescribed this many antibiotics' to know 'this month you prescribed this many antibiotics for this many patients diagnosed with infections' can provide more insights into a GP's actual performance. (Association–15)
>
> Dispensing data we have is really useful for the overall consumption, but it is limited to assess the quality of care. For example, for antibiotics use and to determine the appropriateness of the use you really need to have the diagnosis data. (Association–1)

Increasing data linkages. The interoperability of data systems was a recurrent theme across informants from all levels of the healthcare system. The challenge to link data sources was described both *within* primary care (GPs and community pharmacists) but also *across* levels (GPs, hospitals and community pharmacists). At present, a reliance on manual data exchange between stakeholders was depicted (eg, patients providing data to community pharmacists following hospital discharge, pharmacists providing data to GPs at

FTO meetings). While in part a consequence of privacy regulations, informants underscored issues of fragmentation and siloed data systems.

> In a perfect world we would have more linkages between the GP databases and that of the pharmacy. Because we know that the systems in the GP practice is lacking some of the information that is available to the pharmacist. Also, what is prescribed in hospital. We need a connection between these systems to create really good indicators. (Association–8)

In the absence of data linkages within primary care as well as specialised care, informants emphasised the implications on the completeness of data and potential to "see the whole picture" (EHR supplier–10).

Improving data quality. The quality of coding is a fundamental challenge to the secondary use of prescribing data. As one informant described:

> If a GP wants to prescribe antibiotics, then they can also change the code, for example, if someone presents with a possible infection and I see they are quite sick, I can code this differently. (Association–15)

Additionally, the poor quality of coding itself was raised:

> In many GP practices at the moment there is simply not enough attention for the quality of the prescription [coding]. GPs are using very old codes [medication codes] in their prescriptions, simply by way of copying their old prescriptions. (EHR supplier–10)

The pertinence of this issue is well-studied (eg, [19]) and is underscored in projects such as Nivel's formulary-oriented prescribing initiative (Formulariumgericht voorschrijven) [43], where attention is called to improving the quality of GP prescribing.

Facilitating data sharing. Informants raised privacy barriers as a key cause for untapped opportunities to stimulate data sharing across the healthcare system. The European General Data Protection Regulation (GDPR) and national privacy and data ownership policies were referenced as challenges to the sharing and connecting of different sources of data. As one informant described: "It is a political issue of clarifying who is in fact the owner of the data" (Association–14). Informants emphasised the importance of addressing privacy constraints and data sharing in order to allow for more extensive uses.

Actionable analysis. Informants across all levels described limitations regarding the usefulness of analysed data to inform decision-making. Specifically, at the micro-level opportunities to improve the use of comparators were detailed. For example, the current practice of providing an individual GP with feedback on their performance in relation to the national level was described as too aggregate a summary. The consequence, as one informant noted, is a tendency to defer accountability and cite the uniqueness of one's practice population as a cause for deviating trends. In another example, an informant described the compromised actionability of feedback:

> Informing 'you are adhering to guidelines in 80% of prescriptions issued' is not helpful to a GP. It leaves unanswered questions, such as, what patients were involved. (Association–8)

Other obstacles described included the ability to discriminate performances to capture practice variation, with one informant stating: "the problem with the analysis is that the results are not wide. Everyone ends up at the same place" (Insurer–19). Additionally, analysed data fails to capture at-risk patients and vulnerable groups, of relevance across micro-meso-macro contexts. As one informant described from the perspective of pharmacists, current indicators and approaches to analyse information are strained to provide a clear direction for improvement related to care for patients with greatest needs:

> I think we need more data to better target the patients that are in need of additional care. Not everyone needs additional, specialised care. It's the 20% that needs additional, specialized care, and for that, our pharmaceutical database is not sufficient. (Association–1)

Obstacles to analyse data that meets the timeliness needs of decision-makers were also described as a hurdle to the optimal use of data. One informant detailed this challenge extends to the timeliness and accessibility of how data is ultimately delivered to end-users: "We miss a dashboard or system that would allow gaining access and make use of the available data" (Association–12).

Discussion

In this study, we set out to investigate sources, secondary uses, and key considerations for optimising primary care prescribing data and its actionability for quality of care related decision-making. Much of the existing literature on measurement for improving primary care prescribing focuses on implementation sciences and practice-level interventions (eg, [44-46]). There is also a dedicated field of research on improving prescribing through interventions in direct patient care (eg [27-29]). We add to this evidence by adopting a healthcare performance intelligence lens and exploring the secondary uses of primary care prescribing data for learning and improvement in the Dutch healthcare system.

Our study confirms the numerous secondary uses of electronic primary care data across the clinical, organisational and policy context of the healthcare system in the Netherlands. Nonetheless, data are constrained by professional and organisational siloes and perceived privacy constraints that compromise the completeness of information for secondary uses. Importantly, resolving data-related barriers alone will not increase the use of prescribing data. In addition, attention to the development of strategic, purpose-driven indicators and their embedding in systems of governance and managerial cycles, is needed. These findings are further described to follow.

First, with regards data sources, the incompleteness of individual primary care prescribing data sources is a known limitation [47,48]. Our findings regarding challenges to link available data sources are consistent with recent reporting on the Dutch health information system in general [17] and ultimately, common to many European routine healthcare information systems [48-50]. Importantly, while often justified as a legal constraint, regulations like GDPR in fact leave much room for national legislation [51]. Recent Dutch initiatives like the "Electronic Data Exchange in Health Care Bill" [52] and national quality and information standards for the exchange of medication data [53,54] are important steps being taken for more integrated data at the point of care. However, the same level of policy attention remains needed to ensure that complete data is available for secondary uses.

Second, our findings suggest existing indicators require further development by prescription type and their intended uses. A general fixation on the scientific merits of an indicator in the field of performance measurement has put attention to the development and selection of indicators based on their validity and reliability [55]. However, we observe this focus on scientifically strong indicators in the context of primary care prescribing has distracted from the selection of prescribing indicators based on strategic measurement goals. Our finding that indicators are not differentiated by individual prescription types and information needs of stakeholders attests to this. Similar to previous studies (eg, [13,56,57]), informants described differences in their desired type of information. The development of indicators with a focus on the *use* and *users* of prescribing indicators to achieve performance goals is needed across the micro-meso-macro level.

Third, putting data to work requires an enabling institutional environment [58]. Realizing learning and improvement in practice across the healthcare system is a matter of good governance and management. Challenges to use primary care prescribing data underscores that the use of indicators is a process. The effective use of indicators relies also on governance considerations such as the mandates of stakeholders and alignment of resources [59]. In the absence of an enabling governance system spanning all levels of the healthcare system [60-62], policy priorities like managing antibiotic resistance and responding to the opioid epidemic, risk to remain solely high-level goals rather than cascading the system. Other governance and managerial considerations include how that information is returned to end-users, such as in reports or dashboards, and ultimately, processes for reflection on the information, need to be fostered and tailored to different stakeholders.

Lastly, we note that despite the range of stakeholders and activities found at each level of the healthcare system, we observe that the current uses of prescribing data are primarily for internal, provider-oriented purposes rather than for public reporting and accountability. However, the prescribing data available has a range of potential uses for the public. These uses include for accountability purposes but also for learning regarding side effects and harms related to the inappropriate use of antibiotics or longer-term use of opioids and benzodiazepines, and ultimately, have an important role to play in the patient safety agenda.

Strengths and limitations

This study was enriched by the diverse engagement of stakeholders across all levels of the Dutch healthcare system, resulting in a thorough qualitative dataset. The advanced digitalisation and secondary uses of primary care data in the Dutch setting may be transferable to other data-rich contexts while also serving as an aspirational example for those at an earlier stage of development. For the purposes of this study and its scope, we focused on the use of indicators for antibiotics, benzodiazepines and opioids and the results, therefore, may not reflect the nuances of all prescription types. Other types of medications, such as for chronic conditions, were excluded as the management of healthcare needs is multifaceted and the appropriate rate of prescriptions is highly patient, disease and risk-factor specific. All interviews took place in English with native Dutch-speakers. Lastly, the study by design is exploratory in nature. Therefore, patterns and experiences by stakeholder and data types require testing with a larger sample before they can be generalised. Relatedly, the study has put focus on the secondary uses of prescribing data and, therefore, may not be generalisable to uses for direct patient care, such as in shared decision-making and patient education.

Conclusions

Drawing on the expertise of the diverse sample of stakeholders interviewed, we described the information potential of electronic clinical, administrative, and claims prescribing data for secondary quality of care-related uses. Informants stressed the unique strengths and limitations of available data sources, with the incompleteness of each individually a key challenge. While primary care prescribing data is in use across the Dutch healthcare system, existing indicators require further development. In the case of antibiotics, this is found as a need to better indicate the appropriateness of prescriptions and for benzodiazepines and opioids, to monitoring their long-term use. Beyond methodological considerations about the indicators themselves, contextual considerations related to the information system and regulations as well as managerial considerations influencing an indicator’s use in practice are areas identified for further prioritisation. To curb societal concerns like antibiotic resistance and the misuse of opioids and benzodiazepines, the availability of prescribing data alone is insufficient. Available data sources must be linked and made actionable through fit for purpose and fit for use indicators applied at all levels of the healthcare system.

Acknowledgements

We thank all participants who provided their time and expertise to this study as well as the time of the Data Expert Community members and reviews by HealthPros fellows, Karin Hek, and other Nivel colleagues. We also thank the reviewers for their thoughtful and constructive feedback.

References

1. OECD. Stemming the superbug tide. Paris: OECD; 2018.
2. World Health Assembly. Global action plan on antimicrobial resistance. Geneva: World Health Organization; 2015.
3. United Nations Office on Drugs and Crime. World drug report 2019. Vienna, Austria: United Nations; 2019.
4. OECD. Addressing problematic opioid use in OECD countries. Paris; OECD; 2019.
5. Palinkas LA. Opioid use epidemic in Mexico: global solutions to a global problem. Am J Public Health. 2019;109(1):26–7.
6. Hayhoe B, Lee-Davey J. Tackling benzodiazepine misuse. BMJ (Clinical research ed). 2018;362:k3208.
7. OECD. Health at a Glance 2019. Paris: OECD; 2019.
8. OECD. Safe prescribing in primary care. Health at a Glance 2021: OECD Indicators. Paris: OECD; 2021.
9. Bach P, Hartung D. Leveraging the role of community pharmacists in the prevention, surveillance, and treatment of opioid use disorders. Addict Sci Clin Pract. 2019;14(1):30.
10. Smith P, Mossialos E, Papanicolas I. Performance measurement for health system improvement: eperiences, challenges and prospects. Copenhagen: WHO Regional Office for Europe; 2008.
11. Mainz J. Defining and classifying clinical indicators for quality improvement. Int J Qual Health Care. 2003;15(6):523–30.
12. Raleigh VS, Foot C. Getting the measure of quality: opportunities and challenges. London: The King’s Fund; 2010.
13. Smith P, Mossialos E, Papanicolas I, Leatherman S. Part 1: Principles of performance measurement. In: Smith P, Mossialos E, Papanicolas I, Leatherman S, editors. Performance measurement for health system improvement: experiences, challenges and prospects Copenahgen: WHO Regional Office for Europe; 2008.
14. van den Broek d’Obrenan J, Verheij TJM, Numans ME, van der Velden AW. Antibiotic use in Dutch primary care: relation between diagnosis, consultation and treatment. J Antimicrob Chemother. 2014;69(6):1701–7.

15. Verheij RA, van der Zee J. Collecting information in general practice: ‘just by pressing a single button’? Utrecht, the Netherlands: Nivel; 2006.
16. Kroneman M, Boerma W, van den Berg MJ, Groenewegen P, de Jong J, van Ginneken E. The Netherlands: health system review. Copenhagen: WHO Regional Office for Europe; 2016.
17. OECD. Toward an integrated health information system in the Netherlands: Draft interim brief and recommendations. Paris: OECD; 2021.
18. Panch T, Pearson-Stuttard J, Greaves F, Atun R. Artificial intelligence: opportunities and risks for public health. Lancet Digit Health. 2019;1(1):e13–e4.
19. Verheij RA, Curcin V, Delaney B, McGilchrist MM. Possible sources of bias in primary care electronic health record data use and reuse. J Med Internet Res. 2018;20(5).
20. Barbazza E, Klazinga N, Kringos D. Exploring the actionability of healthcare performance indicators for quality of care: a qualitative analysis of the literature, expert opinion and user experience. BMJ Qual Saf. 2021;30:1010–20.
21. Menear M, Blanchette M-A, Demers-Payette O, Roy D. A framework for value-creating learning health systems. Health Res Policy Syst. 2019;17(1):79.
22. Friedman C, Rubin J, Brown J, Buntin M, Corn M, Etheredge L, et al. Toward a science of learning systems: a research agenda for the high-functioning Learning Health System. J Am Med Inform Assoc. 2015;22(1):43–50.
23. van der Bij S, de Hoon S, Nielen M, de Jong A, de Boer D, Verheij R. Routine recorded care data as a source of quality information [Dutch]. Utrecht, Netherlands: Nivel; 2016.
24. Botje D, ten Asbroek G, Plochg T, Anema H, Kringos DS, Fischer C, et al. Are performance indicators used for hospital quality management: a qualitative interview study amongst health professionals and quality managers in The Netherlands. BMC Health Serv Res. 2016;16(1):574.
25. Giesen P, Willekens M, Mokkink H, Braspenning J, Van Den Bosch W, Grol R. Out-of-hours primary care: development of indicators for prescribing and referring. Int J Qual Health Care. 2007;19(5):289–95.
26. Bos V, Klazinga NS, Kringos DS. Improving performance intelligence for governing an integrated health and social care delivery network: a case study on the Amsterdam Noord district. BMC Health Serv Res. 2021;21(1):517.
27. Moreira L. Health literacy for people-centred care: Where do OECD countries stand? Health Working Papers No. 107. Paris: OECD Publishing; 2018.
28. van Esch TEM, Brabers AEM, Hek K, van Dijk L, Verheij RA, de Jong JD. Does shared decision-making reduce antibiotic prescribing in primary care? J Antimicrob Chemother. 2018;73(11):3199–205.
29. Kuntz JL, Safford MM, Singh JA, Phansalkar S, Slight SP, Her QL, et al. Patient-centered interventions to improve medication management and adherence: a qualitative review of research findings. Patient Educ Couns. 2014;97(3):310–26.
30. RIVM. NethMap 2019: Consumption of antimicrobial agents and antimicrobial resistance among medically important bacteria in the Netherlands. RIVM; 2019.
31. Trimbos Institute. National Drug Monitor: Annual Report. Utrecht: Trimbos Institute; 2019.

32. Rendle KA, Abramson CM, Garrett SB, Halley MC, Dohan D. Beyond exploratory: a tailored framework for designing and assessing qualitative health research. BMJ Open. 2019;9(8):e030123-e.

33. Tong A, Sainsbury P, Craig J. Consolidated criteria for reporting qualitative research (COREQ): a 32-item checklist for interviews and focus groups. Int J Qual Health Care. 2007;19(6):349–57.

34. Vogl S, Schmidt E, Zartler U. Triangulating perspectives: ontology and epistemology in the analysis of qualitative multiple perspective interviews. Int J Soc Res Methodol. 2019;22(6):611–24.

35. Schweikardt C, Verheij RA, Donker GA, Coppieters Y. The historical development of the Dutch Sentinel General Practice Network from a paper-based into a digital primary care monitoring system. J Public Health. 2016;24:545–62.

36. Verheij R, Witvliet C, Jansen T, et al. Reuse of routine care data for policy and science: how things can be improved [Dutch]. Utrecht: Nivel; 2019.

37. Braun V, Clarke V. Using thematic analysis in psychology. Qual Res Psychol. 2006;3(2):77–101.

38. Meyer DZ, Avery LM. Excel as a qualitative data analysis tool. Field Methods. 2008;21(1):91–112.

39. Stoker LJ, Heerdink ER, Janssen R, Egberts TCG. Effect of reimbursement restriction policy on the use of benzodiazepines in the Netherlands: an interrupted time series analysis. BMJ Open. 2019;9(9):e029148.

40. Nivel. Nivel Primary Care Database: Nivel; 2019. Available from: https://www.nivel.nl/en/nivel-primary-care-database.

41. Kollen BJ, van der Veen WJ, Groenhof F, Donker GA, van der Meer K. Discontinuation of reimbursement of benzodiazepines in the Netherlands: does it make a difference? BMC Fam Pract. 2012;13(1):111.

42. Lareb NPC. About Lareb; 2020. Available from: https://www.lareb.nl/en/pages/about-lareb.

43. Ramerman L, Hek K, Sluiter R, Middelweerd A, Meijer A, Dijk L, et al. Formulary-oriented prescribing by the general practitioner: instrument development and monitoring 2018. Utrecht: Nivel; 2020.

44. Trietsch J, van Steenkiste B, Grol R, Winkens B, Ulenkate H, Metsemakers J, et al. Effect of audit and feedback with peer review on general practitioners’ prescribing and test ordering performance: a cluster-randomized controlled trial. BMC Fam Pract. 2017;18(1):53.

45. Rowe TA, Linder JA. Novel approaches to decrease inappropriate ambulatory antibiotic use. Expert Rev Anti Infect Ther. 2019;17(7):511–21.

46. van Eeghen C, Kennedy AG, Pasanen ME, MacLean CD. A new quality improvement toolkit to improve opioid prescribing in primary care. J Am Board Fam Med. 2020;33(1):17.

47. Williams R, Ashcroft DM, Brown B, Rojas E, Peek N, Johnson O. Process mining in primary care: avoiding adverse events due to hazardous prescribing. Stud Health Technol Inform. 2019;264:447–51.

48. Okoli GN, Myles P, Murray-Thomas T, Shepherd H, Wong ICK, Edwards D. Use of primary care data in research and pharmacovigilance: eight scenarios where prescription data are absent. Drug Saf. 2021;44(10):1033–40.

49. Saigí-Rubió F, Pereyra-Rodríguez JJ, Torrent-Sellens J, Eguia H, Azzopardi-Muscat N, Novillo-Ortiz D. Routine health information systems in the european context: a systematic review of systematic reviews. Int J Environ Res Public Health. 2021;18(9).

50. Bogaert P, Verschuuren M, Van Oyen H, van Oers H. Identifying common enablers and barriers in European health information systems. Health Policy. 2021;125(12):1517–26.

51. Hansen J, Wilson P, Verhoeven E, Kroneman M, Kirwan M, Verheij R, et al. Assessment of the EU Member States' rules on health data in light of GDPR. Brussels: European Commission; 2021.

52. Rules regarding the electronic sharing and access of data between healthcare providers in designated data exchanges (Electronic Data Exchange in Healthcare Act), (2021).

53. Directive Transfer of Medication data in the chain Review 2018/2019, (2019).

54. Nictiz. Information standard: digital recipe traffic NEN7503; 2021. Available from: https://www.nictiz.nl/standaardisatie/informatiestandaarden/medicatieveiligheid/Informatiestandaard/#functioneel.

55. Loeb JM. The current state of performance measurement in health care. Int J Qual Health Care. 2004;16 Suppl 1:i5–9.

56. Damberg CL, Sorbero ME, Lovejoy SL, Lauderdale K, Wertheimer S, Smith A, et al. An evaluation of the use of performance measures in health care. RAND health quarterly. 2012;1(4):3.

57. Palin V, Tempest E, Mistry C, van Staa TP. Developing the infrastructure to support the optimisation of antibiotic prescribing using the learning healthcare system to improve healthcare services in the provision of primary care in England. BMJ Health Care Inform. 2020;27(1).

58. OECD. Health in the 21st Century: putting data to work for stronger health systems. Paris: OECD; 2019.

59. Barbazza E, Tello J. A review of health governance: Definitions, dimensions and tools to govern. Health Policy. 2014;116:1–11.

60. Veillard J, Huynh T, Ardal S, Kadandale S, Klazinga N, Brown, A. Making health system performance measurement useful to policy makers: aligning strategies, measurement and local health system accountability in Ontario. Healthcare Policy. 2010;5(3):49–65.

61. Travis P, Egger D, Davies P, Mechbal A. Towards better stewardship: concepts and critical issues. Geneva: World Health Organization; 2002.

62. Baez-Camargo C. Accountability for better healthcare provision: A framework and guidelines to define, understand and assess accountability in health systems. Basel: Institute on Governance; 2011.

Supplementary appendices

Appendix 1: Interview topic guide

Appendix 2: Mapping of stakeholders and uses of prescribing data

Appendix 3: Characteristics of informants

Appendix 1: Interview topic guide

1. Purpose of use of primary care prescribing data

- How does your organization currently use primary care prescribing data? Refer to the table on the following page (Supplementary file 2) listing core actors and purposes of use identified. Is this accurate and complete?
- How would you describe the information you need to carry-out your organization's role? (eg, multi-year information on performance at national-level; aggregate, comparative performance measures on providers; timely, continuous information at patient-level, etc.).
- What actors do you work with directly in the scope of primary care prescribing data?

2. Current use of prescribing data

- **Use of indicators**. Does your organization actively collect data related to the following: (1) Antibiotics; (2) Opioids; (3) Benzodiazepines. If so, what are the indicators or measures used related to each? How long have these been reported on? Is it intended for internal or external use? Who is the target audience (intended user) of the information generated?
- **Data sources**. What is your primary source of primary care prescribing data? (eg, medical records, administrative data, specific research database, others). How is the data collected? If other actors are involved, whom does this include? Is the data considered of quality?
- **Analysis.** How is the data currently analyzed – benchmarking, time trend, international comparison? How would you describe this analysis? (eg, time interval, comparators used, aggregation as composite scores, etc.)

- **Dissemination**. How is the data disseminated? What is the format of reporting (print, electronic, web-based)? What is the lag time in presenting analyzed data? How does it reach the intended target audience?

3. Perceived actionability

- In your opinion, how can the process in which data is analyzed and reported on be improved upon?
- Is the information generated useful for your purposes? That is, are you able to make decisions and learn from the information?
- In general, what are the obstacles to the optimal use of primary care prescribing data at present?

Appendix 2: Mapping of stakeholders and uses of prescribing data

PURPOSE OF USE[1]	STAKEHOLDERS
Micro-level	
Individual professional performance	Individual GP and HIS supplier
	Community pharmacist and HIS supplier
Practice improvement	GP practice/peers using HIS
	GP practice and insurers
	GP practice and affiliate research networks
	Community pharmacy and pharmacy network
Multidisciplinary improvement	Pharmacotherapy audit groups (GPs and pharmacists) (FTOs)
Meso-level	
Organization/ networks performance improvement	Care groups and affiliate GP practices (eg, MCC Omens Care Group, Zorg In Ontwikkeling)
Quality-based financing	Health Insurers (eg, Zilveren Kruis)
Monitoring	Lareb Side Effects Center
	Foundation of Pharmaceutical Statistics (SFK)
Professional development	Dutch Institute for Responsible Drug Use (IVM)
	National Association of GPs (LHV)
Advocacy and standards	Dutch GP Association (NHG)
	The Royal Dutch Society for the Promotion of Pharmacy (KNMP)
	Organization for first line care (InEen)
	Patient Federation Netherlands (Patienten Federatie)
Macro-level	
Strategy development	Ministry of Health, Welfare and Sport
System performance	National Institute for Public Health and the Environment (RIVM)
System quality assurance	Medicines Evaluation Board (MEB)
	National Health Care Institute (ZiNL)
	Health Care Inspectorate (IGJ)
	Dutch Healthcare Authority (NZa)
Cross-cutting	
	Netherlands Institute for Health Services Research (Nivel)
	Institute for Drug Outcomes Research (Pharmo)
	Vektis
	Nictiz Digitalis

[1] Purposes of use draw from the study findings: Barbazza E, Klazinga NS, Kringos DS. Exploring the actionability of healthcare performance indicators for quality of care: a qualitative analysis of the literature, expert opinion and user experience. BMJ Qual Saf. 2021;30:1010-1020.

Appendix 3: Characteristics of informants

Table S3.1. Elaborated breakdown of informants and non-participants

	TOTAL INFORMANTS N=28		NON-PARTICIPANTS N=25		
CHARACTERISTICS	n	%	No reply	Unavailable	Contact mediating
Healthcare system level (context)					
Micro (clinical)	1 (4)	4	1	2	1
Meso (organizational)	11	39	6	0	5
Macro (policy)	9	32	3	0	2
Cross-cutting (research, EHR supplier)	7	25	2	1	2
Type of stakeholder			12	3	10
Association (patient, professional)	8	29	3	0	2
Care group (network)	2	7	0	1	0
Government health agency	9	32	3	0	2
Health professional	1 (4)	4	0	1	1
EHR supplier	4	14	1	0	2
Insurer	1	4	3	0	3
Research	3	11	2	1	0
Gender					
Female	8	29	4	2	4
Male	20	71	8	1	6

EHR: Electronic health record.

[a] Numbers in round brackets indicate the total number of informants when individuals with multiple affiliations are accounted for.

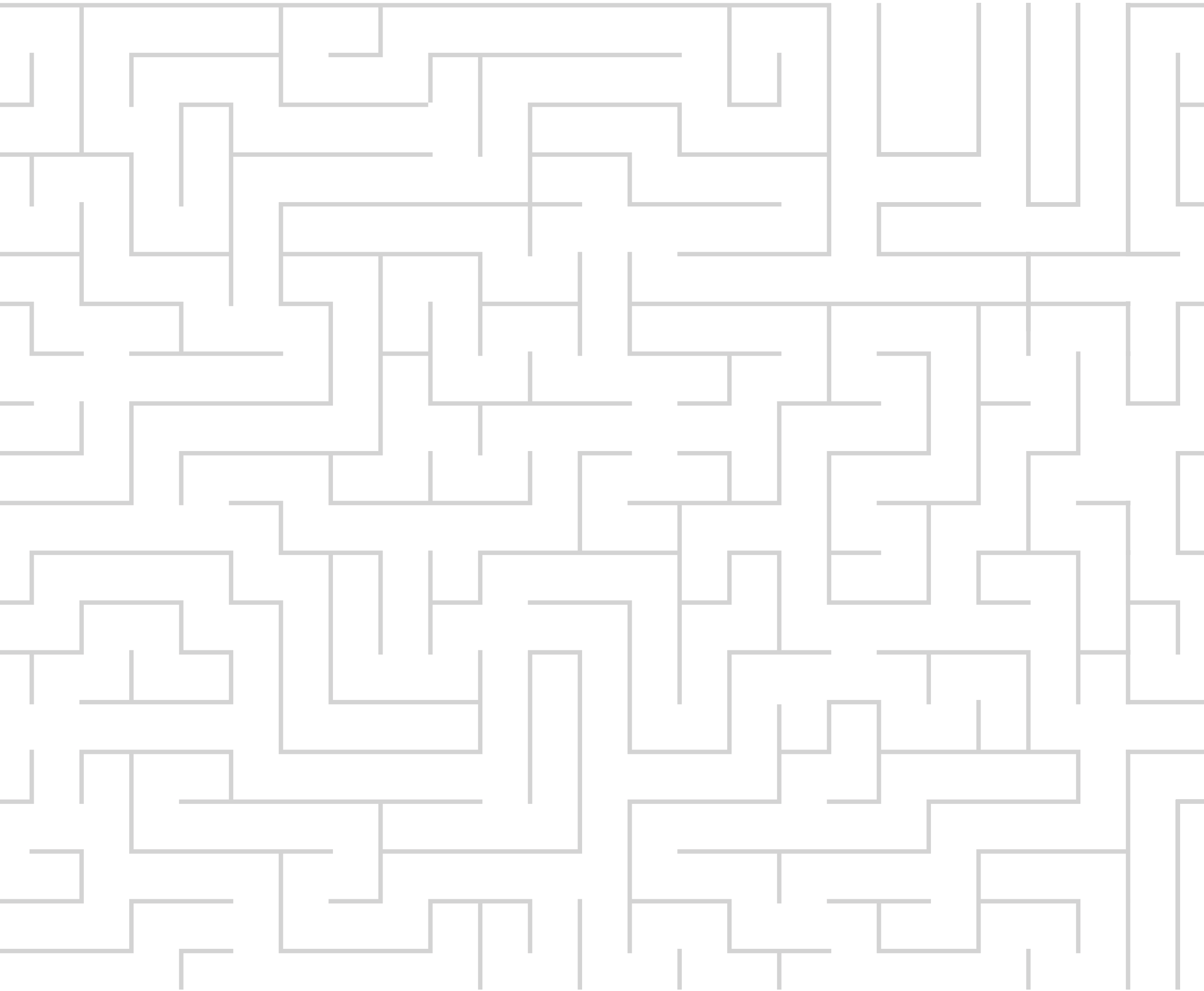
Table S3.2. Overview of informants

#	CODE	LEVEL	STAKEHOLDER	GENDER	FORMAT
1	Association–1	Meso	The Royal Dutch Society for the Promotion of Pharmacy (KNMP)	Female	Phone
2	Health professional–2	Micro	Health Professional	Male	Phone
3	Care group–3	Meso	MCC Omens Care Group	Female	Phone
4	Care group–4	Meso	ZIO	Female	Phone
5	Government–5	Macro	Medicines Evaluation Board (MEB)	Male	Phone
6	EHR supplier–6	Cross-cutting	Digitalis	Male	In-person
7	Association–7	Meso	Organization of Firstline Care (InEen)	Male	Phone
8	Association–8	Meso	Dutch Institute for Responsible Drug Use (IVM)	Female	Phone
9	EHR supplier–9	Cross-cutting	Nictiz	Male	Written
10	EHR supplier–10	Cross-cutting	CampuGroup Medical (CGM)	Male	Phone
11	Government–11	Macro	Ministry of Health, Welfare and Sport	Male	Phone
12	Association–12	Meso	Lareb Side Effects Center	Male	Phone
13	Association–13	Meso	Foundation for Quality Indicators Pharmacy (SFK)	Male	Phone
14	Government–14	Macro	National Institute for Public Health and the Environment (RIVM)	Male	Written
15	Association–15	Meso	Dutch General Practitioners Association (NHG)	Male	Phone
16	Government–16	Macro	Health Care Inspectorate	Male	Phone
17	Research–17	Cross-cutting	Institute for Drug Outcomes Research (Pharmo)	Male	Phone
18	Association–18	Meso	Patient Federation	Male	Phone
19	Insurer–19	Meso	Zilveren Kruis	Male	Phone
20	Association–20	Meso	National General Practitioners Association (LHV)	Male	Phone
21	EHR supplier–21	Cross-cutting	Vektis	Male	Phone
22	Government agency–22	Macro	National Health Care Institute	Male	Phone
23	Government agency–23	Macro	Ministry of Health, Welfare and Sport	Male	Phone
24	Government agency–24	Macro	Dutch Healthcare Authority	Female	Phone
25	Government agency–24	Macro	Dutch Healthcare Authority	Male	Phone
26	Research–25	Cross-cutting	Netherlands Institute for Health Services Research	Female	In-person
27	Research–25	Cross-cutting	Netherlands Institute for Health Services Research	Female	In-person
28	Government agency–26	Macro	National Institute for Public Health and the Environment (RIVM)	Female	Phone

EHR: Electronic health record.

Part III

Exploring actionability applied to COVID-19 dashboards



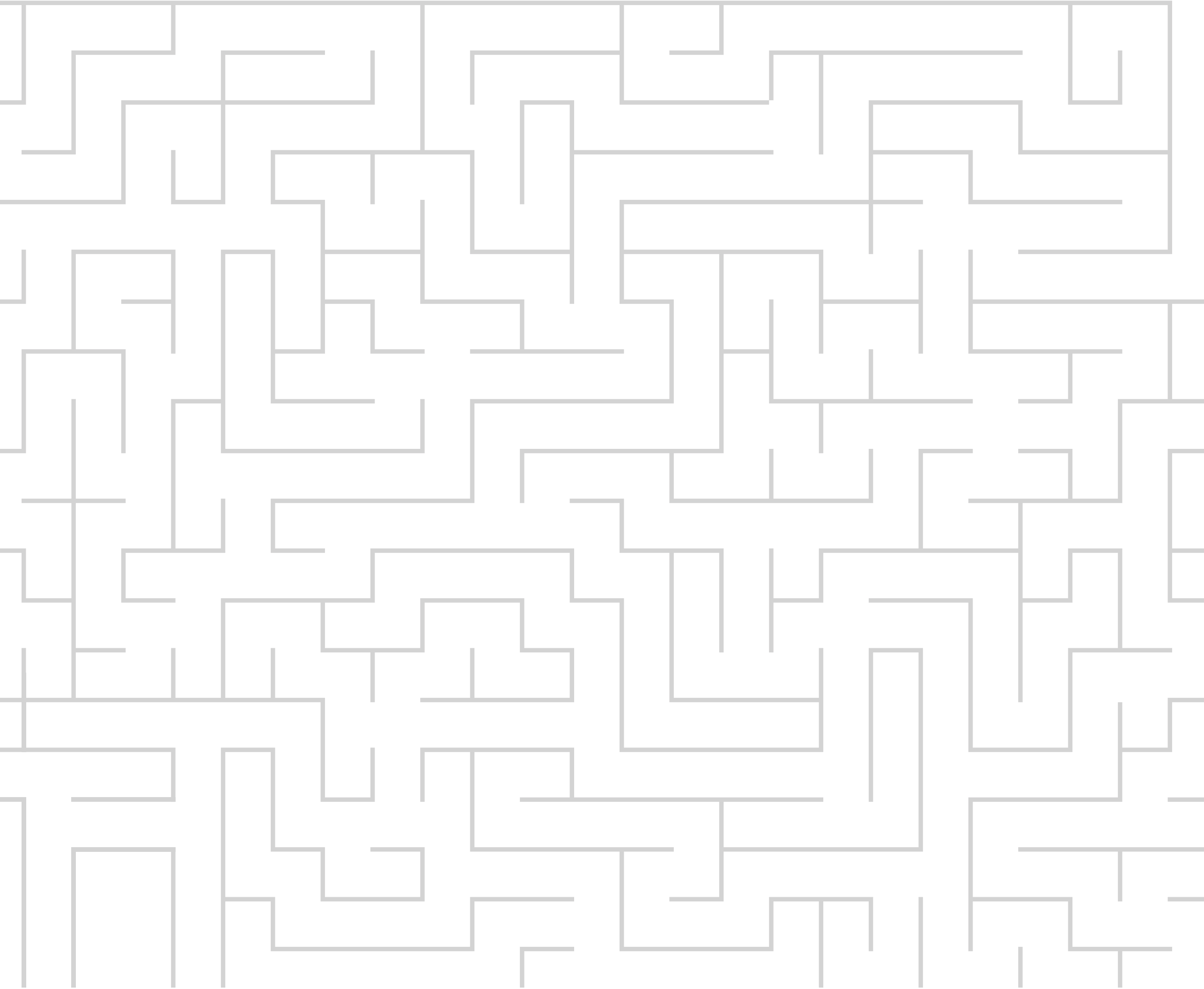
Chapter 5

Features constituting actionable COVID-19 dashboards

This chapter was published as:

Ivanković D*, Barbazza E*, Bos V, Brito Fernandes O, Jamieson Gilmore K, Jansen T, Kara P, Larrain N, Lu S, Meza-Torres B, Mulyanto J, Poldrugovac M, Rotar A, Wang S, Willmington C, Yang Y, Yelgezkova Z, Allin S, Klazinga N, Krinogs D. Features Constituting Actionable COVID-19 Dashboards: Descriptive Assessment and Expert Appraisal of 158 Public Web-Based COVID-19 Dashboards. J Med Internet Res. 2021;23(2): e25682.

*these authors contributed equally



Abstract

Background

Since the outbreak of COVID-19, the development of dashboards as dynamic, visual tools for communicating COVID-19 data has surged worldwide. Dashboards can inform decision-making and support behavior change. To do so, they must be actionable. The features that constitute an actionable dashboard in the context of the COVID-19 pandemic have not been rigorously assessed.

Objective

The aim of this study is to explore the characteristics of public web-based COVID-19 dashboards by assessing their purpose and users (“why”), content and data (“what”), and analyses and displays (“how” they communicate COVID-19 data), and ultimately to appraise the common features of highly actionable dashboards.

Methods

We conducted a descriptive assessment and scoring using nominal group technique with an international panel of experts (n=17) on a global sample of COVID-19 dashboards in July 2020. The sequence of steps included multimethod sampling of dashboards; development and piloting of an assessment tool; data extraction and an initial round of actionability scoring; a workshop based on a preliminary analysis of the results; and reconsideration of actionability scores followed by joint determination of common features of highly actionable dashboards. We used descriptive statistics and thematic analysis to explore the findings by research question.

Results

A total of 158 dashboards from 53 countries were assessed. Dashboards were predominately developed by government authorities (100/158, 63.0%) and were national (93/158, 58.9%) in scope. We found that only 20 of the 158 dashboards (12.7%) stated both their primary purpose and intended audience. Nearly all dashboards reported epidemiological indicators (155/158, 98.1%), followed by health system management indicators (85/158, 53.8%), whereas indicators on social and economic impact and behavioral insights were the least reported (7/158, 4.4% and 2/158, 1.3%, respectively). Approximately a quarter of the dashboards (39/158, 24.7%) did not report their data sources. The dashboards predominately reported time trends and disaggregated data by two geographic levels and by age and sex. The dashboards used an average of 2.2 types of displays (SD 0.86); these were mostly graphs and maps, followed by tables. To support data interpretation, color-coding was common

(93/158, 89.4%), although only one-fifth of the dashboards (31/158, 19.6%) included text explaining the quality and meaning of the data. In total, 20/158 dashboards (12.7%) were appraised as highly actionable, and seven common features were identified between them. Actionable COVID-19 dashboards (1) know their audience and information needs; (2) manage the type, volume, and flow of displayed information; (3) report data sources and methods clearly; (4) link time trends to policy decisions; (5) provide data that are "close to home"; (6) break down the population into relevant subgroups; and (7) use storytelling and visual cues.

Conclusions

COVID-19 dashboards are diverse in the why, what, and how by which they communicate insights on the pandemic and support data-driven decision-making. To leverage their full potential, dashboard developers should consider adopting the seven actionability features identified.

Introduction

Since the outbreak of COVID-19, public reporting of pandemic-related indicators such as new cases, death counts, and testing rates has surged. This heightened level of activity attests to the core function of governments to protect the public's health and safety as well as their critical role of providing information to achieve this end [1-4]. The uses and advantages of publicly reporting health information are known. They include enabling international comparisons [5,6]; monitoring and improving the quality of care [1,6,7]; fostering accountability and transparency [8-10]; empowering the public to form an opinion on and build trust in their government's response; and supporting individuals to make informed, risk-minimizing behavior changes [11,12].

Dashboards are a dynamic modality for reporting data visually; they are typically designed as a single screen with the aim of quickly and effectively presenting users with critical information to act upon [13-15]. Unlike static reporting modalities, such as articles or reports, dashboards have the potential to present real-time (or near–real-time) data updates at a glance [15]. In the health sector, dashboards have been relied on for health system performance assessments [15,16], internal management [17,18], and responses to earlier outbreaks [19,20].

In 2020, the urgent worldwide need for COVID-19 data, coupled with the penetration of the internet [21], digitalization of health information systems [22,23], and access to open-source web-based software [24], has enabled unmatched speed, scale, and diversification of actors in the development of dashboards to monitor and report on the COVID-19 pandemic. As a result, public web-based dashboards have been widely adopted as a reporting modality for

COVID-19 data. Examples extend well beyond national, regional, and local governments to include dashboards by international organizations (eg, the World Health Organization (WHO) [25]), academia (eg, the Johns Hopkins Coronavirus Resource Center [26,27]), and industry (eg, Deloitte [28]), as well as independent initiatives (eg, nCoV2019.live [29]).

Although COVID-19 dashboards may be widely accessible, their effective *use* to modify the course of the pandemic through the translation of data to information, information to opinions, and opinions to decision-making is determined by their actionability. To be actionable, the information should be both *fit for purpose*—meeting a specific information need—and *fit for use*—placing the right information into the right hands at the right time and in a manner that can be understood [30-32]. In other words, the mere accessibility of COVID-19 dashboards does not guarantee data-informed decision-making [12,33]. Although communication sciences, health promotion, and the emerging field of health care performance intelligence offer insights into the effective delivery of information [14,33-36], the factors that make dashboards actionable in the context of COVID-19 have yet to be rigorously assessed.

In this study, we set out to explore the state of the art of publicly available web-based COVID-19 dashboards and identify the features conducive to their actionability. To do so, we took a "snapshot" of this dynamic landscape and assessed COVID-19 dashboards in July 2020. The resulting overview of the dashboard landscape served both to take stock of their use in this initial period and to accelerate their progress in the phases still to come. With these aims, the study was guided by four key questions: (1) Why and for whom were COVID-19 dashboards developed? (2) What information do they provide? (3) How is this information analyzed and presented? and (4) What are the common features of highly actionable dashboards?

Methods

Study design

We conducted an observational descriptive assessment and scoring using nominal group technique (NGT) [37,38] on a global sample of COVID-19 dashboards. Each dashboard was reviewed using a study-specific assessment tool that was piloted and validated among a panel of scorers (n=17) prior to its use [37,38]. NGT was chosen over other consensus methods (eg, Delphi) for scorers to independently appraise a subset of dashboards using the assessment tool and collectively discuss what makes them actionable through a series of workshops [38,39]. All workshops were conducted virtually rather than face-to-face in accordance with pandemic-related public health measures.

Panel of scorers

A panel of scorers was assembled through an existing international network of health care performance intelligence researchers [40]. The scorers had common expertise and training in health care performance data and the use of these data for management and governance. Collectively, the scorers (8 women, 9 men) were of 15 nationalities and were proficient in more than 20 languages (Bosnian, Catalan, Chinese, Croatian, Danish, Dutch, English, French, German, Indonesian, Italian, Kazakh, Malay, Montenegrin, Norwegian, Portuguese, Romanian, Russian, Serbian, Slovenian, Spanish, Swedish, and Turkish). This enabled the dashboards to be assessed in their original languages rather than through translations, avoiding the use of translation software and its limitations when used with data visualizations.

Inclusion and exclusion criteria

We defined a COVID-19 dashboard based on the following criteria: (1) reporting of key performance indicators related to the COVID-19 pandemic; (2) the use of some form of data visualization; (3) dynamic reporting, meaning the data are updated regularly; and (4) public availability in a web-based format. No restrictions were placed on a dashboard's primary level (eg, international, national, regional, or local) or the type of organization responsible for its development (eg, international, governmental, academia, news or media, industry, or private initiative). We excluded dashboards that were available only via mobile apps (eg, Telegram) or that required users to log in (eg, Facebook). Dashboards beyond the language competencies of the panel of scorers were also excluded.

Step one: dashboard sampling

Our search strategy for dashboards aimed to be thorough but not exhaustive. This was in line with our aim of exploring the state of the art of public web-based COVID-19 dashboards. An initial list of dashboards was collected through sampling conducted from May 19 to June 30, 2020. Three methods were applied: (1) surveying the authors; (2) surveying other international networks of public health, health services, and system researchers and practitioners (Young Forum Gastein, European Public Health Association, and European Network of Medical Residents in Public Health); and (3) snowballing of sources identified through (1) and (2). The sampling survey was developed using a Google Forms data collection tool and disseminated by email (Appendix 1).

The consolidated list of dashboards was screened by one team member with the aims to confirm the inclusion criteria were met; exclude duplicates; and assess the available languages for each dashboard against the panel's competencies. Dashboards were labeled as red (exclude), green (include), or yellow (obtain second opinion). A second team member assessed dashboards labeled yellow, from which a final joint decision on inclusion or exclusion was made.

Step two: developing an assessment tool

An assessment tool was developed by drawing primarily on two existing theoretical models. From communication sciences, we applied the Lasswell model (1948) [41], which states that for mass communication processes to be understood, each element of "who (says) what (to) whom (in) which channel (with) what effect" has to be presented and understood. These five elements—the communicator, message, medium, audience, and effect—informed the basis of the assessment tool's considerations. We tailored these considerations to the communication of COVID-19 data by drawing on the emerging discipline of performance intelligence in health [36,42]. Specifically, we incorporated key considerations from a definition of actionability and its notions of fitness for purpose and use (Barbazza et al, unpublished data, 2021). The resulting considerations are in line with existing health information instruments (eg, [43,44]), although they were tailored to the aims of the study.

These considerations were clustered to depict COVID-19 dashboards by their general characteristics and a description of why, what, and how data is communicated, followed by an appraisal of their overall actionability (Table 1). Actionability scores were defined on a Likert scale from "not actionable" (score=1) to "extremely actionable" (score=5) and assigned based on the scorer's judgement of the considerations assessed and their expert opinion of the dashboard's fitness for purpose and use. Scores were accompanied by a written statement explaining the rationale behind the response. In line with the study's aim to consolidate key features of highly actionable dashboards, the scoring was merely a means to this end: the panel's individual appraisal of actionability facilitated the clustering of the actionability of the dashboards as low (score=1 or 2) or high (score=4 or 5) for further collective deliberation on their common features.

Table 1. Overview of the assessment tool

CLUSTER	CONSIDERATIONS
General characteristics	• Level (scale) of focus • Responsible organization and type • Languages available • Scope of web page information
Why	• Purpose of use of the dashboard • Intended audience (user)
What	• Indicator titles • Data sources • Availability of metadata • Frequency of data updates
How	• Use of time trend for analysis • Geographic level (scale) of analysis • Types of possible breakdowns • Use of visualizations • Degree of interactivity • Use of simplicity techniques
Actionability score	• Overall appraisal of actionability

An Excel-based tool (Microsoft Corporation) was developed to record our findings. Each consideration of the assessment tool was formulated as a question with defined answer options. The tool included the underlying theory for the considerations by referring back to the concepts applied and available evidence [1,2,5,16,30,31,33,45-55] (Appendix 2) to remind the panel of the significance of each consideration and aid the assessment and scoring process.

Step three: piloting and calibrating

A prototype of the assessment tool was piloted by two authors on five dashboards. The extracted data were reviewed jointly with two other team members. This resulted in refinements to the phrasing of the questions and answer options. A second iteration of the assessment tool was then piloted with the panel of scorers on a sample of 18 dashboards representing a range of contexts, levels, and organization types. Each dashboard was independently reviewed by two scorers. Prior to piloting, a virtual training session with the panel of scorers was organized, recorded, and disseminated to serve as a resource. Each scorer was given six days (June 17–22, 2020) to review their two assigned pilot dashboards.

The pilot data were reviewed to assess the consistency of responses (ie, scorers of the same dashboard recorded equivalent answers) and meaningfulness of the answers (ie, the answer categories were meaningfully differentiated between dashboards). Where possible, the open-ended answer options of the tool were further specified into categorical values based on recurrent themes in the pilot data set. Definitions were added for key terms based on comments by the scorers. The reviewed pilots and tool amendments were returned to the panel of scorers, and a follow-up meeting was organized to discuss the reviews.

Step four: data extraction and round one scoring

Each scorer was assigned between 5 and 12 dashboards to assess. The dashboards were distributed with first order priority given to the language competencies of each scorer. To synchronize the assessment, the scorers were given a 2-week period to complete data extraction. The assessment was limited to each dashboard's main page, and a "one-click-away policy" was applied by which content accessible within one click of the main page was also assessed. To store a record of the dashboard on the date it was reviewed, the main page of each dashboard was archived, generating a permanent and publicly available record of its contents [56].

Step five: preliminary analysis and first consensus workshop

The data records from each scorer were consolidated by the lead authors into a master data set for analysis and subsequently underwent a series of data quality checks to detect data entry errors, inconsistences, or missed fields. In all instances where errors were detected, corrections were suggested and discussed jointly; once agreed upon, the changes were entered into the master data set.

The findings were totaled and averaged by research question. Free text fields and comments were analyzed in a deductive and inductive approach: topics explored in the tool (Appendix 2) were used to guide the deductive thematic analysis [57], and new themes that emerged were identified using an inductive approach [58]. This included an analysis of indicator titles using an existing classification of types of pandemic-related information [3]. Due to the observed variability in phrasing of indicator titles and calculations, key performance indicators were grouped by themes.

A workshop with the panel of scorers was organized to discuss the preliminary results and distribution of actionability scores. During the workshop, panelists individually shared the rationale for their scoring of dashboards with low (score=1 or 2) and high (score=4 or 5) actionability. The common features of dashboards scored as highly actionable were discussed to further calibrate the panel's scoring of the actionability. From this discussion, a working list of actionability features was consolidated.

Step six: round two scoring and second consensus workshop

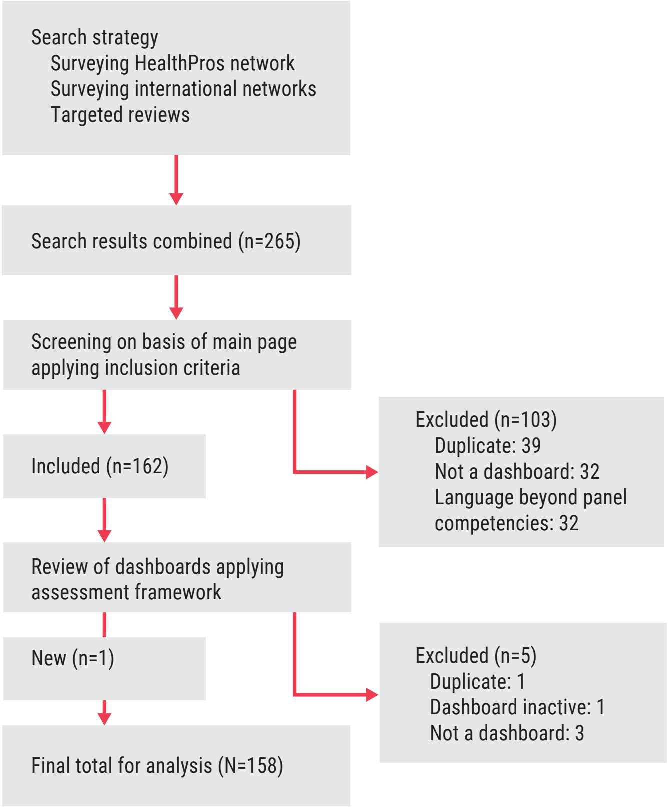
All panelists were returned their original data records and given 1 week to revisit their initial actionability scoring, drawing on the discussion during the workshop. Panelists were given the opportunity to increase each score, lower it, or leave it the same. Following rescoring, the distributions of the scores were recalculated. The data records for the top dashboards (score=5) following this second round were consolidated and provided to the panel, together with the working set of actionability features. A second consensus workshop was convened and, in a similar way to the previous workshop, a round table was conducted for each scorer to share their views. This was followed by a joint discussion to reach agreement on the common features of highly actionable dashboards.

Results

Identified dashboards

Using our multimethod search strategy, we initially identified 265 COVID-19 dashboards. More than 40 respondents contributed to the sampling survey, including all members of the study team and international public health experts. Following screening of each dashboard's main page, 103 dashboards were excluded. The remaining 162 dashboards were distributed among the panel of scorers for full review. During the assessment process, 5 additional dashboards were excluded and 1 new dashboard was included. A final total of 158 dashboards was included for further analysis (Figure 1).

Figure 1. Flow diagram of COVID-19 dashboard sampling



Data extraction and the first round of scoring were conducted in a 2.5-week period between July 6 and 23, 2020. The data extract and archived version of each dashboard were referred to throughout the study. Therefore, any updates following this date were not accounted for. The 158 dashboards were assessed in 22 different languages, predominately in English (n=85, 53.8%), followed by Russian (n=11, 7.0%), Spanish (n=9, 5.7%), French (n=9, 5.7%), and Chinese (n=6, 3.8%). A full listing of the dashboards assessed is available in Appendix 3.

General description of the assessed COVID-19 dashboards

Table 2 summarizes key characteristics of the 158 dashboards assessed. Our sample included dashboards reporting on 53 countries in all 6 WHO regions [59]. On the date of the review, the severity of the pandemic with regard to total cases and deaths varied widely between location as reported in Appendix 3.

Table 2. Characteristics of the assessed COVID-19 dashboards (N=158) from 53 countries

CHARACTERISTIC		VALUE, N (%)
Region[a]		
	Global	20 (12.7)
	Europe and Central Asia	63 (39.9)
	North and South America	45 (28.5)
	Western Pacific	22 (13.9)
	Southeast Asia	4 (2.5)
	Africa	3 (1.9)
	Eastern Mediterranean	1 (0.6)
Level		
	International	25 (15.8)
	National	93 (58.9)
	Regional (provincial, state, county)	33 (20.9)
	Municipal (city, district)	7 (4.4)
Type of organization		
	International organization	7 (4.4)
	Governmental	100 (63.3)
	Academia	9 (5.7)
	News or media outlet	14 (8.9)
	Industry	9 (5.7)
	Independent initiative	16 (10.1)
	Other	3 (1.9)
Languages available with full functionality[b]		
	One language	126 (79.7)
	Two languages	22 (13.9)
	Three or more languages	10 (6.3)
Additional languages available with reduced functionality[c]		
	One or more languages	16 (10.1)
Scope of information[d]		
	Epidemiological information	156 (98.7)
	Infection control measures	65 (41.1)
	Health system management	49 (31.0)
	Social and economic implications	31 (19.6)
	Population behavioral insights	25 (15.8)
	Other	28 (17.7)

[a] Country status and region according to WHO classification [59].

[b] Full functionality: the webpage is equivalent in the different languages.

[c] Reduced functionality: the webpage is available in additional languages but with less information and fewer functionalities compared to the main languages.

[d] According to the WHO classification [3].

More than half of the dashboards (93/158, 58.9%) were developed for use at the national level. Nearly two-thirds of the dashboards (100/158, 63.3%) were developed by government authorities at the national, regional, or municipal level. New initiatives or organizations formed in response to COVID-19 accounted for 10.1% (16/158) of the dashboards assessed [29,60-74].

With regard to language, only one-fifth of the dashboards were available in more than one language with full functionality (32/158, 20.3%). In terms of their scope of information, gauged according to the content of the dashboard as well as information to which users were redirected through affiliate links, almost all the dashboards were epidemiological in focus (156/158, 98.7%), followed by providing information on infection control measures and health system management (65/158, 41.1%, and 49/158, 31.0%, respectively).

Uses and users of COVID-19 dashboards

A quarter of the dashboards (45/158, 28.5%) explicitly stated the intended purpose of their reporting. Of these 45 dashboards, the statements spanned three main themes: (1) high-level reporting to create trust and aid overall compliance (25/45, 56%); (2) sub-national reporting targeting policy interventions, including benchmarking (12/45, 27%); and (3) individual-risk assessment (8/45, 18%).

Only 14.6% (23/158) of the dashboards explicitly stated the intended audience (end users). Target users predominately included the general public (20/23, 87%) and, in a few instances, more specific audiences such as travelers or subject matter experts (6/23, 26%). When examined by the level of reporting, national-level dashboards were less likely to explicitly state the intended audience (9/93, 10%), while international- and municipal-level dashboards were more likely to do so (7/25, 28%, and 2/7, 29%, respectively).

Of the 158 dashboards assessed, 20 (12.7%) reported both the purpose and intended user explicitly. The profiles of these dashboards, in terms of their levels of reporting and the types of organizations that developed them, did not differ from the characteristics of the general sample. For the remainder of the analysis, the sample of dashboards was aggregated rather than subdivided by the intended purpose of the use and audience, due to the limited explicit statements of both.

Content and data of COVID-19 dashboards

Key performance indicators

Table 3 summarizes the frequency of indicator themes reported by the dashboards. See Appendix 4 for illustrative examples of indicator titles. On average, the dashboards reported on 5.3 indicator themes (maximum 15, minimum 1). Almost all the dashboards reported public health and epidemiological indicators (155/158, 98.1%), particularly those that reported on cases and deaths. These account for the only high-frequency indicator themes (indicators present in more than two-thirds of the assessed dashboards). Medium-frequency indicator themes (themes reported in more than one-third but less than two-thirds of dashboards) were related to hospital care (hospitalizations, admissions to infection control units), testing (total tests, testing rates), and spread and death (recovered and active cases).

Only 4.4% of the dashboards (7/158) reported indicators related to social and economic impacts. Indicator themes included employment and hardship relief (eg, [28,75]) and transport, trade, and international travel (eg, [28,75]). Indicators of behavioral insights were also infrequently reported (8/158, 5.1%). Indicator themes included two main types: (1) self-reported adherence related to restrictions (eg, [76,77]) or health and well-being status (eg, [75]) and (2) observed public adherence to restrictions assessed through mobility data or reported breaches of restrictions (eg, [60,78]).

Some use of composite scores to signal overall risk levels or the current status by sector (eg, health, economy) was identified, although this use was infrequent (eg, [28,61,79]).

Data sources and metadata

One quarter of the dashboards did not explicitly report the source of their data (39/158, 24.7%). National-, regional-, and municipal-level government-run dashboards predominately reported the use of data sourced from official public health authorities. International dashboards predominately reported the use of data sourced from the WHO [25] or the Johns Hopkins Centre for Systems Science and Engineering [26].

Less than half of the dashboards (63/158, 39.9%) specified metadata (data dictionaries, indicator specifications) in the format of notes, footnotes, or linked additional web pages to provide further information on the methodology by which an indicator was calculated. Of the 158 dashboards, 39 (24.7%) did not report their data sources or metadata details. The majority of dashboards updated their data daily and explicitly stated the update frequency and time of the last update.

Table 3. Frequency of indicator themes reported for the 158 dashboards assessed

INFORMATION TYPE AND CLUSTER	INDICATOR THEMES	VALUE, N (%)	FREQUENCY[a]
Public health and epidemiological			
Spread and death	Cases (all confirmed cases)	150 (94.9)	High
	Deaths	136 (86.1)	High
	Recovered (healed, cured)	91 (57.6)	Medium
	Active cases	56 (35.4)	Medium
	Mortality rate (case fatality rate)	24 (15.2)	Low
	Reproduction rates (attack rate)	12 (7.6)	Low
	Future projections/risk models	5 (3.2)	Low
	Doubling rate	3 (2.0)	Low
Testing	Testing (total number tested, PCR[b] tests)	80 (50.6)	Medium
	Testing rates (positivity, negative tests)	43 (27.2)	Medium
	Tests–pending results	17 (10.8)	Low
	COVID-19 antibody tests (serology tests)	1 (0.6)	Low
Risk management	Self-quarantine (isolation notices)	18 (11.4)	Low
	Contact tracing	6 (3.8)	Low
Health system management			
Hospital care	Hospitalized (admissions, discharges)	74 (46.8)	Medium
	Admitted to ICU[c] (critical condition)	47 (29.7)	Medium
	On a ventilator	14 (8.8)	Low
Health system capacity	Hospital bed capacity (availability)	12 (7.6)	Low
	ICU bed capacity	10 (6.3)	Low
	Ventilator capacity (available ventilators)	5 (3.2)	Low
	Non–COVID-19 service usage	4 (2.5)	Low
	Personal protective equipment stock	2 (1.3)	Low
	Testing stock	2 (1.3)	Low
Social and economic impact			
N/A[d]	Employment and hardship relief	7 (4.4)	Low
	Transport, trade, and international travel	3 (1.9)	Low
Behavioral insights			
N/A	Observed public adherence to restrictions	4 (2.5)	Low
	Self-reported adherence to restrictions	2 (1.3)	Low
	Self-reported health and well-being status	2 (1.3)	Low

[a] Low: <33%; medium: 34%-66%; high: ≥67%.
[b] PCR: polymerase chain reaction.
[c] ICU: intensive care unit.
[d] N/A: not applicable.

Types of analysis and presentation of data on COVID-19 dashboards

Table 4 summarizes the types of analysis and presentation of data. The dashboards predominately reported indicators over time (138/158, 87.4%), and most of these breakdowns were by day (128/138, 92.8%). Of the dashboards, 40% reported data on two geographic levels (eg, national and regional or regional and municipal). In the case of national-level dashboards (n=93), geographic breakdowns predominately included regional comparisons (73/93, 79%), with some municipal-level (28/93, 30%) and international-level (25/93, 27%) comparisons. Breakdowns by neighborhood (post–code-level) were reported in only a few instances (4/93, 4%).

Table 4. Summary of analysis and presentation of dashboard information

CONSIDERATIONS	VALUE, N (%)
Time trend analysis availability (N=158)	
Time trend analysis available	138 (87.3)
No time trend analysis	20 (12.7)
Use of time trend analysis (n=138)[a,b]	
By day	128 (92.8)
By week	33 (23.9)
By month	19 (13.8)
Geographic levels (scales) of analysis (N=158)[b]	
International (multicountry)	54 (34.2)
National	118 (74.7)
Regional	117 (74.1)
Municipal	54 (34.2)
Neighborhood	13 (8.2)
Other	5 (3.2)
Number of levels (scales) of analysis per dashboard (N=158)	
1 level	34 (21.5)
2 levels	65 (41.1)
3 or more levels	59 (37.3)
Disaggregation availability per dashboard (N=158)	
1 or 2 types of disaggregation	48 (30.4)
3 or 4 types of disaggregation	42 (26.6)
5 or more types of disaggregation	6 (3.8)
No disaggregation options	62 (39.2)

CONSIDERATIONS	VALUE, N (%)
Disaggregation options (n=96)[a,b]	
Age	79 (82.3)
Sex	71 (74.0)
Mode of transmission	26 (27.1)
Long-term care facilities	16 (16.7)
Ethnicity	12 (12.5)
Race	10 (10.4)
Health workers	9 (9.4)
Comorbidities	9 (9.4)
Socio-economic status	2 (2.1)
Other	23 (24.0)
Visualization features (N=158)[b]	
Graphs/charts	134 (84.8)
Maps	111 (70.3)
Tables	95 (60.1)
Video/animations	10 (6.3)
Use of narratives to interpret data (N=158)	
Yes, to clarify the quality of the data only	28 (17.7)
Yes, to clarify the meaning of the data only	23 (14.6)
Yes, to clarify both the quality and the meaning	31 (19.6)
No	76 (48.1)
Simplification techniques used (n=104)[a,b]	
Use of color-coding	93 (89.4)
Size variation	40 (38.5)
Icons	6 (5.8)
Interactive options (n=126)[a,b]	
More information	115 (91.3)
Change of information	61 (48.4)
Change of display	44 (34.9)

[a] Subset of applicable dashboards (ie, 138 dashboards that do use time trends).
[b] Percentages for these considerations do not total to 100%, as multiple considerations could be present per dashboard.

In addition to geographic breakdowns, more than half of the dashboards (96/158, 60.8%) analyzed data by other breakdowns: on average, three types of breakdowns were included. Of these 96 dashboards, the most common breakdowns included by age (79/96, 82%), sex (71/96, 74%), and mode of transmission (26/96, 27%). Other breakdowns, although less frequently reported, included race, ethnicity, long-term care facilities, health care workers, comorbidities, and socioeconomic status.

As per our inclusion criteria, all dashboards used some form of visualization. On average, two types of visualizations were included per dashboard. These included graphs or charts (134/158, 84.8%), maps (111/158, 70.3%), and tables (95/158, 60.1%). Almost half of the dashboards (76/158, 48.1%) did not include written descriptions to clarify either the quality or meaning of the data, while 31/158 dashboards (19.6%) provided both.

More than half of the dashboards (104/158, 65.8%) used some technique to simplify the data. In these 104 dashboards, color-coding was most often used (n=93, 89.4%), followed by size variation (n=40, 38.5%). The majority of dashboards (126/158, 79.7%) included some element of user interaction. These elements mostly included the possibility to present more information (eg, pop-up windows), change the information (eg, different breakdowns), or change the display (eg, switch from table to map).

Features of actionable dashboards

In the first round of scoring, 21 of the 158 dashboards assessed (13.3%) were scored with the highest actionability score (score=5), and 18 dashboards (11.4%) received the lowest score (score=1), for a mean score of 3.01 (SD 1.20). The second round of scoring resulted in a final total of 20 dashboards that were scored as the most actionable. A quarter of the dashboards (40/158, 25.3%) were scored differently: 24 scored lower, and 16 scored higher. All 17 panelists completed both rounds of scoring. Details on the distribution of scoring by panelist and between rounds are summarized in Appendix 5.

The panel workshop following the first round of scoring resulted in a total of 18 features that characterized highly actionable dashboards. After rescoring, these features were further discussed among the panel to consolidate the list in terms of their description and importance as well as its consistency and completeness as a set. A final total of seven key features common to highly actionable dashboards were agreed upon (Table 5). There was consensus among the panelists that some dashboards excelled in certain features over others. These dashboards are noted as illustrative examples.

Table 5. Seven features of highly actionable COVID-19 dashboards

NUMBER	FEATURE	EXPLANATION	EXAMPLES
1	Know the audience and their information needs	Dashboards with a known audience and explicit aim had focus and continuity in their content, analysis and delivery. Techniques such as guiding key questions or overall composite scores clearly communicated the decision they intended to support. Multilanguage functionality and exact timing of updating signaled an awareness and intent to encourage their regular use by the intended decision maker.	#HowsMyFlattening [60], Covid Act Now [61], State of California [79].
2	Manage the type, volume, and flow of information	The selection of a concise number of indicators brought focus and importance to the information and the possibility to view indicators together at a glance. The use of indicators in moderation, although still spanning varied types of information, was especially effective. The ordering of information, from general to specific or in sections based on theme, made the flow of information intuitive.	Covid Act Now [61] reports on five key indicators. Deloitte [28] and the City of Vancouver [78] included a range of types of information.
3	Make data sources and methods clear	A clear source of data and explanation of an indicator's construction, including potential limitations, was found to be an important component of trust in the dashboard and clarity in its reporting. This information can be provided in short narratives that support users to understand what is in fact being presented.	Denmark [80], France [76], Spain [81], and media pages of the Canadian Broadcasting Corporation [82] and the New York Times [83] paid attention to narrating the calculation of indicators.
4	Link time trends to policy (decisions)	Reporting data over time together with the introduction of key infection control measures facilitated an understanding of their effect (or lack thereof). This was found to be conducive to generating public support for infection control measures.	ABC News [84] and Sledilnik [62] embed policy measures over time. The City of Toronto [85] reports city targets.
5	Provide data "close to home"	To inform individuals of risks in their immediate surroundings, granular geographic breakdowns are needed. Data that are highly aggregated are difficult to understand. Maps (over tables and charts) were most effective to provide geographic information.	The United Kingdom [86] offers post–code-level breakdowns. Germany [87] provided city- and borough-level information for Berlin.
6	Break down the population to relevant subgroups	Providing data with the possibility to explore varied population characteristics made indicators relatable to individual users. It enables understanding of risks and trends based on one's own demographics. It can also facilitate equity-driven decision-making by exposing differences among the population.	Ethnicity and race breakdowns were provided in New Zealand [75] and various US dashboards [79,88-92]. #HowsMyFlattening [60] provided breakdowns on economic status.
7	Use storytelling and visual cues	A concise narrative explaining the significance of a trend supports users to understand the importance of the information. Bare statistics without a narrated analysis leave the burden of interpretation solely to the user. Brief explanations on the meaning of trends used in combination with visual techniques, such as intuitive color schemes and icons, supported ease of interpretation.	Covid Act Now [61] narrates the significance of trends. The State of Colorado [88] uses colored icons to signal the direction of trends.

Discussion

Principal findings

With this study, we set out to assess the state of the art of public web-based COVID-19 dashboards globally during the initial stage of the pandemic (July 2020) and identify features common to the dashboards that were found to be highly actionable. We assessed 158 dashboards, each operating in a different context. Their differences aside, the dashboards analyzed in this study ultimately share a common aim: to serve as both a communication tool and call for individual and collective action to respond to the COVID-19 pandemic. Despite their contextual differences (or because of them), our results indicate that some dashboards fulfill their function of communicating, informing decision-making, and supporting behavior change better than others. Moreover, while it is also clear there is no single approach to developing a dashboard, our results suggest that introducing certain features may enhance the actionability of a dashboard.

Knowing the audience and their information needs was identified as a key actionability feature, which corresponds with the Lasswell model for effective communication [1,41]; Barbazza et al, unpublished data, 2021). However, clear reporting of a dashboard's purpose (its "why") and audience (for "whom") was infrequent. This may be explained in part by the fact that the majority of the dashboards were developed by public authorities and hosted on existing web pages. Hence, the target audience (citizens) and the aim (constitutional mandate to protect health) may be considered implicit. However, without clarity on the intended use and user of a dashboard, its development is steered by the *potential* to be useful rather than addressing a specific information need [32,93-95].

"What" a dashboard communicates through its content is not a neutral window into the available data. It is the result of judgment, discernment, and choice [14]. The average of 5 indicator themes reported per dashboard can be considered to be a manageable volume and is in line with the evidence that "less is more" [33,47]. It is the breadth of types of information presented that is concerningly narrow, with only a handful of dashboards addressing the WHO-recommended four types of information needed for a complete picture of the pandemic [3]. For example, indicators reporting on population behavioral insights gauge the compliance of citizens with infection control measures; thus, they are an important tool for maintaining public trust. However, in our sample, this type of information was rarely reported. This may be due to data infrastructure limitations and the limited availability of these data, especially in the early phases of the pandemic. Similarly, less than half of the dashboards reported on health system management indicators, despite the importance of these indicators in informing the management of both COVID-19 and non–COVID-19 services. Dashboards that did report on these non-epidemiological types of information may serve as inspiration for drawing on innovative data sources and indicators [28,60].

Clarity around data sources and indicator calculations (metadata) are critical for overall quality, credibility, and trustworthiness of reporting [46,48,49]. For transparency on how data were collected and insights into "what lies behind" the reported indicators, providing explicit data sources and calculations should be considered a minimum requirement. Nonetheless, our findings signal that these provisions are not a given. Further efforts are needed internationally and nationally to standardize indicator calculations and set requirements of what constitutes good practice in public reporting of pandemic-related data.

In terms of "how" content is presented, dashboards should be viewed as tools for making clear links between current trends and past policy decisions and individual behavior. Doing so connects change-points and actions, which has been found to contribute to an indicator's use [96,97]. It also serves to leverage the two-way communication potential of dashboards. Dashboards that fail to make the connection between the past and present miss the opportunity to communicate the effects of users' decision-making back to them. Beyond describing the past and present, only a handful of dashboards went further and employed predictive analytics by illustrating different future scenarios of "what could happen." The lack of precision of predictive models and simulations early in the pandemic likely stunted their use. Use of both descriptive and predictive approaches to dashboard design and tighter links between infection control policies and their effects should be further explored into the next phases of the pandemic.

We found frequent use of different display options and interactive techniques among the dashboards assessed. However, the analysis of data by location and by population subgroups was limited overall, which may restrict their utility for individual-level decision-making purposes. The challenge to report data locally and disaggregate the data by relevant breakdowns such as age, sex, socioeconomic status, and ethnic or racial groups may be in large part due to data infrastructure limitations and perceived legal obstacles [98]. Without collecting, registering, and using data about meaningful population subgroups, there is a risk of not being informed about these important (and modifiable) differences [98].

Finally, an actionable dashboard is based on complete, timely, and transparent data that is prepared, contextualized, and presented so that it can be used as information [99]. Our assessment found an overall underuse of known and proven delivery techniques, in particular, the use of explanatory narratives. Plain language text to clarify complicated information has proven to make end users more motivated and confident in using information in their decision-making [1,47,54]. Although commonly used software for the development of dashboards (eg, ArcGIS) has served to optimize their single-screen design, the embedding of narratives into templates may be useful for improving interpretation.

Future research could explore the following points. First, recognizing the highly dynamic nature of COVID-19 dashboards, a follow-up study could provide insights into how dashboards have evolved over time, given improvements in disease prevention, testing, and treatment as well as data infrastructure. Second, exploring across official municipal, regional, and national dashboards in a given context was beyond the scope of this study; however, such an exploration may offer insights into the possibility of tailoring dashboards at different levels to specific purposes and audiences. Third, this study has pursued a theoretically informed expert-based appraisal of actionability. A study from the perspective of the target audience is therefore merited and needed to obtain insights from firsthand use. Finally, the developed assessment tool could be used within a specific country context to analyze actions needed to implement the identified features.

Strengths and limitations

To our knowledge, this is the most comprehensive summary of COVID-19 dashboards and assessment of their actionability published to date. The search for COVID-19 dashboards was wide-reaching and used multiple methods to amass a global sample. The approach tapped into a unique and highly specialized international network dedicated to health care performance intelligence, allowing for an expert, context-aware, and multicultural team. The multilanguage competencies of the panel made it possible for the dashboards to be reviewed in their original languages for high-quality data extraction. Through detailed data extraction and a structured process of scoring with joint deliberation, we have identified a set of timely and pragmatic features for optimizing dashboards. This is also the first study to our knowledge on the use of dashboards for public reporting from a communication and health care performance intelligence perspective. Importantly, the study was conducted at pace with the ongoing COVID-19 pandemic to ensure the potential for findings to inform the continued development of dashboards in combination with other communication tools.

We acknowledge the following potential limitations. First, the sample of dashboards is ultimately a subset of publicly available web-based COVID-19 reporting. The sample is also skewed to locations in the European and Pan-American regions, which account for two-thirds of the dashboards reviewed. This can be attributed in part to factors including the thorough but not exhaustive sampling strategy applied; the exclusion of dashboards beyond the 22 language competencies of the panel (ie, Arabic and Hindi); and the focus on web-based dashboards to the exclusion of those exclusively on mobile apps (common to Asian countries). As an exploratory study, reasonable diversity of locations, in combination with different levels (scales) of focus and types of organizations, took precedent and was achieved. Nonetheless, the findings may not be generalizable to all contexts. Second, despite our best efforts to obtain a snapshot of COVID-19 dashboards in a common 2-week period, the severity and specific phase of the pandemic inevitably varied greatly on the date of the review as described. Our approach to assess rather than evaluate the impact of COVID-19 dashboards mitigates the significance of these differences on our findings. Third, the appraised actionability of the dashboards ultimately does not confirm their use in practice, and evaluating this was beyond the scope of this study.

Conclusion

This study has taken stock of the vast landscape of public web-based COVID-19 dashboards; this is a testament to the advancements in health information systems and digitalization of our societies, coupled with the responsibility and imperative to publicly report health information. As could be expected, the 158 dashboards in our sample, spanning a total of 53 countries, are diverse. They have different contexts and levels of focus, purposes, and audiences. They draw from various data sources, offer different content and use a range of ways—albeit at times limited—to break down data and to visualize, simplify, and interact with information. Their actionability also differs, signaling that their fitness for use by decision makers is not a guarantee. The number of dashboards appraised as highly actionable in the period of July 2020 when the dashboards in this study were assessed signals that work is still needed to optimize the use of dashboards. There is no one-size-fits-all template or model to accomplish this. Dashboards must be purpose-driven and context-specific. We urge those working on COVID-19 dashboards to consider the seven features identified in our study and adopt them as called for. By doing so, they stand to fully leverage the potential advantages of public reporting and its use for decision-making and behavior change needed to address the current pandemic.

Acknowledgments

We acknowledge the contributions of and are grateful to the following: Femke Jansen (Management Center Innsbruck); Omid Fekri (WHO Regional Office for Europe); Mekha Mathew (University of Oxford); and respondents to the initial dashboard sampling survey. This work was carried out by the Marie Skłodowska-Curie Innovative Training Network (HealthPros—Healthcare Performance Intelligence Professionals), which has received funding from the European Union’s Horizon 2020 research and innovation program under grant agreement Nr. 765141.

Abbreviations

NGT: nominal group technique

WHO: World Health Organization

References

1. Marshall MN, Romano PS, Davies HTO. How do we maximize the impact of the public reporting of quality of care? Int J Qual Health Care. 2004;16 Suppl 1(suppl_1):i57-i63.
2. Sbaffi L, Rowley J. Trust and credibility in web-based health information: a review and agenda for future research. J Med Internet Res 2017;19(6):e218.
3. Strengthening and adjusting public health measures throughout the COVID-19 transition phases. World Health Organization. Copenhagen: WHO Regional Office for Europe. 2020 Apr 24. URL: https://apps.who.int/iris/bitstream/handle/10665/ 332467/WHO-EURO-2020-690-40425-54211-eng.pdf?sequence=1&isAllowed=y [accessed 2021-02-17].
4. Frieden TR. Government's role in protecting health and safety. N Engl J Med. 2013;368(20):1857–59.
5. Smith P, Mossialos E, Papanicolas I, Leatherman S. Part 1: Principles of performance measurement. In: Smith P, Mossialos E, Papanicolas I, Leatherman S, editors. Performance measurement for health system improvement experiences, challenges and prospects. Cambridge, UK: Cambridge University Press; 2010:1–2.
6. Shekelle P. Public performance reporting on quality information. In: Smith PC, Mossialos E, Papanicolas I, Leatherman S, editors. Performance measurement for health system improvement experiences, challenges and prospects. Cambridge, UK: Cambridge University Press; 2010:537–51.
7. Berwick DM, James B, Coye MJ. Connections between quality measurement and improvement. Med Care. 2003 Jan;41(1 Suppl):I30–8.
8. Flattening the COVID-19 peak: containment and mitigation policies. OECD. Paris: OECD URL: https://read.oecd-ilibrary.org/ view/?ref=124_124999-yt5ggxirhc&title=Flattening_the_COVID-19_peak-Containment_and_mitigation_policies [accessed 2021-02-17].
9. WHO checklist for influenza pandemic preparedness planning. World Health Organization. 2005. URL: https://www. who.int/influenza/resources/documents/FluCheck6web.pdf?ua=1 [accessed 2021-02-17].
10. Managing epidemics: key facts about major deadly diseases. World Health Organization. 2018. URL: https://apps.who.int/ iris/handle/10665/272442 [accessed 2021-02-17].
11. Strengthening the health system response to COVID-19: recommendations for the WHO European Region. World Health Organization. URL: https://apps.who.int/iris/bitstream/handle/10665/333072/WHO-EURO-2020-806-40541-54465-eng.pdf?sequence=1&isAllowed=y [accessed 2021-02-17].
12. Infodemic management. World Health Organization. URL: https://www.who.int/teams/risk-communication/ infodemic-management [accessed 2021-02-17].
13. Few S. Dashboard confusion. Perceptual Edge. 2004 Mar 20. URL: https://www.perceptualedge.com/articles/ie/ dashboard_confusion.pdf [accessed 2021-02-17].
14. Kennedy H. Simple data visualizations have become key to communicating about the COVID-19 pandemic, but we know little about their impact. London School of Economics and Political Sciences Impact Blog. 2020 May 04. URL: https:/ /blogs.lse.ac.uk/impactofsocialsciences/2020/05/04/ simple-data-visualisations-have-become-key-to-communicating-about-the-covid-19-pandemic-but-we-know-little-about-their-impact/ [accessed 2021-02-17].

15. Ghazisaeidi M, Safdari R, Torabi M, Mirzaee M, Farzi J, Goodini A. Development of performance dashboards in healthcare sector: Key practical issues. Acta Inform Med. 2015;23(5):317–21.

16. Damman OC, van den Hengel YK, van Loon AJM, Rademakers J. An international comparison of web-based reporting about health care quality: content analysis. J Med Internet Res. 2010;12(2):e8.

17. Weggelaar-Jansen AMJWM, Broekharst DSE, de Bruijne M. Developing a hospital-wide quality and safety dashboard: a qualitative research study. BMJ Qual Saf. 2018;27(12):1000–7.

18. Lee K, Jung SY, Hwang H, Yoo S, Baek HY, Baek R, et al. A novel concept for integrating and delivering health information using a comprehensive digital dashboard: An analysis of healthcare professionals' intention to adopt a new system and the trend of its real usage. Int J Med Inform. 2017;97:98–108.

19. Kamadjeu R, Gathenji C. Designing and implementing an electronic dashboard for disease outbreaks response - Case study of the 2013-2014 Somalia Polio outbreak response dashboard. Pan Afr Med J. 2017;27(Suppl 3):22.

20. Meng Y, Zhang Y, Wang S, Wu S, Zhou H, Ke C, et al. Lessons learned in the development of a web-based surveillance reporting system and dashboard to monitor acute febrile illnesses in Guangdong and Yunnan Provinces, China, 2017-2019. Health Secur. 2020;18(S1):S14–22.

21. Internet access. OECD. URL: https://data.oecd.org/ict/internet-access.htm [accessed 2021-02-17].

22. Nuti S, Noto G, Vola F, Vainieri M. Let's play the patients music: A new generation of performance measurement systems in healthcare. Manag Decis. 2018;56(10):2252–72.

23. Verheij R, Witvliet C, Jansen T, Hooiveld M, van Hilten H. Reuse of routine care data for policy and science: how things can be improved. Report in Dutch. Nivel. Utrecht: Nivel; 2019. URL: https://www.nivel.nl/sites/default/files/bestanden/ Hergebruik_van_routine_zorgdata_voor_beleid_en_wetenschap.pdf [accessed 2021-02-21].

24. Galea S. The COVID conversation. Interference: International Review of Science (Special reports: SARS-CoV-2 and COVID-19). 2020 Jun 10. URL: https://inference-review.com/report/the-covid-conversation [accessed 2021-02-17].

25. WHO coronavirus disease (COVID-19) dashboard. World Health Organization. URL: https://covid19.who.int/ [accessed 2021-02-17].

26. COVID-19 Dashboard by the Center for Systems Science and Engineering (CSSE) at Johns Hopkins University. John Hopkins Coronavirus Resource Centre. URL: https://www.arcgis.com/apps/opsdashboard/index.html#/ bda7594740fd40299423467b48e9ecf6 [accessed 2021-02-17].

27. Dong E, Du H, Gardner L. An interactive web-based dashboard to track COVID-19 in real time. Lancet Infect Dis. 2020;20(5):533–4.

28. COVID-19 economic recovery dashboard. Archived at archive.today. Deloitte. URL: http://archive.vn/qrJbw [accessed 2020-07-17].

29. Schiffmann A. nCoV2019 live. Archived at archive.today. URL: http://archive.vn/UWv29 [accessed 2020-07-21].

30. Health in the 21st century: putting data to work for stronger health systems. OECD. Paris: OECD; 2019. URL: https://read. oecd-ilibrary.org/social-issues-migration-health/health-in-the-21st-century_e3b23f8e-en#page1 [accessed 2021-02-17].

31. McDowell R. Signs to look for: criteria for developing and selecting fit for purpose indicators. Price Waterhouse Coopers. 2017. URL: https://ourlandandwater.nz/wp-content/uploads/2019/03/IWG_Indicators-thinkpiece-1.pdf [accessed 2021-02-17].
32. Smith P, Mossialos E, Papanicolas I. Performance measurement for health system improvement, experiences, challenges and prospects. Copenhagen: WHO Regional Office for Europe; 2008.
33. Hibbard JH, Peters E. Supporting informed consumer health care decisions: data presentation approaches that facilitate the use of information in choice. Annu Rev Public Health. 2003;24:413–33.
34. Few S. What ordinary people need most from information visualization today. Visual Business Intelligence Newsletter. 2008 Aug. URL: http://www.perceptualedge.com/articles/visual_business_intelligence/what_people_need_from_infovis. pdf [accessed 2021-02-17].
35. Sadique MZ, Devlin N, Edmunds WJ, Parkin D. The effect of perceived risks on the demand for vaccination: results from a discrete choice experiment. PLoS One. 2013;8(2):e54149.
36. Kringos D, Carinci F, Barbazza E, Bos V, Gilmore K, Groene O, HealthPros Network. Managing COVID-19 within and across health systems: why we need performance intelligence to coordinate a global response. Health Res Policy Syst. 2020;18(1):80.
37. Jones J, Hunter D. Consensus methods for medical and health services research. BMJ. 1995;311(7001):376–80.
38. Fink A, Kosecoff J, Chassin M, Brook RH. Consensus methods: characteristics and guidelines for use. Am J Public Health. 1984;74(9):979–83.
39. Van de Ven AH, Delbecq AL. The nominal group as a research instrument for exploratory health studies. Am J Public Health. 1972;62(3):337–42.
40. International training network for healthcare performance intelligence professionals. HealthPros. URL: https://www. healthpros-h2020.eu/ [accessed 2021-02-17].
41. Lasswell HD. The structure and function of communication in society. In: Bryson L, editor. The Communication of Ideas. New York, NY: Harper and Row; 1948:136–9.
42. Kringos DS, Groene O, Johnsen SP. Training the first generation of health care performance intelligence professionals in Europe and Canada. Acad Med. 2019;94(6):747–8.
43. Charnock D. The DISCERN Handbook: Quality criteria for consumer health information on treatment choice. Oxford, UK: Radcliffe Medical Press; 1998.
44. Doak C, Doak L, Root J. SAM: Suitability Assessment of Materials for evaluation of health-related information for adults. Philadelphia, PA: J. B. Lippincott Company; 1996. URL: http://aspiruslibrary.org/literacy/SAM.pdf [accessed 2021-02-17].
45. Blanchet K, Nam SL, Ramalingam B, Pozo-Martin F. Governance and capacity to manage resilience of health systems: towards a new conceptual framework. Int J Health Policy Manag. 2017;6(8):431–35.
46. Sandmeyer B, Fraser I. New evidence on what works in effective public reporting. Health Serv Res. 2016;51 Suppl 2:1159–66.
47. Peters E, Dieckmann N, Dixon A, Hibbard JH, Mertz CK. Less is more in presenting quality information to consumers. Med Care Res Rev. 2007;64(2):169–90.
48. Raleigh VS, Foot C. Getting the measure of quality: opportunities and challenges. London: The King’s Fund; 2010. URL: https://www.kingsfund.org.uk/sites/default/files/Getting-the-measure-of-quality-Veena-Raleigh-Catherine-Foot-The-Kings-Fund-January-2010.pdf [accessed 2021-02-17].

49. van den Berg MJ, Kringos DS, Marks LK, Klazinga NS. The Dutch Health Care Performance Report: seven years of health care performance assessment in the Netherlands. Health Res Policy Syst. 2014;12:1.

50. Kreuter MW, Holt CL. How do people process health information? Applications in an age of individualized communication. Curr Dir Psychol Sci. 2016;10(6):206–9.

51. Kurtzman ET, Greene J. Effective presentation of health care performance information for consumer decision making: a systematic review. Patient Educ Couns. 2016;99(1):36–43.

52. Ellis J. Six modest proposals. English Educ. 2018;2(3):43–7.

53. Better information for improved health: a vision for health system use of data in Canada. Canadian Institute for Health Information. 2013. URL: https://www.infoway-inforoute.ca/en/component/edocman/ 1688-a-vision-for-health-system-use-of-data-in-canada-full-report/view-document?Itemid=0 [accessed 2021-02-17].

54. Hibbard JH, Greene J, Daniel D. What is quality anyway? Performance reports that clearly communicate to consumers the meaning of quality of care. Med Care Res Rev. 2010;67(3):275–93.

55. Ballard A. Promoting performance information use through data visualization: evidence from an experiment. Public Perform Manag Rev. 2019;43(1):109–28.

56. Webpage capture. archive.today. URL: http://archive.vn/ [accessed 2021-02-17].

57. King N. Using templates in the thematic analysis of text. In: Essential Guide to Qualitative Methods in Organizational Research. Newbury Park, CA: Sage Publications; 2004:256.

58. Braun V, Clarke V. Using thematic analysis in psychology. Qual Res Psychol. 2006;3(2):77–101.

59. Alphabetical List of WHO Member States. World Health Organization. URL: https://www.who.int/choice/demography/ by_country/en/ [accessed 2021-02-17].

60. #HowsMyFlattening. Archived at archive.today. URL: http://archive.vn/7T6MT [accessed 2020-07-14].

61. Covid Act Now: America's COVID Warning System. Archived at archive.today. URL: http://archive.vn/7hgsL [accessed 2020-07-14].

62. COVID-19 Sledilnik. Archived at archive.today. URL: http://archive.vn/szM4d [accessed 2020-07-09].

63. Global COVID-19 tracker and interactive charts. 1Point3Acres. Archived at archive.today. URL: http://archive.today/ 2020.07.14-101318/https://coronavirus.1point3acres.com/en [accessed 2020-07-14].

64. COVID-19 information for Switzerland. Archived at archive.today. URL: http://archive.vn/LmvZG [accessed 2020-07-08].

65. COVID-19 in Canada. Archived at archive.today. URL: http://archive.vn/m2dLJ [accessed 2020-07-13].

66. Information about COVID-19 precisely and accurately. Webpage in Indonesian. KawalCOVID19. URL: https://kawalcovid19. id/ [accessed 2020-07-17].

67. COVID Live. Archived at archive.today. URL: http://archive.vn/VtvRw [accessed 2020-07-16].

68. Coronavirus (COVID-19) in Australia. covid19data. Archived at archive.today. URL: http://archive.vn/CVeo8 [accessed 2020-07-08].

69. CoronaTracker. Archived at archive.today. URL: http://archive.vn/STFQO [accessed 2020-07-08].

70. Ustavimokorono. Archived at archive.today. URL: https://archive.vn/RZIgE [accessed 2020-07-09].

71. Koroonakaart. Archived at archive.today. URL: http://archive.vn/XxB8q [accessed 2020-07-17].

72. An interactive visualization of the exponential spread of COVID-19. 91-Divoc. Archived at archive.today. URL: http:/ /archive.vn/fJ9tk [accessed 2020-07-17].

73. Little N. COVID-19 Tracker Canada. Archived at archive.today. URL: http://archive.vn/Lqk6L [accessed 2020-07-18].

74. COVID-19 Dashboard. CoronaBoard. Archived at archive.today. URL: http://archive.vn/aMu3a [accessed 2020-07-17].

75. COVID-19 data portal. Stats NZ. Archived at archive.today. URL: http://archive.vn/8Llz2 [accessed 2020-07-17].

76. COVID-19. Santé Publique France. Archived at archive.today. URL: http://archive.vn/nhsHy [accessed 2020-07-16].

77. Daily COVID-19 Dashboard. Ottawa Public Health. Archived at archive.today. URL: http://archive.vn/3ZL3k [accessed 2020-07-16].

78. COVID-19 dashboard. City of Vancouver. Archived at archive.today. URL: http://archive.vn/jPIlp [accessed 2020-07-20].

79. California SG. Tracking COVID-19 in California. Government of California. Archived at archive.today. URL: http://archive. vn/u41FC [accessed 2020-07-08].

80. Overvågning af COVID-19. Statens Serum Institut. URL: http://archive.vn/zzVm9 [accessed 2020-07-17].

81. COVID-19 in Spain. National Center of Epidemiology. Archvied at archive.today. URL: http://archive.today/ 2020.07.17-123630/https://cnecovid.isciii.es/covid19/ [accessed 2020-07-17].

82. Tracking the coronavirus. CBC News. Archived at archive.today. URL: http://archive.vn/p7Ix2 [accessed 2020-07-13].

83. Coronavirus world map: tracking the global outbreak. New York Times. URL: https://www.nytimes.com/interactive/2020/ world/coronavirus-maps.html [accessed 2021-08-01].

84. Ting I, Scott N, Workman M. Charting the COVID-19 spread in Australia. ABC News. Archived at archive.today. URL: http://archive.vn/o15kK [accessed 2020-07-17].

85. COVID-19: status of cases in Toronto. City of Toronto. Archived at archive.today. URL: http://archive.vn/NoyJh [accessed 2020-07-04].

86. Coronavirus (COVID-19) in the UK. Government of the United Kingdom. Archived at archive.today. URL: http://archive. vn/q5ilb [accessed 2020-07-17].

87. Coronavirus-Monitor. Berliner Morningpost. Archived at archive.today. URL: http://archive.vn/JF9dW [accessed 2020-07-16].

88. Colorado COVID-19 data. Colorado Department of Public Health and Environment and Colorado State Emergency Operations Center. Archived at archive.today. URL: http://archive.today/l3yam [accessed 2020-07-14].

89. LA County COVID-19 Surveillance Dashboard. Los Angeles County Department of Public Health. Archived at archive.today. URL: http://archive.vn/QBXTE [accessed 2020-07-17].

90. Coronavirus disease 2019 (COVID-19) outbreak. Maryland Department of Health. Archived at archive.today. URL: http:/ /archive.vn/up0WC [accessed 2020-07-17].

91. Florida's COVID-19 Data and Surveillance Dashboard. Florida Department of Health. Archived at archive.today. URL: http://archive.vn/ZzNtp [accessed 2020-07-10].

92. COVID-19 data dashboard. Washington State Department of Health. Archived at archive.today. URL: http://archive.vn/ 94G5T [accessed 2020-07-13].

93. Papanicolas I, Smith P. Introduction. In: health system performance comparison: an agenda for policy, information and research. Berkshire, UK: Open University Press; 2013.

94. Klazinga N, Stronks K, Delnoij D, Verhoeff A. Indicators without a cause. Reflections on the development and use of indicators in health care from a public health perspective. Int J Qual Health Care. 2001;13(6):433–8.

95. Hilarion P, Suñol R, Groene O, Vallejo P, Herrera E, Saura RM. Making performance indicators work: the experience of using consensus indicators for external assessment of health and social services at regional level in Spain. Health Policy. 2009;90(1):94–103.

96. Compton-Phillips AT. The "Give a Darn" Method for Outcomes Measurement. NEJM Catalyst 2018 Feb 08.

97. Brehaut JC, Colquhoun HL, Eva KW, Carroll K, Sales A, Michie S, et al. Practice Feedback Interventions: 15 Suggestions for Optimizing Effectiveness. Ann Intern Med. 2016;164(6):435–41.

98. Ploem C, Suurmond J. Registering ethnicity for covid-19 research: is the law an obstacle? BMJ. 2020;370:m3367.

99. Rowley J. The wisdom hierarchy: representations of the DIKW hierarchy. J Inf Sci. 2007;33(2):163–80.

Supplementary appendices

Appendix 1: Dashboard sampling survey

Appendix 2: Assessment tool

Appendix 3: Public web-based COVID-19 dashboards assessed

Appendix 4: Illustrative indicator titles by themes

Appendix 5: Summary of dashboard scoring

Appendix 1: Dashboard sampling survey

Title

Local, regional, national and international web-based reporting on the COVID-19 pandemic: preliminary mapping exercise

Instructions

The aim of this exercise is to collect as many websites, using your (local) knowledge and expertise, which we will later assess for content, interpretability and actionability.

You are kindly asked to fill in this form with information on websites which you are aware of that are doing public reporting on the COVID-19 pandemic data at the national level, but also local, regional and international level.

Begin by first filling in those you know about (and follow or even work on) in countries where you currently live and/or originate from.

Continue with other websites you might know about in other countries as well as international ones providing comparative reporting.

Complete a new submission for each dashboard.

Questions

1. **Name**
   Your name for follow-up as needed.
2. **Link to website**
   URL to main dashboard page.
3. **Comments**
   Briefly, how would you describe this dashboard? Is it for local, regional, national or international use? In which country? Who is doing the reporting? Any additional comments?

Appendix 2: Assessment tool

CONSIDERATIONS	QUESTION	ANSWER OPTIONS	DESCRIPTION	RATIONALE
General				
Reviewer	Who is reviewing the webpage?	First name	Name of the panel member reviewing the dashboard.	For a record of who the page has been reviewed by.
Date of review	When was the page reviewed?	dd-mm-yyyy	Date the review was conducted.	To track the date the page was reviewed.
Webpage link	What is the website reviewed?	Add link	This link should direct specifically to the dashboard page. In some instances that is a standalone website, in others it may be found within a specific organization's page.	For referencing purposes.
Dashboard archive	Have you archived the dashboard page?	Visit: http://archive.vn/	During the assessment, "archive" the main page of the dashboard, using http://archive.vn/ and provide the http://archive.vn/xxxx link in this answer field.	To ensure a record of the dashboard on the date of the review is stored for referencing purposes as websites may change regularly.
Language of review	What language did you review the webpage in?	Specify language	Reviewers are encouraged to review the dashboard in their most proficient language. This is in addition to the question that follows with regard to the languages in which the dashboard is available.	To record the language in which the assessment and data extract is completed.
Context				
Level	What is the primary level (scale) of reporting? *Select one*	International, specify National, specify country Regional (provincial, state, county), specify and country Municipal (city, district), specify and country Other, specify	*International* refers to a multi-country webpage and the range of countries that make up the multiple countries in focus should be specified (eg, European Union, WHO African Region, South-east Asia, etc.). *National* refers to a specific country – specify the country name. *Regional* refers to the first level sub-national administrative division such as provinces, states, counties – specify the specific region of focus. *Municipality* is the second level administrative division such as a city or district – specify the name and country. Other, please specify.	This question aims to assess the primary scale of the webpage and not necessarily the type of analysis. For example, a webpage on Croatia may include international reporting from nearby countries but its primary level is national reporting on Croatia.

CONSIDERATIONS	QUESTION	ANSWER OPTIONS	DESCRIPTION	RATIONALE
Organization	Who (which) organization developed the webpage?	Full name	The full name of the organization responsible for the development of the dashboard. If in doubt, check the copyright of the website or contact details. Avoid abbreviations. Extract full name details if an independent, individual-led initiative.	To know who has developed the dashboard.
Type of organization	What is the organization type? *Select one*	International organization (eg, WHO, OECD, EU) Governmental (eg, Government of Canada) Academia (eg, John Hopkins University) News/media outlet (eg, Financial Times) Other (specify)	Select the relevant organization type. *International organizations* have a remit established in agreement with respective member states. *Governmental* is a government or state agency that exercises political authority for a specific jurisdiction be it national or subnational. *Academia* refers to scholarly organizations concerned with research and education. *News/media outlets* refers to publication or broadcast programs that feature stories through media such as newspapers, radio, television, the internet. Other, refers to any organizations that do not meet the above categories and may include individual-led initiatives or newly established groups.	This question assesses the type of organization that has developed the dashboard. The clusters may allow for analysis on differences between types of organizations. The authority of a website's owner has been found to increase trust and perceived credibility of the information [2]. Differences between organization type will be explored.
Language(s)	What are the languages the dashboard is available in and the level of completeness in each?	List, note if equivalent or partially equivalent in each	Consider (if the dashboard is available in more than one language) is the level of information equivalent in each? It may be the case only some text in other languages is translated, rather than the full page. Fully equivalent means all website content is available in an alternative language, including figures. Partially equivalent means only some of the website is available in another language, be it the text or figures.	To determine the range of languages the website is available in and the extent to which it is comparable in each.
Scope	What information does the dashboard provide or redirects to*? *Select all that apply*	Epidemiological info Infection control measures Health system management Population behavioral insights Social and economic implications Other (specify)	This question aims to gauge the range of information that is found on the dashboard or can be accessed one click away. While the dashboards predominately will provide epidemiological information, they can also be used as a resource for other types of information. These types include: *epidemiological information* relates to the transmission of COVID-10; *health system management* – information relating to the management of health system resources and non-COVID-19 services; *population behavioral insights* such as psychological, societal and cultural factors, and *social and economic implications* such as measures to support families and businesses in response to COVID-19. Select all types of information found on the dashboard reviewed, or *other* if information further to the above are listed.	WHO has identified four key types of information for responding to the pandemic [2]. A focus solely on the epidemiological context can perpetuate a narrow biomedical approach to decision-making and hinder an integrated whole-of-society approach to setting priorities [3,4]. This question aims to gauge to what extent a dashboard reports the core different types of information.

CONSIDERATIONS	QUESTION	ANSWER OPTIONS	DESCRIPTION	RATIONALE
Why				
Purpose	Is the purpose (*why* the dashboard was developed) mentioned? *Select one*	Yes, please specify No	An explicit purpose of use is defined as the clear statement of the intended decision-making task and in effect, information need, that the dashboard aims to meet [5,6]. Does the website/dashboard explain why it was developed? *Why* (the aim/purpose) a dashboard was developed (eg, to inform locals about the status of the COVID-19 outbreak in order to take the necessary precautions and be aware of changing risks) is different from a description as to *what* it is about (eg, a dashboard reporting about COVID-19 in the city of Toronto). If there is a mention of the website's purpose, extract this in full (in English). An example of a clear purpose as to why a dashboard was developed includes: "I created this site and donate my time to update it each day because I want to keep people informed, stop the virus and above all, I believe in the power of data."	A clear purpose of use is central to the actionability of data [7]. If the goal of reporting is undefined, the reporting may diminish in effect [8].
Audience (user)	Is the intended audience mentioned (who the dashboard is for) mentioned? *Select one*	Yes, please specify No	If the website explicitly states the target audience, the response is "Yes" and the text where this is stated, should be copied in English. If it is not clear the response is "No".	To be actionable, public reporting should be understood by the intended audience. In order to achieve this, the intended audience of the public reporting should be known in order to address the information needs and priorities of this group [9].
What				
Content	Which indicators are reported on the dashboard?	List all indicator titles and their variations (eg, per day, past 7 days, cumulative)	This question aims to extract the full range of indicator titles available in the dashboard. The varied ways in which the data can be disaggregated (geographically and by different population subgroups) is assessed separately as the range of break downs to follow (eg, the possibility to disaggregate by sex, age, etc.).	The selection of health care performance indicators and extent to which they respond to the information need is central to fitness for use [7]. The amount of information presented is also of importance, with evidence that "less is more" when presenting the public with information to make choices in health care [10,11].

CONSIDERATIONS	QUESTION	ANSWER OPTIONS	DESCRIPTION	RATIONALE
Data	Is the source of data explicitly noted? *Select one*	Yes, specify No	Select "Yes" if the sources of data are listed explicit either by indicator or for the page in general. These sources may include government databases, national epidemiological institutes, registries, etc. If no data source is explicitly mentioned, select "No".	How and from where data is accessed is a key consideration of use and aspects related to its quality, completeness, and aspects of trustworthiness [12].
Data	Is the metadata specified? *Select one*	Yes No	Select "Yes" if there are supplementary details (eg, as notes, footnotes, a linked additional webpage) that provide further information on the calculation of the indicators reported. Note, metadata is not 'data caveats' that provide information on how to interpret the quality of the data and what it may or may not include. This captured under 'interpretability'.	An indicator's level of standardization has known implications for the comparability and analysis of indicators [13]. Differences in the standardization of information (eg, testing, definitions of mortality and case calculations, varied practices to code COVID-19 related deaths) can lead to inaccurate comparisons when the approach to calculations are not clearly defined. The methodology for gathering data and calculating measures are critical to the accuracy, creditability and understandability of public reporting [9].
Data	How often is the data updated? Is the frequency of updates stated explicitly?	Describe	Take note of a time stamp or explicit mention of data updating frequency (eg, daily at 6:00 am).	The time-sensitive nature of indicators is a key predictor of use [7]. Time lags in gaining access to data can be a key technical barrier to meaningful action [14].
How				
Analysis	Does the analysis include a time trend? If yes, at which interval(s)? *Select all that apply*	By day By week By month No time trend Other (please specify)	This question gauges the time scale used to report the data, eg, changes per day, per week, per month. Please be sure to note <u>all</u> intervals of time used to present and/or aggregate data, and not simply the most granular scale used for a time trend.	The time interval used in analyzing data has been found a key consideration for managing an indicator's actionability [7]. The use of a time trend and interval of reporting should be informed by the indicator's intended purpose of use and users.

CONSIDERATIONS	QUESTION	ANSWER OPTIONS	DESCRIPTION	RATIONALE
Analysis	What are the levels (scales) of analysis used? *Select all that apply*	International (multi-country) National (country) Regional (province, state, county) Municipal (city, district) Neighborhood/post code Other (please specify below)	This question gauges the levels of analysis made. Eg, A national dashboard may report information on the country (national averages), state (subnational averages), and internationally (figures of comparable countries). *International* refers to an analysis across countries. *National* refers to a specific country. *Regional* refers to the first level sub-national administrative division such as provinces, states, counties. *Municipality* is the second level administrative division such as a city or district. *Neighborhood* is the third level of administration division and is typically defined by post codes. If other, specify.	The level (scale) of analysis has been found a key consideration for managing an indicator's actionability. The level to which an indicator can be disaggregated can serve as a tailoring strategy, making data more relatable to the decision-making.
Analysis	What breakdowns are possible? *Select all that apply*	Sex Age Race Ethnicity Long-term care facilities Healthcare workers (incl. long-term care workers) Mode of transmission (incl. imported and/or locally acquired) Comorbidities Socio-economic status None of the above Other (please specify below)	This question gauges the level of granularity of comparisons used in the analysis. Select the breakdowns possible for the dashboard in general. For example, a breakdown by sex may be possible for all indicators but by age only one. In this example, both age and sex should be selected as possible breakdowns as it is the possibility to assess indicators by different types of breakdowns overall that is being considered.	Disaggregating data can serve as a tailoring strategy, easing decisions by making data more relatable, for example, allowing a user to relate to a particular age cohort or ethnic group [11]. Tailoring of information has been shown to be more effective than generic, high-level information [11,15].
Visualization	How is the data visualized? *Select all that apply*	Maps Graphs/charts Tables Video/animations None of the above Other (please specify)	Take note of the way in which information is presented. *Maps* include any presentation of a land area to illustrate indicator values. *Graphs/charts* include all variations of graphs/charts, such as bar graphs, trend lines, bubble graphs, demographic graphs, etc. used to present indicator values. *Tables* include displays of day in rows and columns. *Video/animation* includes any display that is automated to be "played" to illustrate trends. Select other for all types of visualizations that do not fit the above categories but did convey information on the identified indicators.	Studies have found there is large variation in the way in which information is publicly reported [16]. A systematic review of consumers' understanding of online health performance information found that graphs were more effective in communicating quality reports than text of numbers [17].

CONSIDERATIONS	QUESTION	ANSWER OPTIONS	DESCRIPTION	RATIONALE
Interpretation	Is interpretation of the quality and/ or meaning of the data guided by contextualizing text?	Yes, to clarify the quality of the data (describe) Yes, to clarify the meaning of the data (describe) No	The degree of 'storytelling' can inform the interpretation of findings and support an understanding of what is meant and its caveats [14,18,19]. If a website provides explanation of the *quality of the data*, eg, potential differences in numbers or figures, or states how or why data is unavailable or unreliable, this should be judged as a "yes" for supporting correct interpretation of data quality. Include an example. If a website provides an explanation of what the *analysis* signals, eg, this number going down means that there are less cases each day, this should be judged as a "yes" for supporting interpretation of the meaning of the data. Note: Metadata (stating how an indicator was designed or how data was collected) should not be taken into account as interpretative text. (See previous question on metadata)	The use of plain language to clarify the positive direction of an indicator (eg, a high score is better) has been found to be effective to support the interpretation of complex information [10,20]. End users have been found to be more motivated and more likely to use and comprehend reporting when cognitive effort is reduced and the meaning of data is highlighted [11]. Indicators may be intangible and unfamiliar to users, making it unclear whether a high or a low rate is desirable [8].
Simplicity	Are simplification techniques used to support the interpretation of data?	Use of color coding (eg, traffic lights) Size variation (eg, radius of circle to show significance) Icons (eg, thumbs up, smiles, check mark for good) Other, specify	Simplification techniques are distinct from those that are related to the display (map, table, chart etc.) itself and are rather supplementary to the selected display to support the interpretation of the data by signaling a positive or negative result, trends, etc. Note: the use of colors should be specific to inform the meaning, as in one color signals better performance than another, and not simplify the use of colors for differentiating purposes.	To improve interpretation, simplification techniques can be applied [21]. As the complexity of information is lowered, users have a better understanding and ability to make informed choices [17]. The use of simplification techniques has been found to be more effective than approaches that rely on consumers to make sense of information on their own [17].

CONSIDERATIONS	QUESTION	ANSWER OPTIONS	DESCRIPTION	RATIONALE
Interactiveness	Is the data published in an interactive way? If yes, what does this interaction provide? *Select all that apply and describe*	More information, describe (eg, clicking on a map/ graph, additional info appears) Change of information, describe (eg, possible change a graph from cases to deaths) Change of display, describe (eg, move from graph to map, different type of graph etc., adjusted focus on a graph using a sliding tool) Other, describe No interactions possible	If the dashboard provides the option to change an indicator's visualization, this is considered 'interactive'. Consider if any of the listed types of interactions are possible anywhere on the dashboard. For each observed, describe what the interaction.	Personal preferences and information needs may differ by viewer, making the degree of flexibility in reporting, where users can choose more details or a summary based on their preferences preferable [17]. Interactive features in online reporting can also increase the trust and perceived credibility of health information reporting websites [1].
Actionability				
Actionability	In your expert opinion, how actionable is the dashboard? (for the intended audience or assume general public)	Please elaborate. Consider each of the considerations above with regards to what, why and how the dashboard provides information.	Consider, based on the responses above to describe the dashboard, is the dashboard fit for purpose and use by the intended audience and/or citizens (be it a specific country, region, city, or internationally)? Where citizen refers to a lay member of the public. Provide as much detail as possible to explain your interpretation on whether or not this dashboard is a useful (actionable) resource to inform their decision-making. Be sure to reflect on the dashboards in context. For example, an international dashboard should provide information for a range of countries, whereas a local dashboard should provide information on a very local level.	This appraisal of actionability is an input to a subsequent round of scoring following the further calibration of scoring among the panel of reviewers. The dashboards scored more favorably (5s) will be assessed to distill their common features. In this way, this scoring is a means to an end.
Overall score	Overall, on a scale of 1 to 5, how would you rate the actionability of this dashboard? (1=not actionable; 5=extremely)	1=Not actionable 2=Slightly actionable 3=Moderately actionable 4=Very actionable 5=Extremely actionable	Based on your reflection above, on a scale of 1 to 5, how would you rate the actionability of the dashboard? Make an initial score for each website as you review each and once you have finalized all your assigned dashboards to review, revisit this score. Is it clear out of the websites reviewed, which was must useful? Does your scoring reflect that? Note: we will review this scoring in a panel exercise to follow.	This appraisal of actionability is an input to a subsequent round of scoring following the further calibration of scoring among the panel of reviewers. The dashboards scored more favorably (5s) will be assessed to distill their common features. In this way, this scoring is a means to an end.

References

1. Sbaffi L, Rowley J. Trust and credibility in web-based health information: a review and agenda for future research. J Med Internet Res. 2017;19(6):e218.
2. WHO Regional Office for Europe. Strengthening and adjusting public health measures throughout the COVID-19 transition phases. Copenhagen: WHO Regional Office for Europe; 2020.
3. Blanchet K, Nam SL, Ramalingam B, Pozo-Martin F. Governance and capacity to manage resilience of health systems: towards a new conceptual framework. Int J Health Policy Manag. 2017;6(8):431-5.
4. OECD. Health in the 21st Century: putting data to work for stronger health systems. Paris: OECD; 2019.
5. McDowell R. Signs to look for: criteria for developing and selecting fit for purpose indicators Wellington, New Zealand: PricewaterhouseCoopers; 2017.
6. Smith P, Mossialos E, Papanicolas I. Performance measurement for health system improvement: eperiences, challenges and prospects. Copenhagen: WHO Regional Office for Europe; 2008.
7. Barbazza E, Klazinga N, Kringos D. Exploring the actionability of healthcare performance indicators for quality of care: a qualitative analysis of the literature, expert opinion and user experience. BMJ Qual Saf. 2021;30:1010–20.
8. Marshall MN, Romano PS, Davies HT. How do we maximize the impact of the public reporting of quality of care? Int J Qual Health Care. 2004;16 Suppl 1:i57–63.
9. Sandmeyer B, Fraser I. New evidence on what works in effective public reporting. Health Services Research. 2016;51 Suppl 2:1159–66.
10. Peters E, Dieckmann N, Dixon A, Hibbard JH, Mertz CK. Less is more in presenting quality information to consumers. Med Care Res Rev. 2007;64(2):169–90.
11. Hibbard JH, Peters E. Supporting informed consumer health care decisions: data presentation approaches that facilitate the use of information in choice. Annu Rev Public Health. 2003;24:413–33.
12. Raleigh VS, Foot C. Getting the measure of quality: opportunities and challenges. London: The King's Fund; 2010.
13. van den Berg MJ, Kringos DS, Marks LK, Klazinga NS. The Dutch health care performance report: seven years of health care performance assessment in the Netherlands. Health Res Policy Syst. 2014;12:1.
14. Smith P, Mossialos E, Papanicolas I, Leatherman S. Part 1: Principles of performance measurement. In: Smith P, Mossialos E, Papanicolas I, Leatherman S, editors. Performance measurement for health system improvement: experiences, challenges and prospects. Copenahgen: WHO Regional Office for Europe; 2008.
15. Kreuter MW, Holt CL. How do people process health information? Applications in an age of individualized communication. Curr Dir Psychol Sci. 2001;10(6):206–9.
16. Damman OC, van den Hengel YKA, van Loon AJM, Rademakers J. An International comparison of web-based reporting about health care quality: content analysis. J Med Internet Res. 2010;12(2):e8.

17. Kurtzman ET, Greene J. Effective presentation of health care performance information for consumer decision making: A systematic review. Patient Edu Couns. 2016;99(1):36–43.

18. Robicsek A. Six modest proposals for health care measurement. NEJM Catalyst. 2019.

19. Canadian Institute for Health Information. Better Information for Improved Health: A Vision for Health System Use of Data in Canada. Ottawa: CIHI; 2013.

20. Hibbard JH, Greene J, Daniel D. What is quality anyway? performance reports that clearly communicate to consumers the meaning of quality of care. Med Care Res Rev. 2010;67(3):275-93.

21. Ballard A. Promoting performance information use through data visualization: evidence from an experiment. Public Performance & Management Review. 2020;43(1):109-28.

Appendix 3: Public web-based COVID-19 dashboards assessed

#	D-ID	COUNTRY* (SUBREGION IF APPLICABLE)	LEVEL	ARCHIVE	ORGANIZATION	REVIEW DATE DD.MM.YYYY	COVID-19 TOTAL ON REVIEW DATE	
							Case	Deaths
1	77	Andorra	National	http://archive.vn/qs3vr	Government of Andorra	17.07.2020	855	52
2	01	Armenia	National	http://archive.vn/NPTH7	Ampop Media	21.07.2020	34,462	631
3	57	Australia	National	http://archive.vn/VtvRw	COVID Live	16.07.2020	10,810	113
4	67	Australia	National	http://archive.vn/CVeo8	Anthony Macali (Independent)	08.07.2020	8,872	106
5	95	Australia	National	http://archive.vn/o15kK	ABC News	17.07.2020	11,042	116
6	120	Australia	National	http://archive.vn/fQSn7	Australian Government, Department of Health	06.07.2020	8,586	106
7	50	Australia (Queensland)	Regional	http://archive.vn/WxSRF	Queensland Government	17.07.2020	1,071	6
8	28	Australia (Victoria)	Regional	http://archive.vn/9Moo0	Health and Human Services, Victoria State Government	07.07.2020	2,824	22
9	128	Austria	National	http://archive.vn/pAdn0	Bundesministerium für Soziales, Gesundheit, Pflege und Konsumentenschutz	16.07.2020	19,213	706
10	148	Belarus	National	http://archive.vn/ufrRR	Ministry of Health of Belarus	17.07.2020	65,782	491
11	129	Belgium	National	http://archive.vn/px6m3	Sciensano	16.07.2020	63,039	9,675
12	29	Bosnia and Herzegovina	Regional	http://archive.vn/8xm6D	Government of the Federation of Bosnia and Herzegovina, Bosnia and Herzegovina	07.07.2020	2,891	68
13	87	Brazil	National	http://archive.today/FtAC6	Ministry of Health of Brazil	12.07.2020	1,839,850	71,469
14	86	Brazil	National	http://archive.today/dH6lS	Portal GEO	12.07.2020	1,755,779	69,184
15	38	Canada	National	http://archive.vn/ujVQi	Esri Canada	13.07.2020	107,589	8,783
16	39	Canada	National	http://archive.vn/DW6Ow	Government of Canada	13.07.2020	107,590	8,783

#	D-ID	COUNTRY* (SUBREGION IF APPLICABLE)	LEVEL	ARCHIVE	ORGANIZATION	REVIEW DATE DD.MM.YYYY	COVID-19 TOTAL ON REVIEW DATE	
							Case	Deaths
17	40	Canada	National	http://archive.vn/m2dLJ	Jean-Raul R Soucy and Isha Berry (Independent)	13.07.2020	109,920	8,827
18	41	Canada	National	http://archive.vn/p7Ix2	Canadian Broadcasting Corporation	13.07.2020	108,278	8,825
19	111	Canada	National	http://archive.vn/Lqk6L	Noah Little (Independent)	18.07.2020	99,537	8,104
20	112	Canada (Alberta)	Regional	https://archive.vn/hQ9KI	Government of Alberta	18.07.2020	9,114	165
21	110	Canada (British Columbia)	Regional	http://archive.vn/Tspb3	Provincial Health Services Authority, BC Center for Disease Control	18.07.2020	3,198	189
22	113	Canada (Manitoba)	Regional	https://archive.vn/IT4SS	Government of Manitoba	18.07.2020	273	6
23	114	Canada (Montreal)	Municipal	https://archive.vn/Dfwbz	Government of Montreal	18.07.2020	27,863	3,431
24	115	Canada (New Brunswick)	Regional	http://archive.vn/xEOZI	Government of New Brunswick	20.07.2020	164	2
25	116	Canada (Newfoundland and Labrador)	Regional	http://archive.vn/xv4sw	Government of Newfoundland and Labrador	20.07.2020	262	3
26	30	Canada (Northwest Territories)	Regional	http://archive.vn/UNPBb	Government of Northwest Territories	07.07.2020	5	NA
27	58	Canada (Nova Scotia)	Regional	http://archive.vn/LOfCa	Government of Nova Scotia	16.07.2020	1,067	63
28	31	Canada (Nunavut)	Regional	http://archive.vn/HLobA	Nunavut Department of Health	07.07.2020	0	0
29	42	Canada (Ontario)	Regional	http://archive.vn/7T6MT	#HowsMyFlattening	14.07.2020	36,950	2,722
30	59	Canada (Ontario)	Regional	http://archive.vn/YtJVv	Ontario Agency for Health Protection and Promotion	16.07.2020	37,052	NA
31	70	Canada (Ontario)	Regional	http://archive.vn/1Urge	Government of Ontario	09.07.2020	36,178	2,700
32	130	Canada (Ottawa)	Municipal	http://archive.vn/3ZL3k	Ottawa Public Health	16.07.2020	2,167	263

#	D-ID	COUNTRY* (SUBREGION IF APPLICABLE)	LEVEL	ARCHIVE	ORGANIZATION	REVIEW DATE DD.MM.YYYY	COVID-19 TOTAL ON REVIEW DATE	
							Case	Deaths
33	43	Canada (Prince Edward Island)	Regional	http://archive.vn/oXtDj	Government of Prince Edward Island	13.07.2020	33	NA
34	19	Canada (Quebec)	Regional	http://archive.vn/jky19	Government of Quebec	14.07.2020	55,937	5,577
35	20	Canada (Quebec)	Regional	http://archive.vn/D3JfB on 14.07.20http://archive.vn/D3JfB	National Institute of Public Health of Quebec	14.07.2020	56,730	5,633
36	117	Canada (Saskatchewan)	Regional	http://archive.vn/kVUii	Government of Saskatchewan	20.07.2020	943	15
37	44	Canada (Toronto)	Municipal	http://archive.vn/NoyJh	City of Toronto	14.07.2020	14,735	1,110
38	118	Canada (Vancouver)	Municipal	http://archive.vn/jPIlp	City of Vancouver	20.07.2020	NA	NA
39	45	Canada (Yukon)	Regional	http://archive.vn/cG5a0	Government of Yukon	13.07.2020	15	NA
40	79	Chile	National	http://archive.vn/FND66	Chilean Government	17.07.2020	323,698	7,290
41	105	China	National	http://archive.vn/2oPeq	Tencent Holdings Ltd.	14.07.2020	85,671	5,649
42	106	China	National	http://archive.vn/F8Qqf	NetEase	15.07.2020	85,696	4,649
43	107	China	National	http://archive.vn/utd4M	DXY	17.07.2020	NA	NA
44	138	China	National	http://archive.vn/HGVWY	Chinese Center for Disease Control and Prevention	11.07.2020	85,487	4,648
45	139	China	National	http://archive.vn/q7aLz	Sina News	17.07.2020	85,840	4,652
46	140	China	National	http://archive.vn/Tg14i	Baidu Inc.	17.07.2020	85,840	4,651
47	09	Costa Rica	National	http://archive.today/2020.07.14-100448/http://geovision.uned.ac.cr/oges/	Costa Rican Ministry of Health, Geographical Health Observatory	13.07.2020	8,036	NA
48	10	Costa Rica	National	http://archive.today/2020.07.14-100758/https://oddapp2.shinyapps.io/CoronavirusCostaRica/	University of Costa Rica	13.07.2020	8,036	NA
49	80	Costa Rica	National	https://archive.vn/8Spsq	Escuela de Ciencias Geográficas Universidad Nacional	17.07.2020	9,546	NA

#	D-ID	COUNTRY* (SUBREGION IF APPLICABLE)	LEVEL	ARCHIVE	ORGANIZATION	REVIEW DATE DD.MM.YYYY	COVID-19 TOTAL ON REVIEW DATE	
							Case	Deaths
50	21	Cote d'Ivoire	National	http://archive.vn/nnYbl	AFRIX	17.07.2020	13,554	87
51	31	Croatia	National	http://archive.vn/pRybd	Government of the Republic of Croatia	07.07.2020	3,272	113
52	46	Denmark	National	http://archive.vn/zzVm9	State Serum Institute	13.07.2020	13,037	610
53	96	Denmark	National	http://archive.vn/9rlyG	Danish Health Authority	17.07.2020	13,124	610
54	81	Estonia	National	http://archive.vn/XxB8q	Independent	17.07.2020	2,016	69
55	141	Finland	National	http://archive.vn/IznaE	Finnish Institute for Health and Welfare (THL)	17.07.2020	7,361	NA
56	22	France	National	http://archive.vn/7O2ib	Government of France	15.07.2020	NA	NA
57	23	France	National	http://archive.vn/nhsHy	Santé Publique France (Public Health France)	16.07.2020	NA	NA
58	24	France	National	http://archive.vn/E8RSW	Politologue.com	16.07.2020	213,302	30,138
59	132	Germany	National	http://archive.vn/wQLbJ	Robert Koch-Institut	16.07.2020	200,260	9,078
60	135	Germany	National	http://archive.vn/JF9dW	Berliner Morgenpost	16.07.2020	201,450	9,087
61	131	Germany (Bavaria)	Regional	http://archive.vn/W0ASm	Bayerisches Landesamt für Gesundheit und Lebensmittelsicherheit	16.07.2020	49,522	2,610
62	133	Germany (Hamburg)	Municipal	http://archive.vn/9gDMO	City of Hamburg	16.07.2020	5,231	NA
63	47	Greenland (Kingdom of Denmark)	Regional	http://archive.vn/DV4aX	Government of Greenland	13.07.2020	13	0
64	108	Hong Kong	Regional	http://archive.vn/M70Ve	Development Bureau, Lands Department, Smart City Consortium	17.07.2020	1,656	10
65	88	Hungary	National	http://archive.today/tJcw7	Government of Hungary	13.07.2020	NA	235
66	51	Indonesia	National	http://archive.vn/tuJPH	Government of Indonesia	17.07.2020	83,130	3,957
67	53	Indonesia	National	http://archive.vn/kV4Je	KawalCOVID19	22.07.2020	88,214	4,239

#	D-ID	COUNTRY* (SUBREGION IF APPLICABLE)	LEVEL	ARCHIVE	ORGANIZATION	REVIEW DATE DD.MM.YYYY	COVID-19 TOTAL ON REVIEW DATE	
							Case	Deaths
68	52	Indonesia (Central Java)	Regional	http://archive.vn/BIMIA	Government of Central Java	18.07.2020	6,963	599
69	92	Ireland	National	http://archive.today/7araW	Government of Ireland	12.07.2020	25,638	1,746
70	71	Italy	National	http://archive.vn/1nAq6	Department of Civil Protection	09.07.2020	35,708	35,587
71	76	Italy	National	http://archive.vn/JtfvM	Italian National Institute of Health	10.07.2020	NA	NA
72	150	Kazakhstan	National	http://archive.vn/ayFmB	Kazinform	17.07.2020	66,895	374
73	151	Kazakhstan	National	http://archive.vn/nTuiH	National Center for Public Health	17.07.2020	63,514	375
74	153	Kyrgyzstan	National	http://archive.vn/UsuGE	Ministry of Health of Kyrgyz Republic	17.07.2020	13,101	172
75	158	Kyrgyzstan	National	http://archive.vn/QPLQo	Nm4h	17.07.2020	13,101	172
76	122	Luxembourg	National	http://archive.vn/bFcLC	The Luxembourg Government	08.07.2020	4,603	110
77	55	Malaysia	National	http://archive.vn/xB8eM	Government of Malaysia	22.07.2020	6,941	113
78	123	Malta	National	http://archive.vn/UBjWp	Ministry of Health of Malta	08.07.2020	673	9
79	14	Mexico	National	http://archive.today/2020.07.16-230211/https://coronavirus.gob.mx/fHDMap/mun.php	Government of Mexico	16.07.2020	NA	NA
80	16	Mexico	National	http://archive.today/2020.07.17-120351/https://covid19.sinave.gob.mx/mapaestimados.aspx	Ministry of Health of Mexico	17.07.2020	48,857	NA
81	15	Mexico (Mexico City)	Municipal	http://archive.today/2020.07.17-103808/https://hospitales.covid19.cdmx.gob.mx/public/hospitales/EstatusHospitales.xhtml?tamizajeRealizado=true	Ministry of Health of Mexico City	17.07.2020	NA	NA
82	33	Montenegro	National	http://archive.vn/1FC5J	Public Health Institute of Montenegro	07.07.2020	841	14

#	D-ID	COUNTRY* (SUBREGION IF APPLICABLE)	LEVEL	ARCHIVE	ORGANIZATION	REVIEW DATE DD.MM.YYYY	COVID-19 TOTAL ON REVIEW DATE	
							Case	Deaths
83	25	Morocco	National	http://archive.vn/SC0pu	Ministry of Health	17.07.2020	16,638	263
84	124	Netherlands	National	http://archive.vn/7O4Z7	National Institute for Public Health and the Environment (RIVM)	08.07.2020	NA	NA
85	125	Netherlands	National	http://archive.vn/GSsQG	The Netherlands Institute for Health Services Research (Nivel)	10.07.2020	NA	NA
86	137	Netherlands	National	http://archive.vn/IBh0Q	Rijksoverheid	16.07.2020	NA	NA
87	61	New Zealand	National	http://archive.vn/MNW86	New Zealand Environmental Science and Research Institute	17.07.2020	1,549	22
88	62	New Zealand	National	http://archive.vn/zpKDU	New Zealand Ministry of Health – Manatū Hauora	17.07.2020	1,548	22
89	63	New Zealand	National	http://archive.vn/8Llz2	Stats NZ	17.07.2020	NA	22
90	100	Norway	National	http://archive.vn/yv3FO	Norwegian Directorate of Health	17.07.2020	NA	NA
91	101	Norway	National	http://archive.vn/ybdAv	Norwegian Institute of Public Health	17.07.2020	9,011	254
92	56	Philippines	National	http://archive.vn/fuyCK	Government of Philippines	23.07.2020	NA	NA
93	93	Portugal	National	http://archive.today/ZqkTI	Directorate-General of Health	14.07.2020	46,818	1,662
94	04	Republic of Moldova	National	http://archive.vn/74MwO	Ministry of Health, Labour and Social Protection	20.07.2020	20,980	688
95	05	Romania	National	http://archive.vn/xZCf2	National Institute for Public Health	21.07.2020	38,139	2,038
96	06	Romania	National	https://archive.vn/F6Ap3	Code for Romania	20.07.2020	38,139	2,038
97	07	Romania	National	http://archive.vn/ro9Eq	Romanian Ministry of Interior	21.07.2020	38,139	2,038
98	154	Russian Federation	National	http://archive.vn/7sO5i	Ministry of Health of Russian Federation and Federal Service for Supervision of Consumer Rights Protection and Human Well-Being	17.07.2020	759,203	12,123

#	D-ID	COUNTRY* (SUBREGION IF APPLICABLE)	LEVEL	ARCHIVE	ORGANIZATION	REVIEW DATE DD.MM.YYYY	COVID-19 TOTAL ON REVIEW DATE	
							Case	Deaths
99	155	Russian Federation	National	http://archive.vn/lgCmt	Ministry of Health of Russian Federation	17.07.2020	752,797	11,937
100	26	Senegal	National	http://archive.vn/SC0pu	Ministry of Health	17.07.2020	8,544	160
101	34	Serbia	National	http://archive.vn/4bOrf	Serbian Ministry of Health and the Institute of Public Health of Serbia “Dr Milan Jovanovic Batut”	07.07.2020	16,719	330
102	35	Slovakia	National	http://archive.vn/d5VgU	Ministry of Health of the Slovak Republic	07.07.2020	1,767	28
103	72	Slovenia	National	http://archive.vn/szM4d	Sledilnik.org	09.07.2020	1,776	111
104	73	Slovenia	National	http://archive.vn/qQlLH	National Institute of Public Health	09.07.2020	1,776	111
105	74	Slovenia	National	http://archive.vn/eaxEk	Government Communication Office	09.07.2020	NA	NA
106	75	Slovenia	National	https://archive.vn/RZlgE	Matej Kovačič, Tomaž Korenika and Tine Mezgec (Independent)	09.07.2020	NA	NA
107	144	Singapore	National	http://archive.vn/64Plt	Ministry of Health of Singapore	17.07.2020	43,577	27
108	145	South Korea	National	http://archive.vn/aMu3a	Corona Board	17.07.2020	13,672	293
109	17	Spain	National	http://archive.today/2020.07.17-123630/https://cnecovid.isciii.es/covid19/	National Center of Epidemiology	17.07.2020	NA	NA
110	83	Spain	National	http://archive.vn/87f2J	Corporación de Radio y Televisión Española	17.07.2020	258,855	28,416
111	146	Sweden	National	http://archive.vn/fG42h	Swedish Intensive Care Registry (SIR)	17.07.2020	NA	NA
112	147	Sweden	National	https://archive.vn/tfGbi	Public Health Agency of Sweden (Folkhälsomyndigheten)	17.07.2020	77,281	5,619
113	36	Switzerland	National	http://archive.vn/LmvZG	Independent	08.07.2020	1,518	11
114	136	Switzerland	National	http://archive.vn/PbPNU	Bundesamt für Gesundheit BAG	16.07.2020	33,290	1,688

#	D-ID	COUNTRY* (SUBREGION IF APPLICABLE)	LEVEL	ARCHIVE	ORGANIZATION	REVIEW DATE DD.MM.YYYY	COVID-19 TOTAL ON REVIEW DATE	
							Case	Deaths
115	27	Switzerland (Vaud)	Regional	http://archive.vn/9qbXP	County of Vaud	16.07.2020	NA	NA
116	119	Taiwan	Regional	http://archive.vn/80iSm	Taiwan CDC	20.07.2020	513	5
117	156	Tajikistan	National	http://archive.vn/DYZCL	Ministry of Health and Social Protection of the Republic of Tajikistan	17.07.2020	6,786	56
118	102	Turkey	National	https://archive.vn/ZJCKw	Ministry of Health of Turkey	17.07.2020	216,873	5,440
119	48	United Kingdom	National	http://archive.vn/3Qymk	University of Oxford and Royal College of General Practitioners	14.07.2020	NA	NA
120	64	United Kingdom	National	http://archive.vn/q5ilb	Public Health England	17.07.2020	292,552	45,119
121	65	United Kingdom	National	http://archive.vn/JLwQH	British Broadcasting Association	17.07.2020	292,552	45,119
122	08	United States	National	http://archive.vn/TExg1	Centres for Disease Control and Prevention	22.07.2020	3,761,362	140,157
123	18	United States	National	http://archive.today/2020.07.16-003040/https://covidtracking.com/data	The COVID Tracking Project (The Atlantic)	17.07.2020	3,478,419	129,595
124	49	United States	National	http://archive.vn/7hgsL	COVID Act Now	14.07.2020	NA	NA
125	37	United States (California)	Regional	http://archive.vn/u41FC	California State Government	08.07.2020	277,774	6,448
126	94	United States (Colorado)	Regional	http://archive.today/I3yam	Colorado Department of Public Health and Environment	14.07.2020	37,242	1,589
127	126	United States (Florida)	Regional	http://archive.vn/ZzNtp	Department of Health Florida	10.07.2020	232,718	4,009
128	103	United States (Maryland)	Regional	http://archive.vn/up0WC	Maryland Department of Health	17.07.2020	75,664	3,215
129	104	United States (New York State)	Regional	http://archive.vn/hq6td	New York State	17.07.2020	NA	NA
130	85	United States (New York City)	Municipal	http://archive.vn/o1Ngx	NYC Health Department	17.07.2020	217,230	18,754

#	D-ID	COUNTRY* (SUBREGION IF APPLICABLE)	LEVEL	ARCHIVE	ORGANIZATION	REVIEW DATE DD.MM.YYYY	COVID-19 TOTAL ON REVIEW DATE	
							Case	Deaths
131	66	United States (Los Angeles)	Regional	http://archive.vn/QBXTE	Los Angeles County Department of Public Health	17.07.2020	139,841	3,731
132	127	United States (Washington State)	Regional	http://archive.vn/94G5T	Washington State Department of Health	13.07.2020	38,581	1,409
133	157	Uzbekistan	National	http://archive.vn/LwOPM	Ministry of Healthcare of the Republic of Uzbekistan	17.07.2020	15,482	77
134	121	Africa	International	http://archive.vn/zlivC	WHO Regional Office for Africa	08.07.2020	NA	NA
135	12	Europe and Central Asia	International	http://archive.vn/2020.07.14-130813/https://who.maps.arcgis.com/apps/opsdashboard/index.html%23/ead3c6475654481ca51c248d52ab9c61	WHO Regional Office for Europe	14.07.2020	2,956,087	204,061
136	54	South-East Asia	International	http://archive.vn/0DLK8	WHO Regional Office for South-East Asia	22.07.2020	88,214	4,239
137	109	Western Pacific	International	http://archive.vn/N2b8i	WHO Regional Office for Western Pacific	17.07.2020	254,236	7,879
138	02	Global	International	http://archive.vn/UWv29	Avi Schiffmann (Independent)	21.07.2020	14,867,503	613,550
139	03	Global	International	http://archive.vn/HANQA	Visa List	20.07.2020	14,510,000	606,200
140	11	Global	International	http://archive.today/2020.07.14-101318/https://coronavirus.1point3acres.com/en	1Point3Acres	14.07.2020	13,103,290	573,042
141	13	Global	International	http://archive.today/2020.07.16-222335/http://www.ihi.org/Topics/COVID-19/Pages/COVID-19-Data-Dashboard.aspx	Institute for Healthcare Improvement	16.07.2020	NA	NA
142	60	Global	International	http://archive.vn/3govA	The New York Times	16.07.2020	13,330,200	578,800
143	68	Global	International	http://archive.vn/SCIfy	Johns Hopkins University	08.07.2020	11,856,991	544,871
144	69	Global	International	http://archive.vn/STFQO	Corona Tracker	08.07.2020	11,995,641	547,592
145	78	Global	International	http://archive.vn/qrJbw	Deloitte.	17.07.2020	NA	NA

#	D-ID	COUNTRY* (SUBREGION IF APPLICABLE)	LEVEL	ARCHIVE	ORGANIZATION	REVIEW DATE DD.MM.YYYY	COVID-19 TOTAL ON REVIEW DATE	
							Case	Deaths
146	82	Global	International	http://archive.vn/nz2oO	London School of Hygiene and Tropical Medicine	17.07.2020	13,805,296	589,911
147	84	Global	International	http://archive.vn/RBrv0	Financial Times	17.07.2020	NA	NA
148	89	Global	International	http://archive.today/uccB1	Humanistic GIS Lab at University of Washington	13.07.2020	NA	NA
149	90	Global	International	http://archive.today/UFPKo	AccuWeather	13.07.2020	12,910,231	569,123
150	91	Global	International	http://archive.today/g1EGt	European Commission	13.07.2020	NA	NA
151	97	Global	International	http://archive.vn/FC1yH	Worldometer	17.07.2020	13,967,833	593,100
152	98	Global	International	http://archive.vn/KK2cS	The Institute for Health Metrics and Evaluation	17.07.2020	NA	629,995
153	99	Global	International	http://archive.vn/fJ9tk	Prof. Wade Fagen-Ulmschneider (Independent)	17.07.2020	NA	NA
154	134	Global	International	http://archive.vn/rEwvE	University of Oxford	16.07.2020	NA	NA
155	142	Global	International	http://archive.vn/yPffj	European Centre for Disease Prevention and Control	17.07.2020	13,788,300	589,688
156	143	Global	International	http://archive.vn/Kq0az	World Health Organization	17.07.2020	13,615,593	585,727
157	149	Global	International	http://archive.vn/lLkqP	Yandex	17.07.2020	13,044,248	577,885
158	152	Global	International	http://archive.vn/Z5WeI	Radio Ozodi	17.07.2020	13,872,566	591,342

*Country status according to WHO classification https://www.who.int/choice/demography/by_country/en/
NA: not available (not specified or available through archiving); D-1D: dashboard identifier

Appendix 4: Illustrative indicator titles by themes

Note: *Throughout, D-ID refers to dashboard identifiers in Appendix 3.

I. Public health and epidemiological

THEME	ILLUSTRATIVE INDICATOR	EXAMPLE D-ID*
Spread and death		
Cases (all confirmed cases)	All confirmed cases	1-12, 14, 16-22, 24-47
Active cases	Total active cases	81, 82, 121-123, 139, 140,
Recovered (healed, cured)	Total recovered	44, 47, 50-53, 87-91
Deaths	Total deaths; number of confirmed deaths	33-47, 64-99
Mortality rate (case fatality rate)	Lethality rate	9, 68, 87, 96
Reproduction rates (Rt) (viral reproduction, attack rate)	Instantaneous reproductive num (Rt); Reproduction rate R	17, 22, 135, 137, 151
Doubling rate	Cases doubling; doubling rate	3, 12, 17,
Future projections/risk models	Scenario projections	10, 11, 19, 49, 98
Testing		
Testing (total number tested, PCR tests)	Total number of tests	7, 10, 63
	New tests	18
Testing rates (positivity, negative tests)	Persons tested positive and negative	66
	Number of samples and anlyses carried out, negative and positive cases	19
Tests-pending results	Suspected case	138
	Number of suspected cases assessed by medic in person	72
	Number of laboratorial results pending	93
	Testing turn around < 24 h	42
COVID-19 antibody tests (serology tests)	Serology (antibody) surveillance in US	8
Risk management		
Self-quarantine (isolation notices)	Number of people released from isolation	103
	Confirmed cases in epidemiological surveillance by health authorities	93
	Number of people in quarantine	88
	Managed isolation cases	62
	Quarantine and managed isolation figures	63
Contact tracing	Contacts reached within 24 hours	131
	COVID-19 check app responses (daily, cumulative)	123

II. Health system management

THEME	ILLUSTRATIVE INDICATOR	EXAMPLE D-ID
Hospital care		
Hospitalized (admissions, discharge, under treatment)	Total number of patients released from hospital	7
	Total number of hospitalizations	8, 10, 18, 19, 37
	Evolution of the number of current COVID-19 related hospitalizations in Quebec by the type of hospital stay	20
	Total number of patients under treatment	26
Admitted to ICU (critical condition)	Number of COVID-19 patients in ICU	9, 10, 37
	Proportion of all hospitalizations admitted to the ICU	39
On a ventilator	Number of patients on a respirator	34, 42, 66, 79, 100, 102, 127
	Hospitalizations requiring medical ventilation	39
	Current interventions (% and number intubated)	44
	Estimated bed/ICU bed/ventilator use (per day)	98
Health system capacity		
Hospital bed capacity (availability)	Percent of hospital beds used	10
	General care bed availability	15, 37, 128
	Hospital bed occupancy rate	22, 44, 56, 79, 130
	Hospital capacity	51
	Available hospital beds occupied by confirmed and suspected COVID patients	94
ICU bed capacity	Percent of ICU beds used (occupied)	10, 130, 135
	Intensive care unit (bed with ventilator) availability	15, 128, 37, 56
	Total ICU beds occupied; ICU beds left	42
	ICU bed occupancy rate	44
	Potential/anticipated shortage of ICU beds	94
Ventilator capacity (available ventilators)	Ventilators available (percentage)	37
	Ventilators left	42, 79
	ICU-ventilator bed occupancy rate	44, 130
Personal protective equipment (PPE) and testing stock	Laboratory capacity	51
	Equipment distributed (N-95, respirators, procedure masks, gowns, face shields, gloves) in absolute numbers	37
	Estimated number of days of PPE available in Toronto hospitals (N95 masks, surgical masks, PPE eyewear, gloves)	44
Non-COVID service usage	Rate of ER admissions (daily, weekly, men, women) Rate of hospitalizations Rate of medical acts; number of COVID related medical acts; number of medical acts for all causes	23
	Emergency department visits	85
	Accident and emergency waiting times	108

III. Social and economic impact

THEME	ILLUSTRATIVE INDICATOR (SOURCE)	EXAMPLE D-ID
Employment and hardship relief	Unemployment rate (monthly)	78
	Monthly online job advertisements index (Ministry of Business, Innovation and Employment)	63
	Special needs grants for food (Ministry of Social Development)	63
	Temporary additional support and special benefit (Ministry of Social Development)	63
	Tenants of private single room occupancy hotels or low-income housing receiving daily food support	118
	Weekly job postings by sector (Burning Glass Data)	42
	Top ten aid from solidarity fund broken down by classification of economic activities (in million €) (Inter-ministerial Digital Directorate)	22
	Childcare for essential workers (cumulative)	118
Transport, trade and international travel	Customs daily border crossing - arrivals (New Zealand Customs Service)	63
	Total number of people on student visa; work visa (Ministry of Business, Innovation and Employment)	63
	Manufacturing shipments (monthly) (Statistics Canada/Haver Analytics)	78

IV. Behavioral insights

THEME	ILLUSTRATIVE INDICATOR (SOURCE)	EXAMPLE D-ID
Self-reported adherence to restrictions	Prevalence of systematic adoption of wearing a mask in public during the COVID-19 epidemic (%; weighted data) (CoviPrev survey)	23
	In the past 7 days, how often did you practice physical distance with individuals outside your social circle (EKOS Polling)	130
	In the past 7 days, how often did you gather with individuals outside your social circle (EKOS Polling)	130
	In the past 7 days, how often did you use a mask in indoor public places (EKOS Polling)	130
Observed public adherence to restrictions	7-day average percentage change in routing (direction) requests since January 13, 2020 by driving, transit, walking (Apple Mobility)	42
	Percentage change in number of visits to various locations (grocery and pharmacy, parks, residential, retail and recreational, transit stations, workplace) in Ontario compared to baseline value (Google Mobility)	42
	COVID-19 property-use complaints received by 3-1-1 (hotline) (total)	118
	Warnings issued about physical distancing in parks and beaches (total)	118
	Vehicle traffic in and out of Vancouver compared to same week in 2019	118
	Bicycle traffic at key locations compared to same week in 2019	118
	Pedestrian traffic at key locations compared to same week in 2019	118
Self-reported health and well-being status	Respondents who said their overall wellbeing at the current alert level is worse than usual (New Zealand Health Survey)	63
	Percent of respondents who reported experiencing a COVID-19 related scam, over the past 7 days (New Zealand Health Survey)	63
	Respondents’ ability to meet bills and other financial commitments over next 3 months (New Zealand Health Survey)	63
	Respondents who felt lonely or isolated at least a little of the time over the past 7 days (New Zealand Health Survey)	63
	Respondents who said they are either somewhat or completely satisfied with life these days (New Zealand Health Survey)	63

Appendix 5: Summary of dashboard scoring

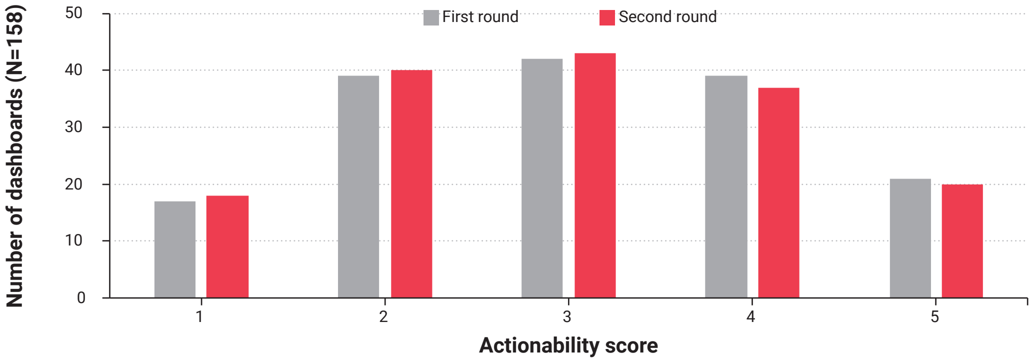
Table A5.1. Distribution of scoring across the panel of scorers

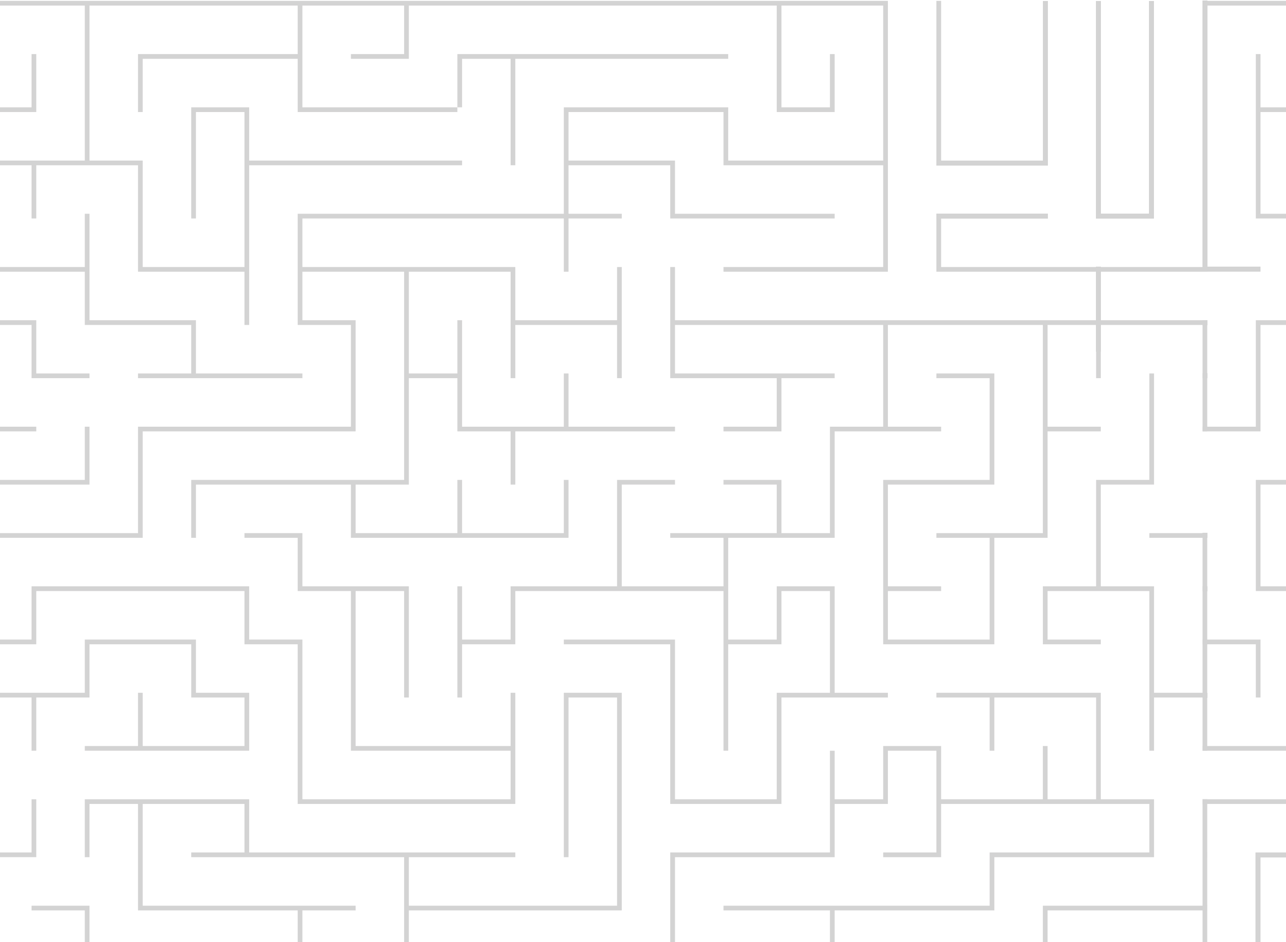
🟥 Mean score lower ⬜ Mean score the same 🟩 Mean score increased

PANEL OF SCORERS	# OF DASHBOARDS REVIEWED	MEAN SCORE[a] ROUND ONE	MEAN SCORE[a] ROUND TWO
1	10	4.30	4.10
2	10	3.90	3.80
3	5	3.80	3.70
4	9	3.67	3.60
5	10	3.50	3.44
6	12	3.42	3.30
7	8	3.25	3.25
8	10	3.10	3.08
9	10	3.00	2.90
10	8	2.75	2.78
11	7	2.71	2.75
12	10	2.70	2.70
13	9	2.67	2.60
14	10	2.60	2.60
15	10	2.40	2.57
16	9	2.22	2.44
17	11	2.09	1.81
Total	**158**	**3.09**	**3.02**

[a] The range in mean scores (1.81, 4.10) may be accounted for in part by the sample of dashboards assigned to each panelist. This distribution was determined by the language competencies of panelists and therefore, the set of dashboards reviewed typically reflected a specific sub-set of countries or region.

Fig. A5.1. Distribution of scores in round one and two of scoring





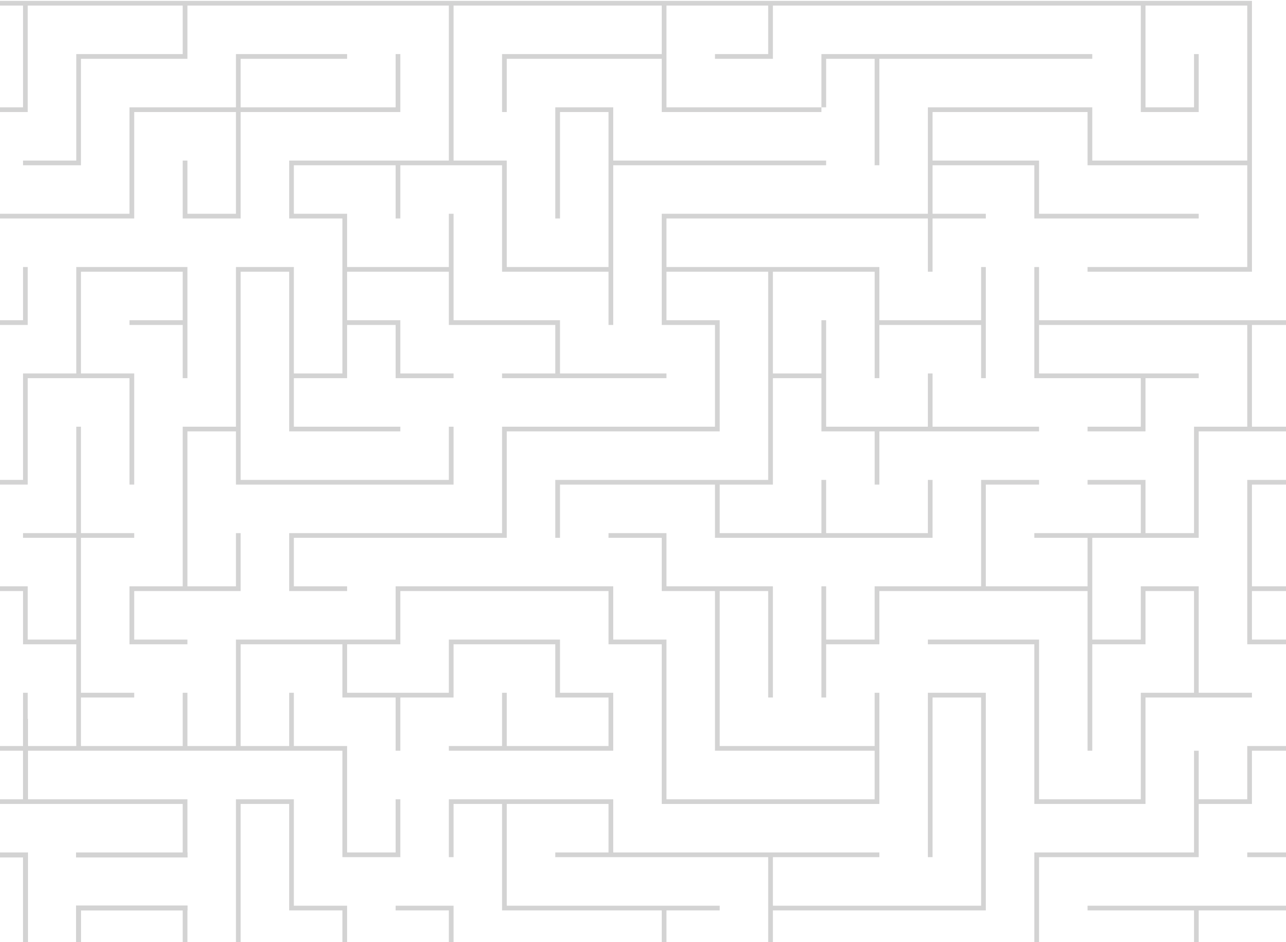
Chapter 6

Exploring changes to the actionability of COVID-19 dashboards over the course of 2020 in the Canadian context

This chapter was published as:

Barbazza E*, Ivanković D*, Wang S, Jamieson Gilmore K, Poldrugovac M, Willimington C, Larrain N, Bos V, Allin S, Klazinga K, Kringos D. Exploring Changes to the Actionability of COVID-19 Dashboards Over the Course of 2020 in the Canadian Context: Descriptive Assessment and Expert Appraisal Study. J Med Internet Res. 2021;23(8):e30200.

*these authors contributed equally



Abstract

Background

Public web-based COVID-19 dashboards are in use worldwide to communicate pandemic-related information. Actionability of dashboards, as a predictor of their potential use for data-driven decision-making, was assessed in a global study during the early stages of the pandemic. It revealed a widespread lack of features needed to support actionability. In view of the inherently dynamic nature of dashboards and their unprecedented speed of creation, the evolution of dashboards and changes to their actionability merits exploration.

Objective

We aimed to explore how COVID-19 dashboards evolved in the Canadian context during 2020 and whether the presence of actionability features changed over time.

Methods

We conducted a descriptive assessment of a pan-Canadian sample of COVID-19 dashboards (N=26), followed by an appraisal of changes to their actionability by a panel of expert scorers (N=8). Scorers assessed the dashboards at two points in time, July and November 2020, using an assessment tool informed by communication theory and health care performance intelligence. Applying the nominal group technique, scorers were grouped in panels of three, and evaluated the presence of the seven defined features of highly actionable dashboards at each time point.

Results

Improvements had been made to the dashboards over time. These predominantly involved data provision (specificity of geographic breakdowns, range of indicators reported, and explanations of data sources or calculations) and advancements enabled by the technologies employed (customization of time trends and interactive or visual chart elements). Further improvements in actionability were noted especially in features involving local-level data provision, time-trend reporting, and indicator management. No improvements were found in communicative elements (clarity of purpose and audience), while the use of storytelling techniques to narrate trends remained largely absent from the dashboards.

Conclusions

Improvements to COVID-19 dashboards in the Canadian context during 2020 were seen mostly in data availability and dashboard technology. Further improving the actionability of dashboards for public reporting will require attention to both technical and organizational aspects of dashboard development. Such efforts would include better skill-mixing across disciplines, continued investment in data standards, and clearer mandates for their developers to ensure accountability and the development of purpose-driven dashboards.

Introduction

The public reporting of data during a pandemic is a core government function to protect population health and safety [1-3]. It is also critical for fostering accountability, ensuring transparency, and supporting individuals in making informed decisions [4-6]. Unlike past pandemics, COVID-19 has been monitored globally in real-time, resulting in unprecedented collection, analysis, and dissemination efforts.

Public web-based COVID-19 dashboards, as a dynamic means to visually display information at a glance [7], have surged as a popular approach for sharing pandemic-related information. Dashboards are powerful vehicles for communication; the Johns Hopkins Coronavirus Resource Center dashboard [8] reported more than 1 billion interactions per day by April 2020 [9]. However, without careful indicator selection and data collection, analysis, and visualization, dashboards have the potential to mislead, misinform, and incite panic [10,11], or simply to be ignored [12].

In the first half of 2020, our international research network of European and Canadian professionals in health care performance intelligence [13] launched a global study of COVID-19 dashboards. It assessed 158 dashboards from 53 countries in July 2020. It also explored what makes dashboards *actionable*, whereby actionability refers to a dashboard's potential to inform decision-making by the intended users [14]. More specifically, to be actionable, the information should be both *fit for purpose* (meeting a specific information need) and *fit for use* (placing the right information into the right hands at the right time and in a manner that can be understood) [14]. Only 12.7% (20/158) of dashboards evaluated in the mid-2020 study were found to be highly actionable. Seven actionability features were identified among them [15].

Due to the speed in which the dashboards were first launched, traditional technical and organizational aspects of development cycles were cut short [16]. While the urgency of reporting took precedent in the early stages, dashboards are designed to be flexible and continuously iterated. Studies also emphasize the importance of frequent reviews to ensure a dashboard's sustained relevance and use [16,17]. As our initial study was merely a snapshot of the early stages of the pandemic, the extent to which COVID-19 dashboards evolved over a longer period was beyond its scope.

Canada provides a relevant context for further investigating the evolution of COVID-19 dashboards for several reasons. First, public health is the remit of federal, provincial or territorial (PT), and local health authorities [18], which, together with PT ministries, are involved in pandemic monitoring and reporting. This was already reflected in Canada's 2018 multi-actor pandemic preparedness plans (for influenza) [19]. In addition to those varied public actors, independent initiatives and the media have also leveraged open data sources in order to generate public-facing COVID-19 dashboards. The range in the types of organizations, and their different target geographies of reporting, have resulted in a diverse Canadian dashboard landscape.

Second, Canada's experience with COVID-19 intensified in the course of 2020, with an initial peak in early May (about 2500 daily cases) and second peak in November (about 8000 daily cases) [20]. Cases spread to areas of Canada previously untouched by the virus [21]. As a result, the demand for dashboards that provide effective communication and support data-driven decision-making increased throughout the year.

Third, Canadian dashboards were criticized early on for possible information blind spots, including a failure to report race-based data and other social determinants [22,23], as well as for presenting highly aggregated data at the PT level [10,24,25]. The extent to which such limitations persisted into the second half of 2020 had yet to be assessed.

This study explores (1) how public web-based COVID-19 dashboards in the Canadian context evolved in 2020 and (2) whether dashboard actionability increased over time.

Methods

Study design

Our study adheres to the Standards for Reporting Qualitative Research [26]. We applied qualitative methods comprising (1) a descriptive assessment applying an existing tool [15] for the purposes of systematically and comparatively depicting COVID-19 dashboards; and (2) an expert appraisal using the nominal group technique [27,28] to score the actionability of the dashboards. The study draws on the global sample of 158 dashboards examined in the study by Ivanković et al [15], now confining the focus to dashboards reporting on COVID-19 in the Canadian context (N=26). Importantly, we extended data collection for this sample by collecting data at a second time point, in order to analyze changes between July 2020 (initial assessment) and November 2020 (second assessment). Subsequently, we evaluated the presence of the actionability features identified in the study by Ivanković et al [15] across the sample for both time points.

Panel of scorers

Data collection was conducted by a panel of eight scorers (EB, DI, SW, KJG, MP, CW, NL, and VB). The panel (four women and four men) aligned with the scorers assembled by Ivanković et al [15] so as to ensure consistency between assessments. The scorers were drawn from an existing international research network of Canadian, European, Latin American, and Asian researchers, each conducting their doctoral research on health care performance intelligence [13]. All scorers had common expertise and training in dealing with health care performance data and in the use of such data for management and governance, as well as prior training and experience with the study's assessment tool. The panel's composition also included French-language competencies (CW) and prior professional policy and research experience in the Canadian context (EB, DI, SW, KJG, MP, and VB).

Assessment instruments

An assessment tool developed, piloted, and validated by Ivanković et al [15] was applied. The tool assesses COVID-19 dashboards in terms of their purpose and users ("why"), content and data ("what"), and analyses and displays ("how"). Table 1 summarizes the considerations assessed. These derive from communication sciences (the 1948 Lasswell model [29]), the health care performance intelligence discipline [14], earlier studies on the public reporting of health performance data and provision of dashboards in the health domain [30-34], and guidance for reporting during public health crises from the World Health Organization (WHO) [1]. The tool also aligns with existing instruments to measure the quality of health information on the internet [35,36].

Table 1. Overview of considerations by the method applied

METHOD	INSTRUMENT	CONSIDERATIONS ASSESSED/SCORED: GUIDING QUESTIONS/ STATEMENTS
Descriptive assessment	Assessment tool[a]	• Purpose and audience: Is the purpose and audience mentioned? • Indicator themes: What indicators are reported on? • Data: Are data sources and metadata specified? • Types of analysis: Does the analysis include time trends, and geographic and population break downs? • Presentation: How is data visualized, interpreted, simplified, and interacted with?
Expert appraisal	Seven features of highly actionable dashboards-scoring tool[b]	• Know the audience and their information needs: The intended audience and their information needs are known and responded to. • Manage the type, volume, and flow of information: The type, volume, and flow of information on the dashboard are well managed. • Report data sources and methods clearly: The data sources and methods for calculating values are made clear. • Link time trends to policy decisions: Information is reported over time and contextualized with policy decisions made. • Provide data “close to home”: Data are reported at relevant geographic break downs. • Break down the population to relevant subgroups: Data are reported by relevant population subgroups. • Use storytelling and visual cues: Brief narratives and visual cues are used to explain the meaning of data.

[a] Refer to the study by Ivanković et al [15] for the full assessment tool.
[b] Refer to Appendix 1 for the full scoring tool.

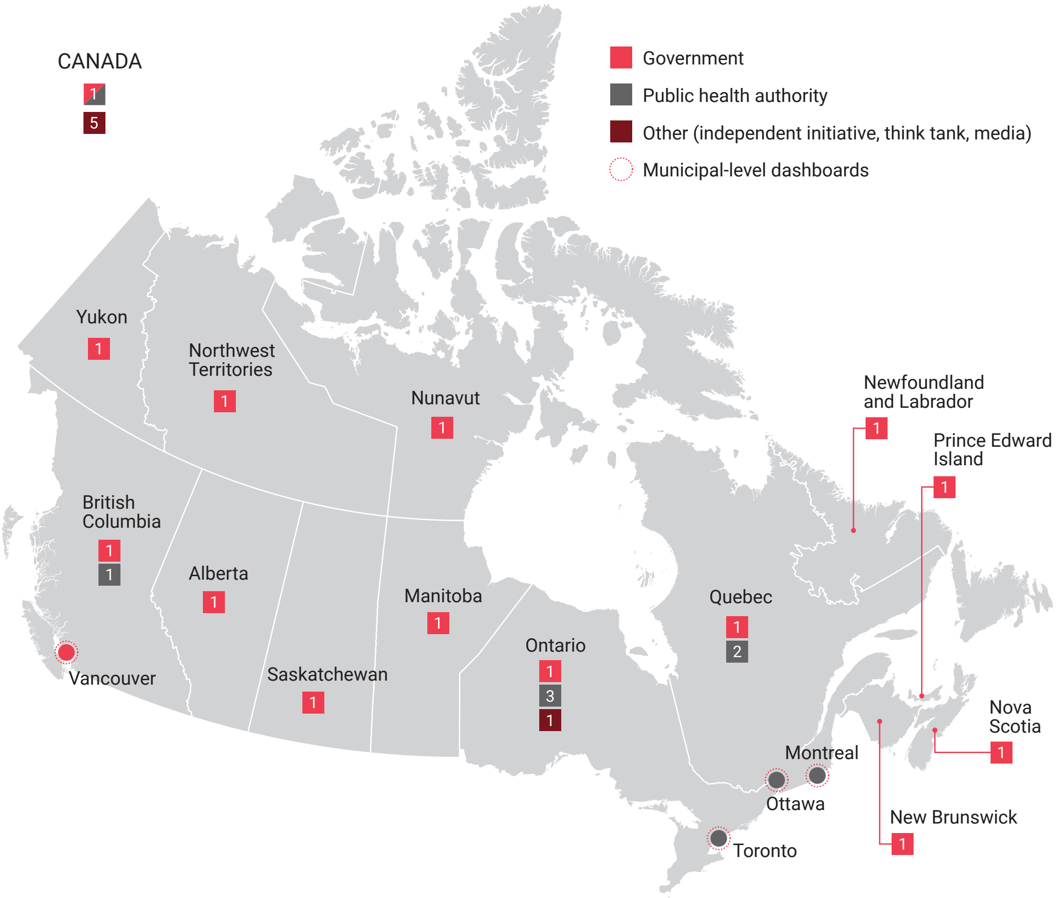
We operationalized the appraisal of a dashboard’s actionability by drawing on the seven features of highly actionable COVID-19 dashboards, as identified in the study by Ivanković et al [15] (see Table 1). A scoring tool was developed (see Appendix 1) to evaluate each feature on a 3-point ordinal scale, scored as “present,” “somewhat present,” or “not present.”

Study sample

COVID-19 dashboards for sample inclusion were determined on the basis of the following three criteria: (1) the reporting of key performance indicators related to COVID-19; (2) the use of some form of visualization; and (3) availability in an online web-based format. It means password-protected COVID-19 dashboards for internal use by public authorities were excluded from this study. No restrictions were imposed in terms of a dashboard’s primary level of reporting (eg, national, regional, and local) or the type of organization responsible for its development (eg, government, academia, news or media, industry, and private initiative). Sampling was conducted from May 19 to June 30, 2020, and involved searches of COVID-19 policy monitoring platforms (eg, the North American COVID-19 Policy Response Monitor [37]) and of research reports (eg, a June 2020 pan-Canadian catalogue of governmental COVID-19 dashboards [38]), as well as expert recommendations from researchers actively engaged in the COVID-19 response, who were contacted via email. In total, 31 dashboards reporting on the Canadian context were identified, five of which were duplicates and excluded from further analysis. Further details about the sampling are mentioned in the study by Ivanković et al [15].

The final sample (N=26) included dashboards reporting at the national level (n=6), PT level (n=16) (including at least one from each of Canada's 13 provinces and territories), and municipal level (n=4), capturing reporting from the capital (Ottawa) and the three largest cities (Montreal, Toronto, and Vancouver). Figure 1 maps the pan-Canadian distribution and the variations in the types of organizations responsible for developing the dashboards. These included federal or PT governments (14/26, 54%), public health authorities (6/26, 23%), and others (6/26, 23%), including independent initiatives (eg, #HowsMyFlattening and COVID-19 Canada Open Data Working Group), industry (eg, Esri and Deloitte), and media (Canadian Broadcasting Corporation). See Appendix 2 for the complete list of dashboards.

Figure 1. Distribution of COVID-19 dashboards sampled and types of organizations responsible for their development



Circles denote municipal-level dashboards included in the sample, and the colors denote the respective organization types. These dashboards are counted in the tally shown per jurisdiction. The Public Health Agency of Canada's COVID-19 dashboard is hosted on the federal Government of Canada webpage. In other instances, dashboards developed by public health authorities are hosted on dedicated webpages.

Descriptive assessment

Each dashboard was assessed in English or French. The assessments were limited to a dashboard's main page and to content accessible within one interaction (click). This approach was designed to increase consistency in the content evaluated, and it enabled us to gauge the dashboard's prioritization and hierarchy of content. Archives were generated to create a record of each dashboard on the date reviewed (see Appendix 2). Dashboards were distributed among the scorers as described in the study by Ivanković et al [15]. This distribution (averaging three dashboards per scorer) remained consistent between time points as follows: the same scorers assessed the same dashboards in both July and November 2020. All assessments additionally underwent reviews by the first authors (EB, DI) to verify completeness and consistency.

Expert appraisal

To assess the presence of the seven defined features of highly actionable COVID-19 dashboards, we organized a series of three-person panels, involving the original scorer of each dashboard joined by two other experts (the first authors or another panel member), in December 2020. Prior to the start of the appraisal by each panel, a workshop with the scorers was organized to calibrate the approach to scoring.

Scoring was informed by the original data records and archives generated in the two descriptive assessments (July and November 2020). Importantly, each of the seven actionability features were appraised with consideration to the dashboard's stated or inferred purpose and audience. It means the appraisal of each feature differentiated between the intended use of the dashboard by national, PT, or municipal general public audiences, unless further specified. In line with the nominal group technique approach [27,28], the three panel members first independently scored the presence of each feature on the dashboard using the scoring tool described above. The proportion of identical ratings for each dashboard was calculated, and virtual panel discussions were convened between the three scorers involved [39,40].

Prior to those discussions, partial or full agreement (two- or three-way consensus) had been reached on 83.5% (304/364) of the items scored, with full three-way agreement on 50% (182/364) (see Appendix 3). During the panel discussions, all items without full agreement were debated. All panels reached final agreement by discussion or re-examining the data records or archives.

Data analysis

We used descriptive statistics to analyze the data at the two time points. We first determined the number and percentage of dashboards in which each item (ie, each consideration) of the descriptive assessment had been recorded as present in the July or November assessment or both. The net change for each item was calculated as the change in the total number of dashboards and the direction of that change between time points. To analyze score changes for the actionability features, we calculated feature-by-feature totals in both July and November, applying a 3-point ordinal scale (not present, somewhat present, and present). Using the same approach applied to analyze changes over time in the descriptive assessments, we calculated the net change per feature as the change in the total number of positively scored dashboards, noting the direction of that change.

For free-text fields in the descriptive assessment tool, we used both deductive and inductive thematic analysis to identify themes [41,42]. This applied to responses on considerations such as a dashboard's purpose of use and audience, indicator titles, and considerations with "other" as an answer category. Topics explored in the assessment tool were used to guide the deductive thematic analysis. In analyzing the titles of indicators reported by the dashboards, we applied the existing WHO classification of types of pandemic-related information. Indicators were analyzed by the types of information as follows: public health and epidemiology, health system management, social and economic impact, and behavioral insights [1]. Given the observed variability in the phrasing of indicator titles, the first authors grouped key performance indicators by themes. New themes that emerged were identified using an inductive approach.

Ethics approval

This study involved the analysis of publicly available COVID-19 dashboards. Ethics approval was not required.

Results

Sampled dashboards

The 26 Canadian COVID-19 dashboards were assessed in the time frames July 7 to 20 and November 23 to December 2, 2020, with an average of 135 days between assessments (range 132-140). All dashboards remained active, with regular, typically daily updating, aside from one (City of Vancouver), which was still accessible but last updated in August 2020. As expected, given the wide differences in population size and density across Canadian provinces and territories, the cumulative number of COVID-19 cases reported by the dashboards for their respective geographic areas ranged from 0 cases in Nunavut to more than 55,000 in Quebec in July, and from 15 cases in Northwest Territories to more than 140,000 in Quebec in November. Cumulative numbers of COVID-19 cases and deaths on the assessment dates are reported in Appendix 2.

Changes to dashboards over time

Table 2 reports how the dashboards changed over time according to the descriptive assessment. The changes can be summarized as follows.

Table 2. Description of changes to Canadian COVID-19 dashboards (N=26) over time in 2020

CONSIDERATION AND DESCRIPTION	JULY VALUE, N (%)	NOVEMBER VALUE, N (%)	NET CHANGE[a]
Purpose and audience			
Purpose: Purpose of use of the dashboard stated	10 (39%)	10 (39%)	0
Audience: Intended audience (user) stated	3 (12%)	4 (15%)	+1
Indicator themes			
Spread and death			
Cases (all confirmed cases)	25 (96%)	25 (96%)	0
Deaths	20 (77%)	21 (81%)	+1
Recovered (healed, cured)	17 (65%)	18 (69%)	+1
Active cases	12 (46%)	12 (46%)	0
Mortality rate (case fatality rate)	4 (15%)	4 (15%)	0
Reproduction rates (attack rate)	1 (4%)	5 (19%)	+4
Testing			
Testing (total number tested, PCR[b] tests)	17 (65%)	19 (73%)	+2

CONSIDERATION AND DESCRIPTION	JULY VALUE, N (%)	NOVEMBER VALUE, N (%)	NET CHANGE[a]
Testing rates (positivity, negative tests)	10 (39%)	15 (58%)	+5
Tests pending results	4 (15%)	2 (8%)	−2
Testing turnaround	0 (0%)	3 (12%)	+3
Risk management			
Self-quarantine (isolation notices)	1 (4%)	1 (4%)	0
Contact tracing	2 (8%)	2 (8%)	0
Hospital care			
Hospitalized (admissions, discharges)	16 (62%)	15 (58%)	−1
Admitted to ICU[c] (critical condition)	10 (39%)	12 (46%)	+2
On a ventilator	3 (12%)	3 (12%)	0
Health system capacity			
Hospital bed capacity (availability)	2 (8%)	2 (8%)	0
ICU bed capacity	3 (12%)	2 (8%)	−1
Ventilator capacity (available ventilators)	3 (12%)	2 (8%)	−1
Non-COVID-19 service usage	1 (4%)	1 (4%)	0
Personal protective equipment stock	1 (4%)	1 (4%)	0
Economic/social impact			
Employment and hardship relief	4 (15%)	4 (15%)	0
Transport, trade and international travel	2 (8%)	3 (12%)	+1
Behavioral: Public risk perception/restriction adherence	5 (19%)	3 (12%)	−2
Other			
Future projections (modelling)	1 (4%)	1 (4%)	0
Risk-level/current phase (composite score)	2 (8%)	4 (15%)	+2
Data sources and metadata			
Sources: Data sources are noted	18 (69%)	18 (69%)	0
Metadata: Metadata is specified	11 (42%)	14 (54%)	+3
Types of analysis			
Time trend			
Time trend analysis available	21 (81%)	23 (89%)	+2
Customizable time trend	4 (15%)	10 (39%)	+6

CONSIDERATION AND DESCRIPTION	JULY VALUE, N (%)	NOVEMBER VALUE, N (%)	NET CHANGE[a]
Number of geographic levels			
1 level	6 (23%)	3 (12%)	−3
2 levels	14 (54%)	15 (58%)	+1
3 and more levels	6 (23%)	8 (31%)	+2
Types of geographic level of analysis			
International	3 (12%)	3 (12%)	0
National	9 (35%)	8 (31%)	−1
Regional (province/territory)	22 (85%)	22 (85%)	0
Health regions	10 (39%)	15 (58%)	+5
Municipal (city)	8 (31%)	8 (31%)	0
Neighborhood (postcode)	3 (12%)	2 (8%)	−1
Disaggregation options			
Age	18 (69%)	17 (65%)	−1
Sex	14 (54%)	15 (58%)	+1
Mode of transmission	5 (19%)	6 (23%)	+1
Long-term care facilities	5 (19%)	5 (19%)	0
Schools	2 (8%)	5 (19%)	+3
Ethnicity	0 (0%)	2 (8%)	+2
Race	0 (0%)	2 (8%)	+2
Comorbidities	1 (4%)	1 (4%)	0
Socioeconomic status	1 (4%)	1 (4%)	0
Health workers	3 (12%)	1 (4%)	−2
Presentation			
Type of visualization			
Table	20 (77%)	25 (96%)	+5
Graph/chart	21 (81%)	22 (85%)	+1
Map	15 (58%)	18 (69%)	+3
Narratives to interpret data			
Yes, to clarify the quality of the data	13 (50%)	18 (69%)	+5
Yes, to clarify the meaning of the data	12 (46%)	11 (42%)	−1

CONSIDERATION AND DESCRIPTION	JULY VALUE, N (%)	NOVEMBER VALUE, N (%)	NET CHANGE[a]
Simplification techniques			
Use of color coding	15 (58%)	15 (58%)	0
Size variation	3 (12%)	4 (15%)	+4
Icons	3 (12%)	7 (27%)	−2
Interactive options			
More information	18 (69%)	18 (69%)	0
Change of information	7 (27%)	10 (39%)	+3
Change of display	5 (19%)	6 (23%)	+1

[a] Net change refers to the total number of dashboards and direction of overall change between time points. Importantly, no net change (0) can mean both no change or the same number of dashboards increased and decreased for the specific consideration.
[b] PCR: polymerase chain reaction.
[c] ICU: intensive care unit.

Purpose and audience

There was no change in the extent to which dashboards stated their purpose of reporting, with just over one-third doing so (10/26, 38%) in both July and November. Where stated, the most frequent specific aims of dashboards were to provide simplified information in an "easy-to-digest, actionable way" [43] and to "help prevention strategies reach those people most affected" [44]. The explicit mention of a target audience was even less frequent, being found on just four dashboards (4/26, 15%) in November, a marginal increase from July (3/26, 12%). Target audiences were denoted as "general public," "businesses," or "public health leaders." Notable improvements over time were made by Ontario's #HowsMyFlattening [43], with the introduction of two dashboard viewing modes ("personal" and "geek") to serve the information needs of different audiences.

Indicator themes

Across the dashboards, public health and epidemiological indicators, followed by health system management indicators, were the most frequently reported indicators at both time points. Behavioral and socioeconomic indicators were rare. An average of seven indicator themes were reported per dashboard in November (range 2-17), compared with six in July (range 2-15). Several indicators became more prevalent in November, including viral reproduction rates, testing rates, testing turnaround times, and composite scores. Six dashboards (6/26, 23%) reduced the number of indicator themes reported, most often removing indicators on active cases. In some instances, indicators had been moved from the dashboard to new tabs or pages, as in Ottawa [45], which relocated indicators on behavioral insights to new tabs no longer within direct access of the main dashboard page assessed.

Indicators on serology tests, doubling rates, and testing stock, which had been present on dashboards previously assessed internationally [15], were not reported at either time point on the sampled dashboards.

Data sources and metadata

A third of the dashboards (8/26, 31%), all government-developed, did not explicitly report data sources in July or November. Dashboards typically drew data from jurisdiction-specific health services and public health authorities, hospital databases, and, for comparisons with other countries, the Johns Hopkins University Coronavirus Resource Center dashboard. Dashboards reporting metadata (supplementary details on the calculation of the indicators) increased to more than 50% (14/26, 54%) by November (from 11/26, 42%, in July). Notably, the COVID-19 in Canada dashboard published a detailed technical report on its data set produced by the COVID-19 Canada Open Data Working Group initiative [46,47].

Types of analyses

A slight increase in the number of dashboards reporting time-trend data was observed between July and November (from 21/26, 81% to 23/26, 88%). Improvements were also made to the availability of customizable time scales, allowing users to zoom in on specific time frames of interest (from 4/26, 15% to 10/26, 38%).

Modifications were made to report subregional geographic breakdowns of data, with more than half (15/26, 58%) of the dashboards including breakdowns by health regions in November, as compared with 10 (10/26, 38%) in July. Age and sex remained the most common population breakdowns in November (17/26, 65%, as against 15/26, 58% in July), followed by mode of transmission (6/26, 23%) and long-term care facilities (5/26, 19%). Schools emerged as a new type of breakdown in November, though present on only one-fifth of dashboards (5/26, 19%).

Presentation

Between July and November, most dashboards slightly improved the number and variety of chart types, simplification techniques, and interactive features they made available. This was mostly done by introducing maps or additional tables and icons, as well as user-directed modifications to the information displayed. New features that emerged in November included options to subscribe to email updates for alerts (eg, #HowsMyFlattening [43] and Ottawa [45]). Two dashboards (Quebec [48] and Ontario [49]) introduced user feedback surveys.

Text providing details on data quality was present on more than two-thirds of dashboards in November (18/26, 69%), compared with half in July (13/26, 50%). For example, Esri's dashboard included lay-language explanations of values with statements such as "*Why do I sometimes see negative numbers?* Some values reported (like total cases) are cumulative.

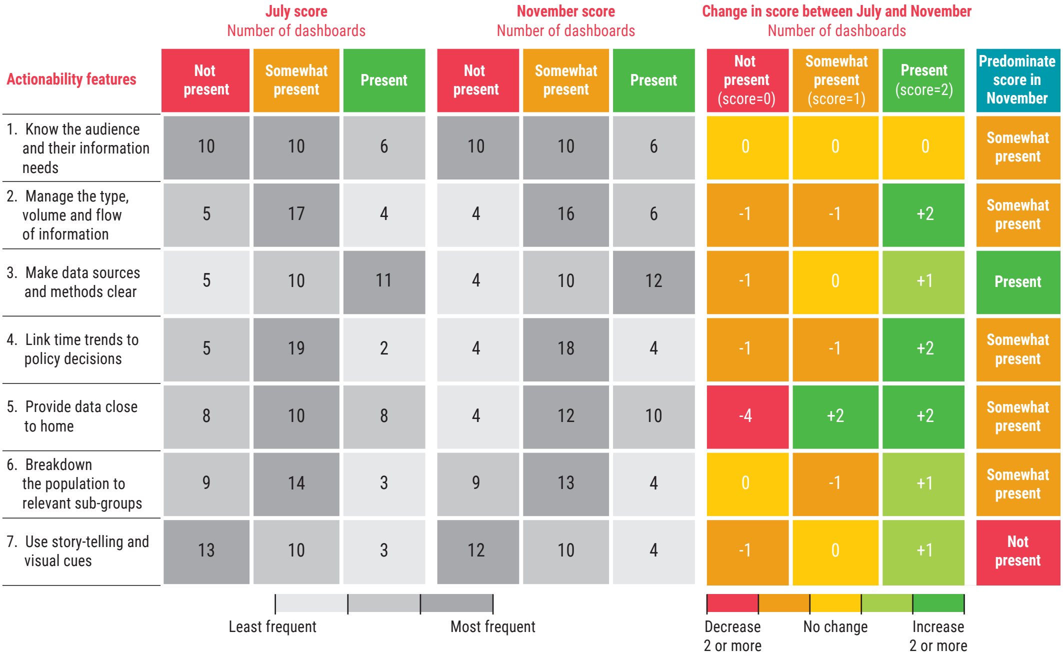
They always go up. Other values (like hospitalizations) fluctuate and can go up or down day-to-day" [50]. Narratives to explain the meaning of statistics and trends were provided by fewer than half of the dashboards in November (11/26, 42%). Explanations of trends and their meaning included this description provided by the COVID-19 in the Canada dashboard: "Graphs display trends for daily cases and deaths over time on a logarithmic scale. An upward slope means the number of cases/deaths reported each day is still growing. A flat line means the number of cases/deaths reported each day is staying the same. A downward slope means the number of cases/deaths reported each day is falling" [20].

Actionability features over time

Of the 26 dashboards assessed, none was found to fully present all seven of the defined actionability features either in July or November. Overall, 8% (2/26) of dashboards were assessed in July as having five or more actionability features fully present, doubling to 15% (4/26) of dashboards in November. Three quarters of dashboards (77%, 20/26) had two or fewer features fully present in July and 65% (17/26) had two or fewer features fully present in November. Seven dashboards increased their score of fully present features. Although two dashboards scored lower in November, the decrease was largely attributable to modifications in the type of information reported on the main dashboard page, as indicators were moved to other dedicated pages.

The actionability feature most widely present on dashboards in both July and November was the clarity of data sources and methods, while the use of storytelling and visual cues was the feature most frequently absent (Figure 2). Among the seven defined features of actionability, improvements were observed in all but one (knowing the audience and their information needs), which was present on fewer than a quarter of the dashboards at either time point. Improvements were most pronounced for the feature involving geographic breakdowns, with average scores increasing by nearly a quarter from July to November. Second to these improvements were improvements in the use of time trends, although explicit links between the data and policy decisions and infection control measures remained infrequent.

Figure 2. Change in actionability across dashboards (n=26) over time in 2020



	July score Number of dashboards			November score Number of dashboards			Change in score between July and November Number of dashboards			
Actionability features	Not present	Somewhat present	Present	Not present	Somewhat present	Present	Not present (score=0)	Somewhat present (score=1)	Present (score=2)	Predominate score in November
1. Know the audience and their information needs	10	10	6	10	10	6	0	0	0	Somewhat present
2. Manage the type, volume and flow of information	5	17	4	4	16	6	-1	-1	+2	Somewhat present
3. Make data sources and methods clear	5	10	11	4	10	12	-1	0	+1	Present
4. Link time trends to policy decisions	5	19	2	4	18	4	-1	-1	+2	Somewhat present
5. Provide data close to home	8	10	8	4	12	10	-4	+2	+2	Somewhat present
6. Breakdown the population to relevant sub-groups	9	14	3	9	13	4	0	-1	+1	Somewhat present
7. Use story-telling and visual cues	13	10	3	12	10	4	-1	0	+1	Not present

Not present: the feature is not found on the dashboard; somewhat present: some elements of the feature are present on the dashboard but room for improvement; present: the specific feature is clearly demonstrated and a good practice example of the feature is present. See Appendix 1 for full scoring details and Appendix 3 for the level of agreement between panel members.

Discussion

Principal findings

In this study, we explored changes made in the course of 2020 to public web-based COVID-19 dashboards in Canada and appraised their actionability for decision-making purposes. Although the dashboards we sampled varied in their specific geographic focuses, they all shared an increasing relevance in supporting data-driven decision-making in their respective audiences as the severity of the COVID-19 pandemic intensified across the country. Broadly speaking, from the perspective of the health care performance intelligence we applied, we observed that subtle improvements were made to the dashboards between July and November 2020. Improvements were most pronounced with regard to dashboard-technology solutions (better customizable time trends, and new charts and graphs) and data provision (new indicators, more transparency on metadata, and more geographic granularity). Modifications to further develop communicative elements were less pronounced or even absent during the period assessed. These results were mirrored in the scoring of actionability features.

COVID-19 dashboards worldwide are powered by a somewhat common range of software service providers (eg, ArcGIS, Tableau, and Power BI). We presume that some improvements observed across our sample can be credited to new technical features rolled out by such providers during 2020. For example, the use of adjustable time trends was a feature introduced on more than a third of the dashboards by November and was evidently an added element in the underlying software. However, while the industry may be credited with spearheading the technical development of dashboards, the current practice from a technological perspective of measuring actionability through *user clicks* [51] exposes some limitations. To give an example, the enhanced sophistication of the technology behind more interactive time trends used on dashboards was not complemented with improvements to incorporate the enactment of policy restrictions into time-trend graphs so as to visualize subsequent effects of those restrictions. This was despite the merits of such a visualization [15] and the fact that such a technique was already being applied on dashboards in countries like Australia [52] and Slovenia [53]. In our sample, we did observe dashboards that excelled in actionability, successfully leveraging the skills of specialists in technology, data, public health, and communication [43,54]. This finding is consistent with the findings in previous studies that have shown the importance of diverse stakeholder engagement for achieving actionable performance measurement, data reporting, and dashboard use [55-57]. In future research, we intend to further explore the perspective of dashboard developers, including their team profiles.

Improved geographic granularity and transparency of methods may be supported by initiatives like the COVID-19 Canada Open Data Working Group [20]. The overall subtlety of changes in available data and its specificity might be a symptom of underlying system barriers, in particular in relation to the collection and reporting of disaggregated data [58]. Researchers in the Canadian context have called attention to data management issues arising from unharmonized privacy laws, public/private data custodianship, and obstacles to the reuse of data for research [59]. The collection of race-based data in Canada is fragmented [60], and a pan-Canadian standard was proposed only in July 2020 [61]. There is a responsibility to act in cases where missing data could be masking inequitable burdens of the pandemic [62,63]. The potential equity-promoting impact of subpopulation-based approaches to the analysis and use of data has already been highlighted in Toronto [64]. Countries that report race- and ethnicity-based COVID-19 data, like New Zealand [65] and the United States [66], may be a source of insights into necessary data governance standards, privacy protections, and data infrastructure.

Our findings also reveal a responsiveness to the evolving nature of the pandemic, with multiple dashboards adding school cases or outbreaks as a data disaggregation option and turnaround times for virus testing as an indicator. Shortly after our second assessment, many dashboards also began reporting on vaccinations. Less advanced dashboards, from areas not seriously affected by the pandemic in the spring of 2020, made considerable progress in the second half of the year, as COVID-19 became more widespread. While such changes confirm that dashboards continued developing with time, the clarity of their intended aims and audiences nevertheless remained an underdeveloped attribute, despite wide recognition of the fundamental importance of data driven by a clear purpose and information need [14,67-70]. This may be a symptom of data governance constraints or, more specifically, of unclear responsibilities and mandates delegated to developers, as evidenced by the multiple public actors (eg, PT governments and PT public health authorities) that were reporting on the same geographies with nearly equivalent content. Although COVID-19 dashboards began as a need-based short-term tool for monitoring and communicating on the pandemic, this function has evolved with time. Dashboards must now face the mid-term challenge of dual-track health system monitoring, reporting both on the pandemic and on non-COVID health care [71], as well as the long-term challenge of integration into standard health system performance measurement. Rethinking the development of dashboards governed by clear mandates will be essential to ensure that relevant high-quality information is transparently delivered to well-defined audiences.

Strengths and limitations

To our knowledge, this is the first study to comparatively explore and critically reflect on changes to COVID-19 dashboards over time from a health care performance intelligence perspective. The study was enriched by the expertise of the panel, whose members had prior experience in assessing COVID-19 dashboards internationally, as well as a shared reflexive lens to gauge both the technical and communication aspects of the dashboards. Additionally, given the sustained relevance of COVID-19 dashboards, our findings are pertinent both to short-term improvements in COVID-19 dashboards and to their longer-term utility in addressing future public health crises.

We acknowledge several limitations. First, the stages of the pandemic and its severity varied considerably across our sample, possibly contributing to differences with respect to the data available and the prioritization of a dashboard's development. Despite this, the general direction of change was found to be common, averaging a threefold increase in COVID-19 cases across locations between our assessment time points (see Appendix 2). Second, the expert-based appraisal of actionability we employed is not a guaranteed reflection of a dashboard's use in practice. The first-hand experiences of dashboard users merit further study to obtain practical real-world insights that can complement the concepts explored here. Third, our archiving of dashboards was limited to their main page. Dashboards with multiple tabs could therefore not be revisited in full for scoring purposes. To minimize the potential loss of information, all dashboards were assessed and evaluated by the same scorer in both July and November. Lastly, to permit comparisons over time, our sample was limited to dashboards identified in our search in May 2020. Any new dashboards that followed would have been missed. An exhaustive sample was beyond the study's aims; however, we achieved geographic representativeness, as well as reasonable diversity in level (national, jurisdictional, and municipal) and in the types of providing organizations.

Conclusion

Actionable dashboards are needed to enable effective decision-making across audiences. Dashboards are tools of continuing importance during the COVID-19 pandemic, but sustaining their actionability requires responsiveness to the pandemic's stages. Improvements made to COVID-19 dashboards in the Canadian context from July to November 2020 appear to be driven mainly by certain technological and data improvements. The effective use of communication features remained underdeveloped at both points in time. COVID-19 dashboard developers need to better leverage the expertise of public health and communication specialists, in order to ensure that data will truly become information that is readily accessible and relevant to a public audience. Strategic system improvements to prioritize data standards, for example with respect to subpopulation-based data, are needed to achieve more significant gains in actionability. As the pandemic continues to evolve, attention will need to shift toward converting dashboards from their initial status as temporary monitoring and communication tools into instruments that are integrated into routine health system performance monitoring. Accomplishing that will also require improved governance arrangements that clarify roles and responsibilities. In the short term, continued improvements are urgently needed with respect to all seven of the identified actionability features, in order to make COVID-19 dashboards more fit for their purpose and use.

Acknowledgments

The authors thank and recognize the full team involved in the work on the international sample of COVID-19 dashboards that preceded this study. We also thank the reviewers who commented on an earlier version of the paper and Michael Dallas for language editing. This work was carried out by the Marie Skłodowska-Curie Innovative Training Network Healthcare Performance Intelligence Professionals (HealthPros) that has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement number 765141.

Abbreviations

PT: provincial/territorial

WHO: World Health Organization

References

1. Strengthening and adjusting public health measures throughout the COVID-19 transition phases: policy considerations for the WHO European Region, 24 April 2020. World Health Organization. 2020. URL: https://apps.who.int/iris/handle/10665/ 332467 [accessed 2021-07-31].
2. Frieden TR. Government's role in protecting health and safety. N Engl J Med. 2013;368(20):1857–9.
3. UN/DESA Policy Brief #61: COVID-19: Embracing digital government during the pandemic and beyond. United Nations. 2020. URL: https://www.un.org/development/desa/dpad/publication/ un-desa-policy-brief-61-covid-19-embracing-digital-government-during-the-pandemic-and-beyond/ [accessed 2021-07-31].
4. Strengthening the health systems response to COVID-19: policy brief: recommendations for the WHO European Region (1 April 2020). World Health Organization. 2020. URL: https://apps.who.int/iris/handle/10665/333072 [accessed 2021-07-31].
5. Infodemic Management. World Health Organization. URL: https://www.who.int/teams/risk-communication/infodemic-management [accessed 2021-07-31].
6. Flattening the COVID-19 peak: containment and mitigation policies. OECD. 2020. URL: https://read.oecd-ilibrary.org/ view/?ref=124_124999-yt5ggxirhc&title=Flattening_the_COVID-19_peak-Containment_and_mitigation_policies [accessed 2021-07-31].
7. Ghazisaeidi M, Safdari R, Torabi M, Mirzaee M, Farzi J, Goodini A. Development of performance dashboards in healthcare sector: Key practical issues. Acta Inform Med. 2015;23(5):317–21.
8. COVID-19 Dashboard by the Center for Systems Science and Engineering (CSSE) at Johns Hopkins University. ArcGIS Online. URL: https://www.arcgis.com/apps/dashboards/bda7594740fd40299423467b48e9ecf6 [accessed 2021-07-31].
9. Perkel J. Behind the Johns Hopkins University coronavirus dashboard. Nature Index. 2020. URL: https://www. natureindex.com/news-blog/behind-the-johns-hopkins-university-coronavirus-dashboard [accessed 2021-07-31].
10. Rocha R. The flurry of daily pandemic data can be overwhelming. Here's how to make sense of it. CBC. 2020. URL: https:/ /www.cbc.ca/news/health/covid-19-pandemic-data-primer-stats-charts-1.5513222 [accessed 2021-07-31].
11. Tomes N. Managing the modern infodemic. CMAJ. 2020;192(43):E1311–2.
12. Shelton T. A post-truth pandemic? Big Data & Society 2020 Oct 21;7(2):205395172096561.

13. International Training Network for Healthcare Performance Intelligence Professionals. HealthPros. 2020. URL: https://www.healthpros-h2020.eu/ [accessed 2021-07-31].

14. Barbazza E, Klazinga NS, Kringos DS. Exploring the actionability of healthcare performance indicators for quality of care: a qualitative analysis of the literature, expert opinion and user experience. BMJ Qual Saf. 2021;30:1010–20.

15. Ivanković D, Barbazza E, Bos V, Brito Fernandes, Jamieson Gilmore K, Jansen T, et al. Features Constituting Actionable COVID-19 Dashboards: Descriptive Assessment and Expert Appraisal of 158 Public Web-Based COVID-19 Dashboards. J Med Internet Res. 2021;23(2):e25682.

16. Weggelaar-Jansen AMJWM, Broekharst DSE, de Bruijne M. Developing a hospital-wide quality and safety dashboard: a qualitative research study. BMJ Qual Saf. 2018;27(12):1000–7.

17. Yigitbasioglu OM, Velcu O. A review of dashboards in performance management: Implications for design and research. International Journal of Accounting Information Systems. 2012;13(1):41–59.

18. Marchildon GP, Allin S. Chapter 5: Provision of services. In: Merkur S, editor. Canada: Health System Review 2020: Health Systems in Transition. Copenhagen, Denmark: WHO Regional Office for Europe; 2020:100–29.

19. Canadian Pandemic Influenza Preparedness: Planning Guidance for the Health Sector. Public Health Agency of Canada. 2018. URL: https://www.canada.ca/en/public-health/services/flu-influenza/ canadian-pandemic-influenza-preparedness-planning-guidance-health-sector.html [accessed 2021-07-31].

20. COVID-19 Canada Open Data Working Group: Monitoring Canada's COVID-19 epidemic. COVID-19 Canada Open Data Working Group. 2021. URL: https://opencovid.ca/ [accessed 2021-07-31].

21. Coronavirus disease (COVID-19): Outbreak update. Government of Canada. 2020. URL: https://www.canada.ca/en/ public-health/services/diseases/2019-novel-coronavirus-infection.html#a7 [accessed 2021-07-31].

22. McKenzie K. Race and ethnicity data collection during COVID-19 in Canada: if you are not counted you cannot count on the pandemic response. Royal Society of Canada. 2020. URL: https://rsc-src.ca/en/ race-and-ethnicity-data-collection-during-covid-19-in-canada-if-you-are-not-counted-you-cannot-count [accessed 2021-07-31].

23. Bain B, Dryden O, Walcott R. COVID-19 discriminates against Black lives via surveillance, policing and lack of data: U of T experts. University of Toronto. 2020. URL: https://www.utoronto.ca/news/covid-19-discriminates-against-black-lives-surveillance-policing-and-lack-data-u-t-experts [accessed 2021-07-31].

24. Hansen G, Cyr A. Canada's decentralized "human-driven" approach during the early COVID-19 pandemic. JMIR Public Health Surveill. 2020;6(4):e20343.

25. Matukas LM, Dhalla IA, Laupacis A. Aggressively find, test, trace and isolate to beat COVID-19. CMAJ. 2020;192(40):E1164–5.

26. O'Brien BC, Harris IB, Beckman TJ, Reed DA, Cook DA. Standards for reporting qualitative research: a synthesis of recommendations. Acad Med. 2014;89(9):1245–51.

27. Jones J, Hunter D. Consensus methods for medical and health services research. BMJ. 1995;311(7001):376–80.

28. Fink A, Kosecoff J, Chassin M, Brook RH. Consensus methods: characteristics and guidelines for use. Am J Public Health. 1984;74(9):979–83.

29. Lasswell HD. The structure and function of communication in society. In: Bryson L, editor. The communication of ideas. New York, NY: Harper and Row; 1948:136–9.

30. Sbaffi L, Rowley J. Trust and Credibility in Web-Based Health Information: A Review and Agenda for Future Research. J Med Internet Res. 2017;19(6):e218.

31. McDowell R. Signs to look for: criteria for developing and selecting fit for purpose indicators. PricewaterhouseCoopers. 2017. URL: https://ourlandandwater.nz/wp-content/uploads/2019/03/IWG_Indicators-thinkpiece-1.pdf.

32. Peters E, Dieckmann N, Dixon A, Hibbard JH, Mertz CK. Less is more in presenting quality information to consumers. Med Care Res Rev. 2007;64(2):169–90.

33. Hibbard JH, Peters E. Supporting informed consumer health care decisions: data presentation approaches that facilitate the use of information in choice. Annu Rev Public Health. 2003;24:413–33.

34. Ballard A. promoting performance information use through data visualization: evidence from an experiment. Public Performance & Management Review. 2019;43(1):109–28.

35. Charnock D. The DISCERN handbook: quality criteria for consumer health information on treatment choices. Oxford, UK: Radcliffe Medical Press; 1998.

36. SAM: Suitability Assessment of Materials for evaluation of health-related information for adults. Aspirus Library. 2008. URL: http://aspiruslibrary.org/literacy/SAM.pdf [accessed 2021-07-31].

37. North American COVID-19 Policy Response Monitor. University of Toronto. 2020. URL: https://ihpme.utoronto.ca/ research/research-centres-initiatives/nao/covid19/ [accessed 2021-07-31].

38. Provincial and Territorial Covid-19 Reporting Dashboards. Public Health Physicians of Canada. URL: http://www. phpc-mspc.ca/resources/Documents/Respository/PHPC%20 COVID19%20Dashboard%20Summary%2006-16-2020.pdf [accessed 2021-07-31].

39. Murphy MK, Black NA, Lamping DL, McKee CM, Sanderson CF, Askham J, et al. Consensus development methods, and their use in clinical guideline development. Health Technol Assess. 1998;2(3):i-iv.

40. Costa-Santos C, Antunes L, Souto A, Bernardes J. Assessment of disagreement: a new information-based approach. Ann Epidemiol. 2010;20(7):555–61.

41. King N. Using templates in the thematic analysis of text. In: Essential Guide to Qualitative Methods in Organizational Research. Newbury Park, CA: Sage Publications; 2004.

42. Braun V, Clarke V. Using thematic analysis in psychology. Qual Res Psychol. 2006;3(2):77–101.

43. How's My Flattening. URL: https://howsmyflattening.ca/ [accessed 2021-07-31].

44. COVID-19: Case Counts. City of Toronto. URL: https://www.toronto.ca/home/covid-19/covid-19-latest-city-of-toronto-news/ covid-19-pandemic-data/covid-19-weekday-status-of-cases-data/ [accessed 2021-07-31].

45. Daily COVID-19 Dashboard. Ottawa Public Health. URL: https://www.ottawapublichealth.ca/en/ reports-research-and-statistics/daily-covid19-dashboard.aspx [accessed 2021-07-31].

46. Berry I, Soucy JR, Tuite A, Fisman D, COVID-19 Canada Open Data Working Group. Open access epidemiologic data and an interactive dashboard to monitor the COVID-19 outbreak in Canada. CMAJ. 2020;192(15):E420.

47. COVID-19 in Canada. COVID-19 Canada Open Data Working Group. URL: https://art-bd.shinyapps.io/covid19canada/ [accessed 2021-07-31].

48. Data on COVID-19 in Québec. Government of Quebec. URL: https://www.quebec.ca/en/health/health-issues/a-z/ 2019-coronavirus/situation-coronavirus-in-quebec [accessed 2021-07-31].

49. All Ontario: Case numbers and spread. Government of Ontario. URL: https://covid-19.ontario.ca/data [accessed 2021-07-31].

50. COVID-19 Resources. URL: https://resources-covid19canada.hub.arcgis.com/ [accessed 2021-07-31].

51. Verhulsdonck G, Shah V. Lean data visualization: Considering actionable metrics for technical communication. Journal of Business and Technical Communication. 2020;35(1):57–64.

52. Ting I, Scott N, Workman M. Charting the COVID-19 spread in Australia. ABC News. 2020. URL: https://www.abc.net.au/ news/2020-03-17/coronavirus-cases-data-reveals-how-covid-19-spreads-in-australia/12060704 [accessed 2021-07-31].

53. COVID-19 Sledilnik. 2020. URL: https://covid-19.sledilnik.org/en/stats [accessed 2021-07-31].

54. Tracking the coronavirus. CBC News. 2020. URL: https://newsinteractives.cbc.ca/coronavirustracker/ [accessed 2021-07-31].

55. Nuti S, Vola F, Bonini A, Vainieri M. Making governance work in the health care sector: evidence from a ‘natural experiment’ in Italy. Health Econ Policy Law. 2016;11(1):17–38.

56. Compton-Phillips AT. The give a darn method for outcomes measurement, in NEJM Catalyst. NEJM Catalyst. 2018. URL: https://catalyst.nejm.org/doi/full/10.1056/CAT.18.0262 [accessed 2021-07-31].

57. Kurtzman ET, Greene J. Effective presentation of health care performance information for consumer decision making: A systematic review. Patient Educ Couns. 2016;99(1):36–43.

58. A stronger and more resilient Canada: Speech from the Throne to Open the Second Session of the Forty-Third Parliament of Canada. Canada.ca. 2020. URL: https://www.canada.ca/en/privy-council/campaigns/speech-throne/2020/ stronger-resilient-canada.html [accessed 2021-07-31].

59. Bernier A, Knoppers BM. Pandemics, privacy, and public health research. Can J Public Health. 2020;111(4):454–7.

60. Datta G, Siddiqi A, Lofters A. Transforming race-based health research in Canada. CMAJ. 2021;193(3):E99–100.

61. Proposed Standards for Race-Based and Indigenous Identity Data Collection and Health Reporting in Canada. Canadian Institute for Health Information. 2020. URL: https://www.cihi.ca/sites/default/files/document/ proposed-standard-for-race-based-data-en.pdf [accessed 2021-07-31].

62. Disaggregated demographic data collection in British Columbia: The grandmother perspective. British Columbia’s Office of the Human Rights Commissioner. 2020. URL: https://bchumanrights.ca/wp-content/uploads/ BCOHRC_Sept2020_Disaggregated-Data-Report_FINAL.pdf [accessed 2021-07-31].

63. Ploem C, Suurmond J. Registering ethnicity for covid-19 research: is the law an obstacle? BMJ. 2020;370:m3367.

64. McKenzie K. Socio-demographic data collection and equity in covid-19 in Toronto. EClinicalMedicine. 2021;34:100812.

65. COVID-19 data portal. Stats NZ. 2020. URL: https://www.stats.govt.nz/experimental/covid-19-data-portal [accessed 2021-07-31].

66. Demographic trends of COVID-19 cases and deaths in the US reported to CDC. Centers for Disease Control and Prevention. 2020. URL: https://covid.cdc.gov/covid-data-tracker/#demographics [accessed 2021-07-31].

67. Klazinga N, Stronks K, Delnoij D, Verhoeff A. Indicators without a cause. Reflections on the development and use of indicators in health care from a public health perspective. Int J Qual Health Care. 2001;13(6):433–8.

68. Smith PC, Mossialos E, Papanicolas I. Performance measurement for health system improvement: experiences, challenges and prospects. World Health Organization. 2008. URL: https://www.who.int/management/district/performance/PerformanceMeasurementHealthSystemImprovement2.pdf [accessed 2021-07-31].

69. Smith PC, Mossialos E, Papanicolas I, Leatherman S. Introduction. In: Performance Measurement for Health System Improvement. Cambridge, UK: Cambridge University Press; 2010:3–24.

70. Hilarion P, Suñol R, Groene O, Vallejo P, Herrera E, Saura RM. Making performance indicators work: the experience of using consensus indicators for external assessment of health and social services at regional level in Spain. Health Policy. 2009;90(1):94–103.

71. Jakab M, Nathan NL, Pastorino G, Evetovits T, Garner S, Langins M, et al. Managing health systems on a seesaw: Balancing the delivery of essential health services whilst responding to COVID-19. Eurohealth. 2022;26(2).

Supplementary appendices

Appendix 1: Scoring tool on actionability features

Appendix 2: Overview of Canadian COVID-19 dashboards assessed

Appendix 3: Scoring distribution and extent of agreement prior to joint workshops

Appendix 1: Scoring tool on actionability features

FEATURE[a]	QUESTION/ STATEMENT	ANSWER OPTIONS	DESCRIPTION	RATIONALE
1. Know the audience and their information needs	The intended audience and their information needs are known and responded to. *Select one*	Present Somewhat present Not present	Considerations to look for: clear guiding key questions or aims; use of overall composite scores; clear intended audience; user-facing conveniences like multi-language functionality and exact timing of updating.	Dashboards with a known audience and explicit aim have better focus and continuity in their content, analysis and delivery.
2. Manage the type, volume, and flow of information	The type, volume and flow of information on the dashboard is well managed. *Select one*	Present Somewhat present Not present	Considerations to look for: manageable number of indicators; logical flow of information (general to specific, clustered as themes, etc.; indicators spanning types of information (epidemiological, health systems, social/economic, behavioural insights).	The selection of a concise number of indicators, yet ranging types of information, brings focus and importance to the information and the possibility to view indicators together, at-a-glance.
3. Make data sources and methods clear	The data sources and methods for calculating values are made clear. *Select one*	Present Somewhat present Not present	Considerations to look for: clear reporting of data sources; available (on page or redirected to) metadata data, data dictionary or similar; brief explanations (short narratives) that explain to a user about the data.	A clear source of data and explanation of an indicator's construction, including potential limitations, is an important component of trust in the dashboard and clarity in its reporting.
4. Link time trends to policy decisions	Information is reported over time and contextualized with policy decisions. *Select one*	Present Somewhat present Not present	Considerations to look for: data is reported over time; time trends are customizable and can be tailored to a specific period of interest; policy decisions and their implications on rates is communicated.	Reporting data over time together with the introduction of key infection control measures facilitated an understanding of their effect (or lack of).
5. Provide data 'close to home'	Data is reported at relevant geographic breakdowns. *Select one*	Present Somewhat present Not present	Considerations to look for: information is broken down to levels relevant for the dashboard (eg, city dashboard includes reporting at the municipal-level but also by boroughs and/or zip codes).	To inform individuals of risks in their immediate surroundings, granular geographic breakdowns are needed. Data that is highly aggregated is difficult to understand.
6. Break down the population to relevant sub-groups	Data is reported by relevant population sub-groups. *Select one*	Present Somewhat present Not present	Considerations to look for: data is reported by a range of breakdowns (eg, sex, age, ethnicity, co-morbidities, etc.); breakdowns can be analyzed in ways that signal the relative risk of different population sub-groups.	Providing data with the possibility to explore varied population characteristics makes indicators relatable to individual users. It allows an understanding of risks and trends based on one's own demographics.
7. Use story-telling and visual cues	Brief narratives and visual cues are used to explain the meaning of data. *Select one*	Present Somewhat present Not present	Considerations to look for: brief explanations are provided on the meaning of trends; use of visual techniques, such as intuitive color schemes and icons; effective display of information for a visually pleasing dashboard that facilitates an understanding of key figures.	A concise narrative explaining the significance of a trend supports users to understand the importance of the information. Bare statistics without a narrated analysis leave the burden of interpretation solely to the user.

[a] Features are derived from the findings reported in: Ivanković D, Barbazza E, Bos V, Brito Fernandes Ó, Jamieson Gilmore K, Jansen T, Kara P, Larrain N, Lu S, Meza-Torres B, Mulyanto J, Poldrugovac M, Rotar A, Wang S, Willmington C, Yang Y, Yelgezekova Z, Allin S, Klazinga N, Kringos D. Features Constituting Actionable COVID-19 Dashboards: Descriptive Assessment and Expert Appraisal of 158 Public Web-Based COVID-19 Dashboards. J Med Internet Res. 2021;23(2):e25682 doi: 10.2196/25682.

Appendix 2: Overview of Canadian COVID-19 dashboards assessed

#	LOCATION LINK	LEVEL	TYPE	ORGANIZATION	AUDIENCE	REVIEW DATES	ARCHIVE BY REVIEW DATE	CASES ON REVIEW DATE	DEATHS ON REVIEW DATE
1	Canada	National	Government/ public health authority	Government of Canada	General public[b]	13.07.2020	http://archive.vn/DW6Ow	107,590	8,783
						23.11.2020	https://archive.vn/MrS33	330,503	11,455
2	Canada	National	Other	Esri Canada	General public, data specialists[b]	13.07.2020	http://archive.vn/ujVQi	107,589	8,783
						23.11.2020	https://archive.vn/sl4bp	333,803	11,494
3	Canada	National	Other	Jean-Raul R Soucy and Isha Berry (Independent)	General public, data specialists[b]	13.07.2020	http://archive.vn/m2dLJ	109,920	8,827
						23.11.2020	https://archive.vn/2E9md	333,560	11,483
4	Canada	National	Other	Canadian Broadcasting Corporation	General public[b]	13.07.2020	http://archive.vn/p7Ix2	108,278	8,825
						23.11.2020	https://archive.vn/esdVA	330,503	11,454
5	Canada	National	Other	Noah Little (Independent)	General public[b]	18.07.2020	http://archive.vn/Lqk6L	99,537	8,104
						30.11.2020	https://archive.vn/QEDPE	373,664	12,053
6	Canada	National[a]	Other	Deloitte.	Business decision-making, international organizations or those that depend on export markets	17.07.2020	http://archive.vn/qrJbw	NA	NA
						01.12.2020	https://archive.vn/E5b56	364,810	11,976
7	Newfoundland and Labrador	Regional	Government	Government of Newfoundland and Labrador	General public of Newfoundland and Labrador[b]	20.07.2020	http://archive.vn/xv4sw	262	3
						30.11.2020	https://archive.vn/YXOUf	337	4
8	Prince Edward Island	Regional	Government	Government of Prince Edward Island	General public of Prince Edward Island[b]	13.07.2020	http://archive.vn/oXtDj	33	NA
						23.11.2020	https://archive.vn/YIC4d	68	3
9	Nova Scotia	Regional	Government	Government of Nova Scotia	General public of Nova Scotia[b]	16.07.2020	http://archive.vn/LOfCa	1,067	63
						30.11.2020	https://archive.vn/kTtBU	1,257	65

#	LOCATION LINK	LEVEL	TYPE	ORGANIZATION	AUDIENCE	REVIEW DATES	ARCHIVE BY REVIEW DATE	CASES ON REVIEW DATE	DEATHS ON REVIEW DATE
10	New Brunswick	Regional	Government	Government of New Brunswick	General public of New Brunswick[b]	20.07.2020	http://archive.vn/xEOZI	164	2
						30.11.2020	https://archive.vn/bvwvF	495	7
11	Quebec	Regional	Government	Government of Quebec	General public of Quebec	14.07.2020	http://archive.vn/jky19	55,937	5,577
						29.11.2020	https://archive.vn/Guu40	136,643	7,021
12	Quebec	Regional	Public health authority	National Institute of Public Health of Quebec	General public of Quebec[b]	14.07.2020	http://archive.vn/D3JfB on 14.07.20	56,730	5,633
						30.11.2020	https://archive.vn/i3Fwl	141,038	7,033
13	Montreal	Municipal	Public health authority	Santé Montréal	General public of Montreal[b]	18.07.2020	https://archive.vn/Dfwbz	27,863	3,431
						02.12.2020	http://archive.vn/KfneS	51,462	3,628
14	Ontario	Regional	Government	Government of Ontario	General public of Ontario[b]	09.07.2020	http://archive.vn/1Urge	36,178	2,700
						26.11.2020	https://archive.vn/htWsi	107,883	3,554
15	Ontario	Regional	Public health authority	Ontario Agency for Health Protection and Promotion	General public of Ontario[b]	16.07.2020	http://archive.vn/YtJVv	37,052	NA
						30.11.2020	https://archive.vn/QK7RK	116,492	3,656
16	Ontario	Regional	Other	#HowsMyFlattening	Ontarians and public health leaders	14.07.2020	http://archive.vn/7T6MT	36,950	2,722
						24.11.2020	https://archive.vn/J5oAF	NA	NA
17	Toronto	Municipal	Public health authority	City of Toronto	Toronto Public Health and general public	14.07.2020	http://archive.vn/NoyJh	14,735	1,110
						23.11.2020	https://archive.vn/a4lFD	37,824	1,538
18	Ottawa	Municipal	Public health authority	Ottawa Public Health	General public of Ottawa[b]	16.07.2020	http://archive.vn/3ZL3k	2,167	263
						30.11.2020	https://archive.vn/JGtyq	8,458	374
19	Manitoba	Regional	Government	Government of Manitoba	General public of Manitoba[b]	18.07.2020	https://archive.vn/IT4SS	273	6
						30.11.2020	https://archive.vn/XFXLo	16,483	301
20	Saskatchewan	Regional	Government	Government of Saskatchewan	Citizens of Saskatchewan	20.07.2020	http://archive.vn/kVUii	943	15
						30.11.2020	https://archive.vn/6najD	8,239	45

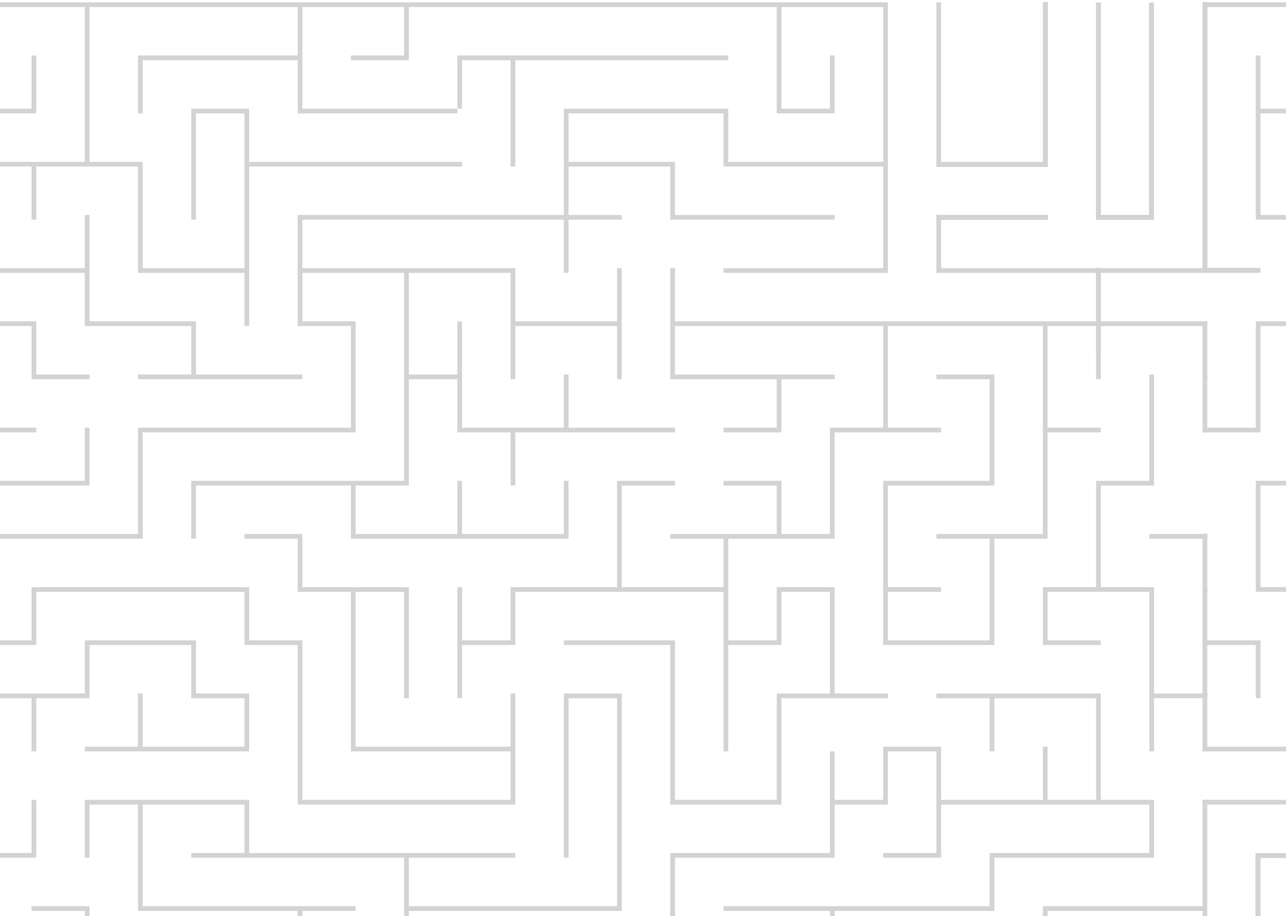
#	LOCATION LINK	LEVEL	TYPE	ORGANIZATION	AUDIENCE	REVIEW DATES	ARCHIVE BY REVIEW DATE	CASES ON REVIEW DATE	DEATHS ON REVIEW DATE
21	Alberta	Regional	Government	Government of Alberta	Albertans	18.07.2020	https://archive.vn/hQ9Kl	9,114	165
						30.11.2020	https://archive.vn/AMWsk	56,444	533
22	British Columbia	Regional	Public health authority	Provincial Health Services Authority, BC Center for Disease Control	General public of British Columbia[b]	18.07.2020	http://archive.vn/Tspb3	3,198	189
						30.12.2020	https://archive.vn/Vx7Hy	10,884	395
23	Vancouver	Municipal	Government	City of Vancouver	General public of Vancouver[b]	20.07.2020	http://archive.vn/jPIlp	NA	NA
						30.11.2020	https://archive.vn/t3Eve	NA	NA
24	Yukon	Regional	Government	Government of Yukon	General public of Yukon[b]	13.07.2020	http://archive.vn/cG5a0	15	NA
						23.11.2020	https://archive.vn/xKf7F	32	11
25	Northwest Territories	Regional	Government	Government of Northwest Territories	General public of Northwest Territories[b]	07.07.2020	http://archive.vn/UNPBb	5	NA
						23.11.2020	https://archive.vn/74wC9	15	0
26	Nunavut	Regional	Government	Nunavut Department of Health	General public of Nunavut[b]	07.07.2020	http://archive.vn/HLobA	0	0
						23.11.2020	https://archive.vn/iz5Bw	134	0

Notes:
[a] This dashboard is available for countries other than Canada.
[b] The intended audience was not explicitly stated and as such, the noted audience is inferred.
NA: not available.

Appendix 3: Scoring distribution and extent of agreement prior to joint workshops

	DISTRIBUTION OF DASHBOARDS		PRE-PANEL SCORING		PROPORTION OF SCENARIOS ON WHICH THE PANEL	
SCORERS	Dashboards discussed	Data points per reviewer	Partial/full agreements	Full agreements	Partially or fully agreed	Fully agreed
NL, EB and DI	1	14	10	8	71.43%	57.14%
VB, EB and DI	1	14	13	9	92.86%	64.29%
MP, EB and DI	5[a]	70	62	40	88.57%	57.14%
KJG, EB and DI	5[a]	70	60	35	85.71%	50.00%
CW, EB and DI	5[a]	70	62	36	88.57%	51.43%
SW, EB and DI	9	126	97	54	76.98%	42.86%
Total	**26**	**364**	**304**	**182**	**83.52%**	**50.00%**

[a] Dashboards discussed included a subset of dashboards originally scored by EB or DI.



Chapter 7

The experiences of 33 national COVID-19 dashboard teams during the first year of the pandemic in the WHO European Region

This chapter was published as:

Barbazza E*, Ivanković D*, Davtyan K, Poldrugovac M, Yelgezekova Z, Willmington C, Meza-Torres B, Bos VLLC, Brito Fernandes Ó, Rotar A, Nuti S, Vainieri M, Carinci F, Azzopardi-Muscat N, Groene O, Novillo-Ortiz D, Klazinga N, Kringos D. The experiences of 33 national COVID-19 dashboard teams during the first year of the pandemic in the WHO European Region: a qualitative study. Digit Health. 2022;8:1–16.

*these authors contributed equally

Abstract

Background

Governments across the WHO European Region have prioritised dashboards for reporting COVID-19 data. The ubiquitous use of dashboards for public reporting is a novel phenomenon.

Objective

This study explores the development of COVID-19 dashboards during the first year of the pandemic and identifies common barriers, enablers and lessons from the experiences of teams responsible for their development.

Methods

We applied multiple methods to identify and recruit COVID-19 dashboard teams, using a purposive, quota sampling approach. Semi-structured group interviews were conducted from April to June 2021. Using elaborative coding and thematic analysis, we derived descriptive and explanatory themes from the interview data. A validation workshop was held with study participants in June 2021.

Results

Eighty informants participated, representing 33 national COVID-19 dashboard teams across the WHO European Region. Most dashboards were launched swiftly during the first months of the pandemic, February to May 2020. The urgency, intense workload, limited human resources, data and privacy constraints, and public scrutiny were common challenges in the initial development stage. Themes related to barriers or enablers were identified, pertaining to the pre-pandemic context, pandemic itself, people and processes, and software, data and users. Lessons emerged around the themes of simplicity, trust, partnership, software and data, and change.

Conclusions

COVID-19 dashboards were developed in a learning-by-doing approach. The experiences of teams reveal that initial underpreparedness was offset by high-level political endorsement, the professionalism of teams, accelerated data improvements, and immediate support with commercial software solutions. To leverage the full potential of dashboards for health data reporting, investments are needed at the team, national and pan-European levels.

Introduction

Governments, as the stewards of healthcare systems, have the chief responsibility for protecting and promoting the health and well-being of the population [1]. The stewardship role includes collecting and reporting relevant information and supporting its use as performance intelligence by all health system actors, including the general public [2,3]. This task has taken on new pertinence in the context of a public health emergency such as the COVID-19 pandemic [4-7]. Governments worldwide have prioritised tools for delivering pandemic-related information, most often through the development of public web-based dashboards [8,9].

Dashboards can be characterised as dynamic, visual displays of key performance indicators, arranged on a single screen for viewing at a glance [10-12]. The ubiquitous use of dashboards as public reporting tools during a pandemic is a novel [13,14] development, but the use case for dashboards in a pandemic is clear. Contrary to static reporting, through their dynamic nature they iterate content and its display daily, evolving with the stages of the pandemic [15]. By design, dashboards can manage large datasets and this, together with their near–real-time reporting capabilities, makes them highly responsive to the information urgency in a pandemic [8]. And, when paired with geographic information systems (GIS) and interactive drilldowns, dashboards are critical for local monitoring, reporting and decision-making [12].

In the health sector, dashboards have traditionally been used for internal purposes, assisting managers in strategic and operational decision-making, particularly in hospitals [16], and supporting clinicians in clinical care and quality improvement [11]. There are also notable examples of public web-based dashboards for international health system benchmarking [17-22]. In contrast to COVID-19 dashboards, these have traditionally not been updated in near–real-time. Previous studies have explored optimising the design of dashboards in healthcare [10], their effects on quality in clinical practice [11] and their development and implementation cycles [15,23]. In the context of the COVID-19 pandemic, scientific accounts have documented the technical development of dashboards [9,24-28] and their applications in clinical practice [29,30]. From a healthcare performance intelligence perspective, our research group HealthPros [31] has conducted international comparative research on COVID-19 dashboards, exploring features common to highly actionable dashboards [32] and their evolution over time [33,34].

In this context, there are two critical gaps in the available scientific evidence. First, describing the processes of developing COVID-19 dashboards over the course of the pandemic's first year has predominately focused on individual, anecdotal country accounts (eg, [35-38]). While these provide some insight into the process, scientific methods to describe their development remains needed, offering critical historical intelligence for the future. Several systematic approaches to capture pandemic experiences have already been published, offering important insights from the perspective of healthcare providers [39-41], patients [42,43], and the general public [44-46]. Second, the anecdotal evidence and our previous COVID-19 dashboard research signal a gap in cross-country collaboration in the development process. This is despite the presence of several international actors (eg, World Health Organization (WHO), European Centre for Disease Control, and Eurostat) that have led initiatives for multi-country COVID-19 surveillance. The absence of established cross-country exchanges suggests there is untapped potential for the sharing of experiences and learning between countries.

Objective and research questions

To support governments during the current pandemic, and to better prepare for future health threats as well as for other potential uses of dashboards, our research group set out to conduct a multi-country study on the process of developing COVID-19 dashboards across Europe and central Asia. To do so, we partnered with the WHO Regional Office for Europe, a key convening actor in the region and counterpart of our targeted health system stewards. With this aim, our study was guided by two research questions: (1) How can the development process of COVID-19 dashboards during the first year of the pandemic be described from the perspective of the teams responsible for development? (2) what common barriers, enablers and lessons can be derived from their experiences?

Methods

Design

The study adheres to the Consolidated Criteria for Reporting Qualitative Research [47]. To retrospectively examine the development process, we undertook a series of semi-structured group interviews with COVID-19 dashboard developer teams across the WHO European Region. We employed multiple methods to identify and recruit dashboard teams, using a purposive, quota sampling approach. Group interviews in the local language of teams, to the extent possible, provided rich, collective team reflections on experiences with the process [48]. To address our research questions, we adapted an approach previously developed by the study team to describe and assess the actionability of COVID-19 dashboards [32]. We also drew on the findings of prior COVID-19 dashboard research to help determine the characteristics and features to explore [32] (Table 1).

The study team included researchers from HealthPros and WHO European experts on health data. The multinational nature of the study team ensured broad and complementary expertise on contexts, research, policy and subject matter. Team members conducting interviews (four women, six men) had previously researched COVID-19 dashboards [32,49]. They were trained in health services research and had prior research and professional experience in countries of the WHO European Region. Interviewers were collectively proficient in 13 languages used in the WHO European Region.

The research protocol was developed in accordance with the ethical requirements of our primary research base, the Amsterdam University Medical Centres affiliated with the University of Amsterdam. Participants provided written consent during the recruitment stage and verbally restated their consent at the start of their interview. Confidentiality was assured by assigning each participating dashboard team a random code (eg, D1) and removing identifying information from verbatim quotes used throughout the paper.

Table 1. Overview of characteristics and features explored

FOCUS BY RESEARCH QUESTION	CHARACTERISTICS AND FEATURES EXPLORED
Development process	Responsible organisations, teams and launch
	Aims, users and content
	Data sources and breakdowns (geographic, population)
	Data display, interpretation and visualisation
	Future plans
Reflections on process	Barriers
	Enablers
	Lessons learned

Sample of dashboards and informant recruitment

We defined our target sample of COVID-19 dashboards using five criteria: (1) reporting of key performance indicators related to the pandemic; (2) use of some form of visualisation; (3) public availability in a web-based format; (4) reporting at national level within the WHO European Region; and (5) development by a governmental organisation or appointed authority. To maximise the generalisability of our findings, we set out to recruit a geographically representative sample of COVID-19 dashboards from the region's 53 Member States. We applied the country subgroups from the WHO's European Health for All database [51] and set a target of 50% representation within each: European Union (EU) members from before May 2004 (EU15) (n = 15); EU members from after May 2004 (EU13) (n = 13); Commonwealth of Independent States (CIS) members (n = 12); and other European Region countries not included in those groups (n = 13).

To identify COVID-19 dashboards, we consulted the affiliated country data sources of the international COVID-19 Situation Dashboard of the WHO European Region [51] as well as the sample from our previous COVID-19 dashboard work [32]. Additionally, we manually web-searched national, governmental COVID-19 webpages. Our target informants were referred to as *dashboard teams*, specified as members of core teams directly involved in developing and managing national COVID-19 dashboards, ideally right from their inception.

Following identification of appropriate dashboards, we used multiple methods to recruit dashboard teams for interviews. In cases where contact details were listed, teams were reached directly via email and/or through social media (Twitter, Facebook, LinkedIn). Alternatively, where no direct contact was publicly available, we applied a snowball approach, soliciting the advice of existing networks on health information systems across Europe, including country focal points of the European Health Information Initiative (EHII) [52] and the Population Health Information Research Infrastructure (PHIRI) Project [53], as well as other experts known to the study team. To further the recruitment process, the WHO together with the study team, organised and hosted a public webinar in March 2021, convening EHII and PHIRI focal points, at which the study protocol was presented. Approximately 45 participants attended and, when appropriate, bilateral contacts were made by the study team. For countries in which these methods did not result in direct contact with dashboard teams, support from WHO Country Offices was obtained to contact their respective ministries of health, informing them of the study and soliciting participation. During correspondence with all prospective informants, an overview of the study was provided in English or Russian (see Appendix 1). When possible, correspondence took place in the local language.

Data collection

A detailed interview guide was developed by the first authors (EB,DI) and reviewed by the study team. Once finalised, a training session for interviewers was organised to calibrate the interview process. Interviews consistently explored two main themes: (1) the dashboard's development and (2) reflections on the process over the course of the first year of the pandemic (see Table 1). A brief version of the interview guide was prepared in English and Russian and provided to informants in advance of the interviewing (see Appendix 2). A structured pre-interview process was developed for interviewers to familiarise themselves with the corresponding dashboard. For this, we adapted our descriptive COVID-19 dashboard assessment tool [32] and approach to scoring a dashboard's actionability.

Between April and June 2021, 60-minute semi-structured group interviews were conducted with participating dashboard teams, either virtually or in person. Dashboard teams were assigned to interviewers based on their language and context expertise. Interviews were conducted in pairs (a lead interviewer and second team member), where language competencies allowed and provided that the lead interviewer was not a first author (see Appendix 3 for the distribution of interviewers and languages used). With the agreement of informants, interviews were recorded, transcribed verbatim and, when necessary, translated to English. Transcripts were made available to informants upon request. Interview data were stored by the first authors. Fortnightly meetings were organised for interviewers to exchange impressions on the process and to update themes.

Data analysis

The first authors analysed the translated interview transcripts to identify descriptive and explanatory themes using elaborative coding [54] and thematic analysis [55] in an Excel tool developed in the approach set out by Meyer and Avery [56]. The analysis process included familiarisation with the data, development and piloting of a coding framework, independent coding, peer review, mapping and interpretation of results. The coding framework was aligned with the research questions and was developed based on the characteristics and features (Table 1) of the semi-structured interviews (level 1). Additional themes (level 2) were generated through open (unrestricted) coding. The first authors independently coded three test transcripts each, then collaboratively reconciled and revised their coding. The approach was reviewed and discussed during the piloting phase with two other study team members (NK,DK) and an external qualitative researcher. The transcripts were divided between the first authors for independent coding.

Once coding had been peer-reviewed by the second coder, and reconciled by the first, a consolidated dataset for analysis was developed. For analysis of the dataset, the characteristics/features explored were divided equally between the first authors for re-reading, mapping and interpretation. In this process, we iteratively noted recurrent themes, as well as outliers. For reporting on the results by research question, verbatim quotes were extracted from the transcripts. To ensure validity of the findings, we employed different techniques, including researcher reflexivity, debriefing with all interviewers, and reviews by the full study team. Additionally, validation of the findings with informants was organised through a virtual workshop, again hosted by the WHO and attended by 55 study participants in June 2021.

Results

Sample of participating COVID-19 dashboards

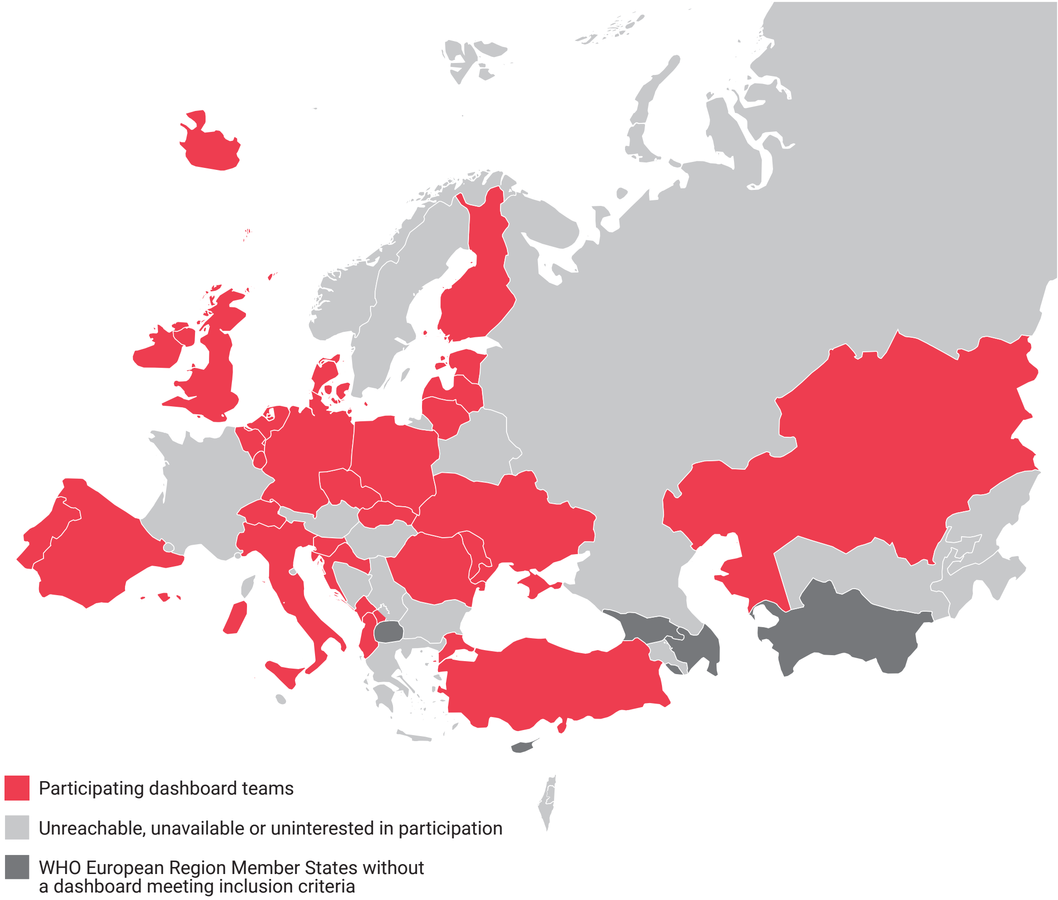
Five WHO European Region Member States (5/53, 9%) did not have an applicable dashboard at the time of sampling. Three COVID-19 dashboards from non-members, yet representing territories within the WHO European Region, were identified through our sampling and included during the recruitment stage (Figure 1).

In total, 33 dashboard teams participated in the study; see Appendix 3 for direct links to each dashboard. The dashboards represented 31 out of 53 WHO European Region Member States, and 65% (33/48) of total Member States with eligible dashboards (Figure 1). Seventeen Member States (17/48, 35%) were unreachable, unavailable or uninterested in participating.

We met our target for representation in all but one regional subgroup, the CIS countries, where a quarter of Member States did not have an applicable dashboard (3/12, 25%). Overall, participation rates of *eligible* dashboards by subgroups ranged from 83% (10/12) of EU13 countries, to 73% (11/15) of EU15 countries, to 57% (8/14) of other countries or territories, and to 44% (4/9) of CIS countries.

Interviews engaged a total of 80 informants (45 men and 35 women). On average, two informants per dashboard were interviewed (range 1–8), with three or more informants contributing in 42% (14/33) of dashboard teams. Two dashboard teams provided written responses and two others required a second interview to finalise data collection. One informant was directly involved in the development of two dashboards. Interviews were conducted in eleven languages (see Appendix 3).

Figure 1. Geographic representation of participating COVID-19 dashboard teams



Note: Azerbaijan, Cyprus, Georgia, North Macedonia, and Turkmenistan did not have a dashboard meeting the inclusion criteria at the time of sampling. Others included in the sample, though not Member States, were Kosovo, Scotland and Liechtenstein. Data on Liechtenstein was reported on jointly on Switzerland's dashboard.

Description of the development process

Responsible organisations, teams and launch. The development of dashboards was initiated predominately by high-level officials, namely a country's health minister, prime minister or president. Units of government or ministries of health (16/33, 48%) or national public health institutes (12/33, 36%) were mostly appointed to lead their development (see Appendix 4 for a listing by country/territory). In a few cases, governments appointed other organisations (5/33, 15%), such as NGOs, private companies or academic institutions, to develop the national dashboard, typically due to resource constraints. An awareness of the Johns Hopkins COVID-19 dashboard [57] and other national COVID-19 dashboards was often cited in connection with the initial request.

The launch dates of participating dashboards were in three main time periods (listed in Appendix 4): February to May 2020, the first months of the pandemic (24/33, 73%); late 2020, in parallel to the pandemic's second wave across Europe (6/33, 18%); and early 2021, in connection with vaccination campaigns (3/33, 9%). Dashboards launched after the first months of the pandemic shared similar challenges, often data constraints or issues in identifying a responsible organisation. The unprecedented speed and workload involved in launching dashboards was a recurrent theme across teams. Many could vividly recount the initial days, recalling the level of uncertainty that characterised the process. As one informant remarked, 'We were flying the plane as we were building it' (D31).

While some teams had prior experience with developing dashboards for internal use, most had never worked on dashboards intended for public reporting. Where possible, internal teams of data management units were re-purposed or new internal teams formed. Often, non-COVID activities were paused. For a quarter of dashboards (8/33, 25%), external teams were contracted to develop the dashboard. In two instances these teams worked on a volunteer basis. Most teams started small, typically with one or two persons, though growing with time to about three to five core persons, and in some contexts, to more than twenty. The importance of multidisciplinary teams was emphasised, involving epidemiologists, public health specialists, information technology professionals, data analysts, policy experts and administrative staff. As teams expanded, additional expertise engaged included business intelligence and analytics experts, geographic information systems (GIS) specialists, user experience researchers and communication professionals. Support received from private front-end dashboard software suppliers was described as a critical addition to teams, especially in the early stages following the launch.

Aims, users and content. The dashboards were depicted as a vehicle for *informing*, but also as a tool for *partnering* with the public to 'achieve greater participation of people in fighting the pandemic' (D9). Specific aims and target users were often implied rather than explicitly defined, with many citing the 'chaotic' (D2) period that characterised the initial phase as a cause for this. Above all, the dashboards targeted the general public, though no dashboard team described having direct or formal contact with the public in the early development stage. Time constraints were consistently cited as the cause for this: 'We would normally have done some user engagement to understand user needs, but the pace and expectation and demand to get the information out was so high' (D31). Other target users included national, regional and municipal officials, health professionals and the media.

In the early stages following a dashboard's launch, the monitoring of user analytics was not pursued, for one common reason: 'there wasn't time for deep analysis of user behaviour' (D1). The intensity of the dashboards' use was described as an effect of high expectations and 'insatiable demands [for data]' (D8), new requests, and questions. While internal feedback mechanisms to dashboard teams were well established, with dedicated pandemic crisis management teams or committees meeting daily, a structured process to manage feedback from the general public was largely absent. Communication teams were described as playing an important role in triaging such comments, predominantly received via email and social media. However, the core dashboard team was typically tasked with providing technical replies – a demanding task given the magnitude and the work pace.

Most dashboards (27/33, 82%) reported two or more types of content, most often data on spread and death, on health systems or on vaccination (Appendix 4). More than half (21/33, 64%) had added vaccination data by late 2020 or early 2021, either as new tabs or as separate dashboards. The latter were typically attributable to one of three reasons or a combination: (1) a different organisation was mandated to coordinate and report on vaccinations; (2) existing or new data collection infrastructure for vaccinations differed from the epidemiological system; (3) a different software solution was used. Beyond the addition of vaccination data, major changes were usually avoided, due either to lack of time or to concerns about reactions from a public accustomed to the dashboard and trusting the *original* version.

Data sources and breakdowns. 'In the beginning, there were Excel spreadsheets' (D24). Many recounted similar intense manual data processing, especially countries or territories with more decentralised, less digitised information systems. The availability, completeness and quality of data ultimately played an important role in determining what indicators could be reported, especially in the initial stages. Many described the trade-off between speed and quality, facing intense demands to publish data in near–real-time. This challenge intensified as the volume of data points increased with time. As one informant recounted, 'Our data are usually ready for deployment 15 to 25 minutes before 4:00 pm, which is the time at which we usually deploy the data. So we have that much time to curate 40 million records' (D10). Choosing to report open data was a political decision, typically made with a view to ensuring full transparency. More than half of the dashboards reported open data (21/33, 64%), meaning full data sets could be directly downloaded from the webpage (Appendix 4). Some went so far as to completely democratise their reporting: 'The prime minister of [country] sees the data at the same time as the guy down the road' (D10).

Data protection rules influenced a number of dashboard features, including what indicators were reported, data sources used, and the geographic and population breakdowns applied. Clearances about what could be published reportedly caused delays, as one dashboard team noted in reference to vaccination data: 'We have had it ready for months, but right now the lawyers are debating, writing back and forth with the ministry' (D16). Fear of exposing personal health data was a repeated issue, with different interpretations of the lowest level of granularity when reporting cases locally, such as groups 'larger than 20' (D16), 'smaller than 10' (D2) or 'no less than 5' (D19).

Many reported that there was great interest in breaking down data to local or municipal levels. This became increasingly relevant with the progression of the pandemic, as infection control measures were being introduced sub-nationally. Possibilities to report data more locally also improved with time, as data collection processes became increasingly automated and of better quality. Persisting challenges included protecting privacy and ensuring that declining numbers were not universally interpreted by the public as low levels of risk. Resolving issues of incomplete denominators was also faced by some teams, which described outdated census data and challenges in recording migrants, undocumented persons and seasonal workers. Beyond geographic breakdowns, disaggregations by age and gender were common, but the use of ethnicity- and race-related data and socioeconomic status breakdowns were generally not pursued. In some cases that was due to a lack of data, but more often it was a political decision. Specifically, some informants reported uncertainty about its relevance for decision-making in the general public and fears of provoking discrimination.

Data display, interpretation and visualisation. Dashboard teams relied on front-end dashboard display solutions either developed in-house (14/33, 42%) or commercially available (19/33, 58%). Most started with commercial solutions (21/33, 64%), typically ArcGIS by Esri (11/33, 33%), which had a 'COVID dashboard module' by early March 2020 (Appendix 4). Selecting a commercial solution was determined by a range of considerations: a team members' previous experience with the software, which eased the learning curve; availability free of charge (often for a limited period), meaning that public procurement processes could be avoided; proactive outreach and support by vendors; comparison with solutions used by other countries; and technical considerations, such as the degree of automation. Despite the speed-to-launch advantages of commercial solutions, they often posed limitations in terms of available templates and customisation. Most notably, the software selected was described as limiting the range and types of visualisations and multi-language capabilities. Additionally, most commercial solutions were cloud-based, which was described by some as suboptimal, predominately due to data security concerns. For such reasons, four dashboard teams (12%) switched software over time.

Many described the task of visualising data in a clear, understandable way as a challenge. Incorporating policy measures in order to explain data trends was seen by some as beyond their function of reporting *facts*. Providing detailed explanations and interpretations of the data were rather left to the media or to what were described as ‘data enthusiasts’ (D24) among the public. The dashboard was often part of a larger COVID-19 data and reporting ecosystem. Supplementary reporting efforts, mostly through static weekly situation reports, typically included additional indicators and more sophisticated analytics. These reports accommodated more text than the dashboard, making detailed explanations of data possible.

The dashboard teams described the importance placed on preparing simple, easy-to-understand and interactive visualisations. In the early stages, visualisations were often not prioritised, as one developer described: ‘I can imagine maybe hundreds of other ways to visualise data describing the COVID situation. Unfortunately, because of lack of time, we decided to implement only the simple versions’ (D1). Maps were consistently used to present local information, though privacy considerations also influenced visualisations, with some describing the challenge of avoiding the suggestion that specific addresses were sites of cases and outbreaks.

Future plans. In discussions of what is next for COVID-19 dashboards, four non-mutually exclusive scenarios were identified: (1) continuing to update existing dashboards, though less frequently over time; (2) further developing content (eg, on vaccines, wastewater studies), data management (eg, automation, quality, open data), design (eg, visuals, organisation) and user elements (eg, low literacy levels, user behaviour studies); (3) exploring non-COVID uses of dashboards for monitoring other communicable diseases (eg, influenza) and registry data (eg, cancers); and (4) preparedness planning, including investing in centralised data warehouses, in-house dashboard teams, coordinating across European countries, and exploring alternative server and software options.

Barriers and enablers

Six main themes and fifteen subthemes were identified as recurrent barriers for some dashboard teams, yet enablers for others. These are briefly described below and listed in Tables 2a and 2b.

Pre-pandemic context. The existing data infrastructure was a major challenge facing some dashboard teams, exposing the limitations of traditional data collection and processing for near–real-time dashboard reporting. In contrast, teams working in settings with more advanced data systems and a culture of data use and re-use credited this as a contributor to their success. Similarly, some described the challenge resulting from highly decentralised data structures and processes, which contributed to a lack of clarity around data ownership and custodianship. The limited level of preparedness for handling privacy regulations was a key barrier for some, whereas prior experience with interpreting privacy and security legislation in a context of public reporting was an enabler for others.

Pandemic context. For most teams, a chronic lack of time caused by the pandemic’s urgency and the demand for publishing near–real-time data meant that other needs such as analysing user behaviour, managing feedback, improving visualisations and engaging across stakeholders became secondary. However, some teams did cite the constant urgency of the pandemic as an incentive for streamlined processes and end-goal orientation, which in turn fostered committed teams and focused efforts. The political context, including changes in leadership positions and the content demands of high-level decision-makers, was highlighted as a barrier for some. An additional barrier was for some a lack of a common understanding on the purposes and audiences of dashboards and their position in the COVID-19 data ecosystem. Contrary to that experience, some teams credited high-level political endorsements for the development of national COVID-19 dashboards as a key enabler, providing ample resources and direction, yet autonomy, to the teams developing them.

People and processes. Seven-day work weeks, an immense workload and shortages of competent specialists hindered the development of dashboards in the experience of some teams. So did bureaucratic processes, including those involving partnering with stakeholders, accessing and linking data, and public procurement. Others, however, considered assets such as having experienced data dashboard and business analytics teams in place, working across departments and organisations, and engaging new team members with necessary competencies to be enabling factors. Flattening hierarchical structures and streamlining processes to facilitate decision-making were also seen as playing supporting roles.

Software. Front-end dashboard software solutions occasionally impaired the development of dashboards, according to some teams, due to their limited visualisation potential, lack of multi-language functionality and other customisation options, or prohibitive pricing. For others, the re-use of existing, in-house-developed data analytics and dashboard tools (where available) provided more flexibility. If in-house options were not available, some teams described commercial software as an aid to accelerating the launch of dashboards. Some software vendors waived initial fees and provided direct support at the outset, and this was cited as a key enabling factor.

Data. Publishing reliable, accurate, consistent and timely data proved challenging for many dashboard teams. Agreeing on data standards, including daily cut-off times, and the absence of granular data needed for reporting *close to home* and broken down by different population subgroups, were described as key hindrances. Conversely, the availability of interoperable data, coordination across data custodians, existing data and methodology standards, and cultures of secondary data use and open data publishing were cited by others as benefits.

Users. Managing users was described by some teams as a critical challenge, who recounted intense scrutiny over the content of dashboards, issues of user misinterpretation of data, and negative reactions to mistakes or modifications. Some teams also detailed high expectations from users (eg, for real-time reporting), challenges in explaining methodologies (eg, to lay audiences), and a lack of systematised processes to handle user feedback. For others, having clearly defined target audiences, knowing their information needs, engaging with media outlets, systematically improving user experience, and handling feedback was a way of partnering with users, and hence an overall advantage to the process. Transparency on methods, and in acknowledging mistakes that inevitably happen at this volume and speed of work, were perceived as enablers.

Table 2a. Summary of themes and illustrative quotes describing barriers

THEME	SUBTHEME	BARRIER	ILLUSTRATIVE QUOTE
Pre-pandemic context	Data infrastructure	Lack of data infrastructure. Outdated, slow processes of data collection and processing. Data ownership and custodianship challenges. Highly decentralised data platforms.	'The epidemiological surveillance systems were not effectively prepared for a pandemic of this scale, either in the volume of information analysed or in the usability of the information systems themselves.' (D9)
	Privacy regulations	Undefined rules and/or lack of practical experience in publishing health data and in conditions for ensuring anonymity.	
Pandemic context	Urgency	Lack of time to analyse user behaviour, manage feedback, improve visualisations and engage across stakeholders.	'There was quite a lot of shuffling about who was responsible – which institution should be responsible for announcing and disseminating aggregated data.' (D4)
	Leadership	Political instability and influence on dashboard's content.	
	Mandate	Lack of common understanding on the purpose of a dashboard, with different interpretations on its use and target users. Unclear responsibilities.	
People and processes	Human resources	Huge workload. Lack of human resources and competencies in working with dashboards. Regular work tasks in parallel.	'At the resource level, we are quite limited. It's complicated to find the right people with the required expertise. It's difficult to recruit, and the team has changed quite a lot over time.' (D17)
	Partnerships	Lack of time and possibilities to engage users and other key stakeholders through 'traditional' processes of engagement.	
	Processes	Slow and convoluted public procurement processes. Underprepared or nonexistent plans for pandemic situations. Issues with prioritising resources.	
Software	Availability	Prohibitive pricing on licensing fees in immediate and longer term. Slow speed of data processing and publishing.	'We needed a Venn diagram. Like really needed it.... But we just couldn't use it because ArcGIS doesn't have one. They only have bar charts, maps and pie charts.' (D4)
	Functionality	Software dictating the look and feel of dashboard. Limitations in visualisation options.	
Data	Availability and quality	Data unavailable and/or not sufficient in timeliness, completeness, structure, consistency or granularity across geographies. Issues to link data from various sources. Labour-intensive, error-prone data processing. Outdated population registration data.	'One primary point that was a large problem was the exact place where someone lives, which is taken from the national census. And they didn't want to share it with us because we were not legally able to obtain them....We have information about [approximately half the population]. The rest of them, we're not sure where they live now.' (D27)
	Data culture	Data siloed by different data custodians. Different data standards among sources. Lack of open data culture.	
	Automation	Challenges in setting update times and cut-offs across data sources and custodians. Demand for real-time data compromises quality.	
Users	Target groups	Lack of defined target audience. Broad definition of user group (eg, general public, regional public health authorities, national policymakers, media).	'The biggest thing was the reactions in the media. Kind of, a lot of negativity online about everything you do, and not enough positivity.' (D2)
	Information needs, user experience and expectations	Limited or no knowledge of users' information needs. No systematic way of dealing with user feedback. Oversimplifying content, thereby posing risk of misinterpretation. Users with high expectations and low data literacy. Negative reactions to modifications to content and visualisations.	

Table 2b. Summary of themes and illustrative quotes describing enablers

THEME	SUBTHEME	ENABLERS	ILLUSTRATIVE QUOTE
Pre-pandemic context	Data infrastructure	Electronic, centralised data flows with automated data management. Ability to link data sources.	'The existing infrastructure, the central health information system and so on, those were definitely enabling factors. If we hadn't had them, or integration with the labs, with the hospitals, we would have been in the Stone Age.' (D24)
	Privacy regulations	Supportive privacy and security legislation and practice. Enabling state-of -emergency conditions.	
Pandemic context	Urgency	End-goal orientation fostering committed and focused efforts. Not being perfectionist. 'Once-in-a-lifetime experience' as a motivator.	'chain of command was clear. That was an enabler, for sure. We all knew [the dashboard] was the official communication channel. It was, practically considered, an extended arm of the government.' (D15)
	Leadership	Political and upper-management support and endorsement in providing access to sufficient resources. High-level directives.	
	Mandate	Clear purpose and mandate. High degree of autonomy. Easy access to data. Skills needed in-house and/or potential to outsource for added capacity.	
People and processes	Human resources	Committed, competent, multidisciplinary and proactive team. Prior experience with public reporting, dashboards and visualisations.	'This then also led, with an agile development, to changing relationships between people, who became much less structured and hierarchical and became much more intellectual and free.' (D12)
	Partnerships	Improvements to intra- and inter-organisational communication and collaboration. Need-based stakeholder collaboration and engagement, including communication specialists and decision-makers.	
	Processes	Flattened hierarchy. Streamlined and agile internal organisation. Change of mentality towards a more operational one.	
Software	Availability	Supportive technological solutions. Commercial software offered free of charge, for a period. Reusing existing solutions.	'There is no doubt that ten years ago the management of this pandemic would have been much more difficult, and now we have technology that has enabled us to fight the pandemic much more effectively.' (D9)
	Functionality	Easy to build and automate. Flexible and easy to maintain once set up. Extensive vendor support.	
Data	Availability and quality	Available, accurate, and timely data of sufficient granularity. Ability to link data across sources and organisations.	'Because we are a data department... it's very easy for us, since we are data managers, all of us, and we have access to all the data. So when we're asked to do something, we don't have to ask anybody "Can you get me this data?" This access is very important for quick results.' (D16)
	Data culture	Aligned data standards and methodologies. Culture of data interoperability, open data and secondary data use.	
	Automation	Streamlined data processes including automation of collection, processing and reporting.	
Users	Target groups	Clearer definition of target audience. Separate dashboards or modules for different user groups with different information needs. Curious, rather than malicious, users. Partnership with media. Support and readiness for data-driven decision-making at all levels. Dissemination aids, including social media platforms, high-level officials, transitional media, and data champions.	'We've had a good relationship with the media and there's a short communication line from the public to us. So, if there's something the public is insecure about or wants to know more about or wants, [they can easily reach us], and that's good.' (D26)
	Information needs, user experience and expectations	Systematic approaches to researching user experience, implementing improvements and managing user feedback. Tradition of public using data for decision-making.	

Lessons learned

When informants were asked to consider, with the benefit of hindsight, what dashboard teams would have done differently or what advice they would offer others to best prepare for public reporting in the context of a crisis, five recurrent themes were identified. One theme was the importance of *simplicity* – reporting only essential information, prioritising content that can be easily interpreted and supported by explanations. A second was the importance of *trust*. Teams described the inevitably of errors, given the urgency and volume of data, and the importance of disclosing errors as they happen. Using open data and prioritising data security and privacy were also important lessons for building user trust. Third, the necessity of working in *partnerships* was emphasised – working in agile and collaborative ways with system leaders as well as across in-house units, with other stakeholders and with the target audience. A fourth theme was the importance of *software and data*. While this was intuitive and recognised at the outset, teams were continuously confronted with the parameters set by the software chosen and were reminded of the importance of automating processes and investing in quality data. A last theme was about confronting the truly *dynamic nature* of dashboards, finding ways to learn from others in order to improve, adapt to the stages of the pandemic and embed dashboards within other reporting modalities. Recurrent themes, lessons learned, and representative quotes are summarised in Table 3.

Table 3. Summary of lessons learned, recurrent themes and representative quotes

THEME	LESSON	REPRESENTATIVE QUOTE
Simplicity	Report essential information only	'From the beginning, one of the main aims was to make it as simple as possible to understand. I avoided providing additional information, so that it was as simple as possible.' (D7)
	Ensure interpretation is straightforward	'I mean, that's not to say there aren't a lot of other types of users, but our primary focus is always that this is for the public and therefore anything that is there for the public should be understandable.' (D10)
	Include explanations	'We learned it is super-extra important to describe all the measures as soon as possible... the first-time people see a number, [that is] the way they understand it and they will continue misinterpreting it forever.' (D4)
Trust	Report errors	'Be brave enough to try it out, to put stuff out and also be transparent while doing it. And, if you have mistakes, also be transparent about it.' (D24)
	Use open data	'Publishing open data took a lot of work off our hands and made it a lot easier, more transparent and, yeah, that's one of the lessons from the crisis, definitely.' (D24)
	Prioritise data security and privacy	'I also noticed issues in terms of data protection.... I think that's another lesson learned, integrating data protection right from the get-go to make it easier later on.' (D17)
Partnership	Involve the right people	'It was a kind of multidisciplinary team that met to design the needs for the dashboard, the functionalities, the data that is necessary to communicate, the functions of the dashboard.' (D29)
	Ensure high-level endorsement	'And then with the support and the initiative of the minister's office, the decision was made to come together in collaboration between my agency and the ministry. We resolved to add transparency and to be more efficient in ensuring a dedicated website for coronavirus data.' (D20)
	Listen to your audience	'We also take into account the needs of politicians: what do they need to make their decisions? So, there is the public health side and the political side that have to be taken into account.' (D17)
Software and data	Choose software wisely	'The tooling influences a lot how the dashboard looks in the end and what is feasible.' (D2)
	Automate when possible	'Unlike other diseases, we are talking about a very large volume of data... using more basic tools that, at this point, no longer works. So everything we want to represent must be represented in an automatic way, with a great capacity to go "drinking at the source". we are talking about a lot of data, millions of millions of data.' (D9)
	Quality data is essential	'If the data is not collected in a way they can utilise [it], they will not be able to produce dashboards... Try to predict how they are going to grow their data warehouses, because that is one of the problems as the pandemic progresses: you need to respond quickly.' (D7)
Change	Learn from others	'We looked at many of the versions [from countries] to see which one will be more appropriate for [us] and how we can design it better for the country. So, examples from other countries helped a lot, I think.' (D29)
	Adapt with the situation	'I would say they evolved very organically as the pandemic evolved, and the data became available in ways that were meaningful to visualise to the public and to the media.' (D32)
	Embed in reporting ecosystem	'We never saw the website as a separate entity, but as a central place from which we disseminate information to other communication platforms.' (D15)

Discussion

In this study, we retrospectively explored the development of COVID-19 dashboards over the first year of the pandemic across the WHO European Region. It is a geographically vast region, comprised of countries and territories with widely differing population sizes, health information systems at varied stages of development [59-60], and diverse data and administrative cultures and traditions [4], among other key differences. Nonetheless, we encountered more similarities than differences in the development stories related by the 33 national COVID-19 dashboard teams we met with. The factors that hindered or facilitated the development process, and the resulting lessons learned, also shared many commonalities.

COVID-19 dashboards were developed across the Region, albeit with little cross-national cooperation

The overall speed with which governments requested the development of public-facing COVID-19 reporting reflects the WHO European Region's tradition of prioritising good governance [61]. Even so, the ubiquitous use of dashboards for delivering COVID-19 data was driven more so by an international ripple effect than by activation of pre-existing emergency response plans. The wide uptake of dashboards appears to have been triggered by early adopters (eg, [9]) and sustained by a proactive commercial software vendor market. In that light, the observation by Bouckaert and colleagues [4] that 'coping with the crisis has been first and foremost an issue of the national states, whereas the European voice has been weak' likewise holds true for COVID-19 public reporting tools, including dashboards. To foster more pan-European collaboration, the convening role of international actors needs to be leveraged. That could advance a common approach to public reporting using dashboards and an exchange of lessons across contexts.

Data behind dashboards is crucial, but so are visual presentations and data interpretation

Dashboards feed on relevant, quality data. In the literature, data sources are cited as an essential aspect in dashboard development [15,62,63]. Initially, national health information systems struggled to provide accurate, timely data for COVID-19 dashboards – a key challenge also reported by other observers [14,64,65]. Our findings signal the need for continued investment in national-level health data sources that are integrated and interoperable, and in digital infrastructure that spans systems of secondary, primary and social care [14]. Preparedness to tackle data privacy and security issues, including practical applications of the General Data Protection Regulation (GDPR) in EU contexts, needs further prioritisation, with the guiding aim of reporting data in 'proportionate, ethical and privacy-preserving' ways [14]. Cross-national efforts like the European Health Data Space [66] may advance the development of common data standards, indicator sets and methodologies, thus enhancing both national and pan-European reporting.

While dashboards are an important communication tool, they are, like other digital technologies [14], not a silver bullet. Previous research has emphasised that the features of dashboards must fit their intended purposes [15]. The actionability of data for end users depends on how clearly and understandably the information is communicated [67-69]. We observed differences in the extent to which teams were exploring, discussing and defining their dashboards' purposes. Some saw the purpose as solely presenting data (raw numbers) for the public to interpret on its own; others endeavoured to provide explanations using narratives or visual methods. As reported in other studies, the ways in which information is presented may affect not only the subjective perception but also the objective comprehension of the information [11,70,71]. Systematic approaches to exploring user needs and use patterns are necessary if dashboards are to bridge the gap between mere managerial tools and full-fledged public reporting devices.

Dashboards seem to be "here to stay" for monitoring and reporting

The interviewed teams agreed that dashboards – as well as other near–real-time, web-based, interactive and visual reporting tools – are the likely future of public reporting. COVID-19 dashboards have served to demonstrate how much can be achieved with limited resources and in high urgency. They also serve to flag imminent areas for improvement and to spot new challenges like potentially harmful misinformation [72]. Running dashboards in the longer term will likely include further expanding their policy, public health and clinical use into areas such as resilience and recovery plans [73], late complications of COVID-19 [74-76] and its influence on specific population and patient groups, such as people living with HIV [77] or diabetes [78-80], but also non-COVID monitoring, like on cancer, seasonal flu and patient safety. More research is needed into the implementation and management costs of the long term and extended use of dashboards. Past studies have warned that such costs could be prohibitive [15,16]. These were managed (or avoided) during the pandemic through the mobilisation of emergency resources. Ultimately, the continued and expanded use of dashboards will require more intentional resource planning and investment.

Strengths and limitations

Working in partnership with the WHO gave us unique access to the targeted teams from COVID-19 dashboards associated with national government. The diverse composition of our research team enabled the use of an extensive range of languages during data collection, thus aiding both informant recruitment and the richness of exchanges during the actual interviews. The study captured COVID-19 dashboards at a critical point in their development: teams were actively improving and making adjustments to their dashboards at the time of the interviews. Hence, teams were still deeply immersed in their dashboard work and had little difficulty recalling the processes that took place over the previous year.

We acknowledge several potential limitations. First, the size and composition of core dashboard teams varied across countries or territories, causing some variability per dashboard in the profiles and numbers of informants and, ultimately, in the nature of their experiences. Second, although group interviews stimulated joint reflections across teams and thus enriched data collection, such an approach could have also induced group pressure resulting in socially desirable responses. Third, the findings are a snapshot of the initial year of the COVID-19 pandemic and may not reflect later stages of the pandemic. Lastly, the study encompassed national, government-associated COVID-19 dashboards in the WHO European Region, and findings may not be generalisable to the experiences of sub-national dashboards or of other types of developers, such as academia, independent initiatives, media outlets or industry. They may also not apply to other regions globally, and in particular to low-income countries.

Conclusion

The study revealed more similarities than differences among the 33 participating COVID-19 dashboard teams from across the WHO European Region. The learning-by-doing approach described by the teams reflects the novelty of the use of dashboards as tools for public reporting during a pandemic. The experiences of the dashboard teams show that initial underpreparedness was compensated for by high-level political endorsement, the teams' own professionalism, accelerated data improvements and commercial software solutions. Recurrent barriers and enablers deriving from the pre-pandemic and pandemic contexts, from people and processes, and from software, data and users should inform future investments, both in dashboard teams and at the national and pan-European levels. Many lessons have been learned in relation to the themes of simplicity, trust, partnership, software and data, and change. These highlight areas where action is needed to ensure a data-informed approach to health data stewardship using dashboards.

Acknowledgements

The authors thank Jeanine Suurmond for methodological advice, Michael Dallas for language editing, and all the interviewees who generously shared their time to participate in the study: Assel Abakova; Anna Artsruni; Georgi Asatryan; Jonas Bačelis; Simon Bak; Senad Begić; Tania Boa; Lovro Bucić; Stefan Buttigieg; Alan Cahill; Fabrizio Carinci; Gianfranco Costabile; Phillip Couser; Igor Crnčić; Olgeta Dhono; Michaela Diercke; Mykola Dobysh; Marjolein Don; Anna Fumačová; Aram Ghulijanyan; Clare Griffiths; Veaceslav Gutu; Pouria Hadjibagheri; Luc Hagenaars; Scott Heald; Jonas Kähler; Kristjan Kolde; Martin Komenda; Kristina Kovačikova; Tanja Kustec; Terje Lasn; Sonia Leite; Renata Lenhardcziková; Pedro Licínio Pinto Leite;

Jana Lepiksone; Mathias Leroy; Avet Manukyan; Elena Martinez; Graham McGowan; Emma McNair; Lorraine McNerney; Matej Mišik; Susana Monge; Teemu Möttönen; Maja Mrzel; Gints Muraševs; Hugo Agius Muscat; Martina Nagyová; Valentin Neevel; Aleksandar Obradović; André Peralta-Santos; Natalia Plugaru; Ane Radović; Anders Rasmussen; Raul Ritea; Leonardo Rocchi; Josep Romagosa; Giulio Siccardi; Fernando Simon; Margita Štāle; Alexandra Ștefănescu; Kristian Sufliarsky; Patrick Suter; Maríanna Þórðardóttir; Nataša Terzić; Vitaliy Trenkenshu; Alexander Ullrich; Zuzana Vallová; Jeroen van Leuken; Jana Vanagė; Giordano Veltro; Olivia Vereha; Solange Vogt; Liina Voutilainen; Martina Vrbiková; Marjana Vrh; Pauline White; Piotr Wlodarczyk; Kıvanç Yilmaz; Tatiana Zvonnikova.

References

1. World Health Organization, The World Health Report 2000: Health Systems: Improving Performance. Geneva: World Health Organization; 2000.
2. Barbazza E, Tello J. A review of health governance: Definitions, dimensions and tools to govern. Health Policy. 2014;116:1–11.
3. Travis P, et al. Towards better stewardship: concepts and critical issues. Geneva: World Health Organization; 2002.
4. Bouckaert G, et al. European Coronationalism? A hot spot governing a pandemic crisis. Public Adm Rev. 2020:10.1111/puar.13242.
5. World Health Organization. Global surveillance during an influenza pandemic. Geneva: World Health Organization; 2009.
6. WHO Regional Office for Europe. Strengthening and adjusting public health measures throughout the COVID-19 transition phases. Copenhagen: WHO Regional Office for Europe; 2020.
7. Boin A, McConnell A. Preparing for critical infrastructure breakdowns: the limits of crisis management and the need for resilience. Journal of Contingencies and Crisis Management. 2007;15(1):50–9.
8. Kamel Boulos MN, Geraghty EM. Geographical tracking and mapping of coronavirus disease COVID-19/severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) epidemic and associated events around the world: how 21st century GIS technologies are supporting the global fight against outbreaks and epidemics. Int J Health Geogr. 2020;19(1):8.
9. Dong E, Du H, Gardner L. An interactive web-based dashboard to track COVID-19 in real time. Lancet Infect Dis. 2020;20(5):533–4.
10. Yigitbasioglu OM, Velcu O. A review of dashboards in performance management: Implications for design and research. Int J Account Info Syst. 2012;13(1):41–59.
11. Dowding D, et al. Dashboards for improving patient care: review of the literature. Int J Med Inform. 2015;84(2):87–100.

12. Kamel Boulos MN, Geraghty EM. Geographical tracking and mapping of coronavirus disease COVID-19/severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) epidemic and associated events around the world: how 21st century GIS technologies are supporting the global fight against outbreaks and epidemics. Int J Health Geogr. 2020;19(1):8.

13. Zhang Y, et al. Mapping the landscape of COVID-19 crisis visualizations. In Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems. Yokohama, Japan: Association for Computing Machinery; 2021.

14. Budd J, et al. Digital technologies in the public-health response to COVID-19. Nature Med. 2020;26(8):1183–92.

15. Ghazisaeidi M, et al. Development of performance dashboards in healthcare sector: key practical issues. Journal of the Society for Medical Informatics of Bosnia & Herzegovina. 2015;23(5):317–21.

16. Weggelaar-Jansen AMJWM, Broekharst DSE, de Bruijne M. Developing a hospital-wide quality and safety dashboard: a qualitative research study. BMJ Qual Saf. 2018;27(12):1000.

17. Primary Health Care Performance Initiative. Country data. 2021. Available from: https://improvingphc.org/explore-country-data.

18. World Health Organization. Global Health Expenditure Database. 2021. Available from: https://apps.who.int/nha/database/country_profile/Index/en.

19. Eurostat. Eurostat regional yearbook 2021. 2021. Available from: https://ec.europa.eu/eurostat/statistical-atlas/gis/viewer/?config=config.json&mids=BKGCNT,BKGNT22016,C-01M01,CNTOVL&o=1,1,1,0.7&ch=PEO,C01&center=50.00754,19.98211,3&.

20. Institute for Health Metrics and Evaluation. Data visualizations. 2021. Available from: http://www.healthdata.org/results/data-visualizations.

21. Gapminder. Resources. 2021. Available from: https://www.gapminder.org/resources/.

22. Our World in Data. Health. 2021. Available from: https://ourworldindata.org/#entries.

23. Pauwels K, et al. Dashboards as a service: why, what, how, and what research is needed? J Service Research. 2009;12(2):175–89.

24. Florez H, Singh S. Online dashboard and data analysis approach for assessing COVID-19 case and death data [version 1; peer review: 2 approved, 1 approved with reservations]. F1000Research, 2020;9(570).

25. Komenda M, et al. Complex reporting of the COVID-19 epidemic in the Czech Republic: Use of an interactive web-based app in practice. J Med Internet Res. 2020;22(5):e19367.

26. Ulahannan JP, et al. A citizen science initiative for open data and visualization of COVID-19 outbreak in Kerala, India. J Am Med Inform Assoc. 2020;27(12):1913–20.

27. Berry I, et al. Open access epidemiologic data and an interactive dashboard to monitor the COVID-19 outbreak in Canada. CMAJ. 2020;192(15):E420.

28. Dixon BE, et al. Leveraging data visualization and a statewide health information exchange to support COVID-19 surveillance and response: Application of public health informatics. J Am Med Inform Assoc. 2021;28(7):1363–73.

29. de Lusignan S, et al. COVID-19 surveillance in a primary care sentinel network: in-pandemic development of an application ontology. JMIR Public Health Surveill 2020;6(4):e21434.

30. Ibrahim H, et al. Rapid development and utilization of a clinical intelligence dashboard for frontline clinicians to optimize critical resources during Covid-19. Journal of the Society for Medical Informatics of Bosnia & Herzegovina. 2020;28(3):209–13.

31. HealthPros. International Training Network for Healthcare Performance Intelligence Professionals. 2020; Available from: https://www.healthpros-h2020.eu/.

32. Ivanković D, et al. Features constituting actionable COVID-19 dashboards: descriptive assessment and expert appraisal of 158 public web-based COVID-19 dashboards. J Med Internet Res. 2021;23(2):e25682.

33. Bos V, et al. Development and actionability of the Dutch COVID-19 dashboard: descriptive assessment and expert appraisal study. JMIR Public Health Surveill. 2021;7(10):e31161.

34. Barbazza E, et al. Exploring changes to the actionability of COVID-19 dashboards over the course of 2020 in the Canadian context: descriptive assessment and expert appraisal study. J Med Internet Res. 2021;23(8):e30200.

35. Tindemans M. COVID dashboard: 'Good conversations aobut data have started'. In DeCrisismanager. Arnhem, the Netherlands: Maaike Tindemans and Pieter Jongkind; 2021.

36. Jensen S. What we can learn from open data: COVID-19 in the Netherlands. 2021; Available from: https://www.tableau.com/about/blog/2021/4/what-we-can-learn-open-data-covid-19-netherlands.

37. Perkel J. Behind the Johns Hopkins University coronavirus dashboard. 2020; Available from: https://www.natureindex.com/news-blog/behind-the-johns-hopkins-university-coronavirus-dashboard.

38. Merrick J. Behind the scenes of the coronavirus dashboard: a record 76.5m views, 2bn rows of data and 100 computers. UK: iNews; 2021.

39. Liu Q, et al. The experiences of health-care providers during the COVID-19 crisis in China: a qualitative study. Lancet Glob Health. 2020;8(6):e790–8.

40. Bennett P, et al. COVID-19 confessions: a qualitative exploration of healthcare workers experiences of working with COVID-19. BMJ Open. 2020;10(12):e043949.

41. Eftekhar Ardebili M. et al. Healthcare providers experience of working during the COVID-19 pandemic: A qualitative study. Am J Infect Control. 2021;49(5):547–54.

42. Zomerdijk N, et al. Experiences and needs of people with haematological cancers during the COVID-19 pandemic: A qualitative study. Psycho-Oncology. 2021;31:416–24.

43. Drury A, Eicher M, Dowling M. Experiences of cancer care during COVID-19: Phase 1 results of a longitudinal qualitative study. Int J Nurs Stud Adv. 2021;3:100030.

44. Williams SN, et al. Public perceptions and experiences of social distancing and social isolation during the COVID-19 pandemic: a UK-based focus group study. BMJ Open. 2020;10(7):e039334.

45. Mondino E, et al. Public perceptions of multiple risks during the COVID-19 pandemic in Italy and Sweden. Scientific Data. 2020;7(1):434.

46. Branquinho C, et al. "Hey, we also have something to say": A qualitative study of Portuguese adolescents' and young people's experiences under COVID-19. J Community Psychol 2020;48(8):2740–52.

48. Frey JH, Fontana A. The group interview in social research. Soc Sci J. 1991; 28(2):175–87.

49. Ivanković D, Barbazza E, Klazinga N, Kringos D. Comment on Verhulsdonck and Shah's 'Lean Data Visualization: Considering Actionable Metrics for Technical Communication.' J Bus Tech Commun. 2022;36(1):105–13.

50. WHO Regional Office for Europe. European health for all database. 2021; Available from: https://gateway.euro.who.int/en/datasets/european-health-for-all-database/.

51. WHO Regional Office for Europe. COVID-19 situation in the WHO European Region 2021; Available from: https://who.maps.arcgis.com/apps/dashboards/ead3c6475654481ca51c248d52ab9c61.

52. WHO Regional Office for Europe. European Health Information Initiative (EHII) 2021; Available from: https://www.euro.who.int/en/data-and-evidence/european-health-information-initiative-ehii.

53. PHIRI. The PHIRI project. 2021; Available from: https://www.phiri.eu/.

54. Auerbach CF, Silverstein LB. Analyzing your next study using elaborative coding, in Qualitative data: an introduction to coding and analysis. New York: New York University; 2003.

55. Braun V, Clarke V. Using thematic analysis in psychology. Qual Res Psychol. 2006;3(2):77–101.

56. Meyer DZ, Avery LM. Excel as a qualitative data analysis tool. Field Methods. 2008;21(1):91–112.

57. COVID-19 Dashboard by the Center for Systems Science and Engineering (CSSE) at Johns Hopkins University 2020; Available from: https://www.arcgis.com/apps/opsdashboard/index.html#/bda7594740fd40299423467b48e9ecf6.

58. Carinci F, et al. Towards actionable international comparisons of health system performance: expert revision of the OECD framework and quality indicators. Int J Qual Health Care. 2015;27(2):137–46.

59. Saigí-Rubió F, et al. Routine health information systems in the european context: a systematic review of systematic reviews. Int J Enviro Res Public Health. 2021;18(9):4622.

60. Bogaert P, et al. Identifying common enablers and barriers in European health information systems. Health Policy. 2021;125(12):1517–26.

61. WHO Regional Office for Europe. Implementation of the Tallinn Charter: Final report. Copenhagen: WHO Regional Office for Europe; 2015.

62. McAvey K. Investing in the data systems we need to create the health system we deserve, in Health Affairs 2021; Available from: https://www.healthaffairs.org/do/10.1377/forefront.20210528.555489/.

63. Barnum T, et al. Your data looks good on a dashboard. Online Journal of Nursing Informatics, 2019; Available from: https://www.himss.org/resources/your-data-looks-good-dashboard.

64. Dagliati A, et al. Health informatics and EHR to support clinical research in the COVID-19 pandemic: an overview. Brief Bioinform. 2021;22(2):812–22.

65. Rutter H, Wolpert M, Greenhalgh T. Managing uncertainty in the covid-19 era. BMJ. 2020;370:m3349.

66. European Union. European Health Data Space. 2021; Available from: https://ec.europa.eu/health/ehealth/dataspace_en.

67. Damman OC, et al. an international comparison of web-based reporting about health care quality: content analysis. J Med Internet Res. 2010;12(2):e8.

68. Kurtzman ET, Greene J. Effective presentation of health care performance information for consumer decision making: A systematic review. Patient Educ Couns. 2016;99(1):36–43.

69. Hibbard JG. Supporting people to manage their health: An introduction to patient activation. London: The King's Fund; 2014.

70. Belle N, et al. Factoring in the human factor: experimental evidence on how public managers make sense of performance information. Int Public Management J. 2021:1–14.

71. Karami M, Langarizadeh M, Fatehi M. Evaluation of effective dashboards: key concepts and criteria. Open Med Inform J. 2017;11:52–7.

72. The Lancet Infectious Disease. The COVID-19 infodemic. Lancet Inf Dis. 2020;20(8):875.

73. OECD. OECD COVID-19 Recovery Dashboard. 2022; Available from: https://www.oecd.org/coronavirus/en/recovery-dashboard.

74. SeyedAlinaghi S, et al. Late Complications of COVID-19; a Systematic Review of Current Evidence. Arch Acad Emerg Med 2021;9(1):e14.

75. American Academy of Physical Medicine and Rehabilitation. AAPM&R Long COVID Dashboard Released. 2021; Available from: https://www.aapmr.org/members-publications/member-news/member-news-details/2021/08/24/aapm-r-long-covid-dashboard-released.

76. Pledge Times. A dashboard for the long-term complications of "Covid-19" in Abu Dhabi. 2022; Available from: https://pledgetimes.com/a-dashboard-for-the-long-term-complications-of-covid-19-in-abu-dhabi/.

77. SeyedAlinaghi S, et al. The clinical outcomes of COVID-19 in HIV-positive patients: A systematic review of current evidence. Immun Inflamm Dis 2021;9(4):1160–85.

78. Capak K, et al. Prevalence of somatic comorbidities among coronavirus disease 2019 patients in Croatia in the first pandemic wave: data from national public health databases. Croat Med J. 2020;61(6):518–24.

79. Diabetes Center Berne. COVID-19 pandemic and Type 1 Diabetes: Weekly questionnaire to learn more about the experiences of the community during those challenging times. 2020; Available from: https://www.dcberne.com/en/2020/03/covid-19-pandemic-and-type-1-diabetes/.

80. Cerovečki I, Švajda M. COVID-19 pandemic influence on diabetes management in Croatia. Front Clin Diabetes Healthc 2021;2:723855.

Supplementary appendices

Appendix 1: Study overview

Appendix 2: Brief interview topic guide

Appendix 3: Sample details

Appendix 4: Overview of dashboard characteristics

Appendix 1: Study overview

Pandemic public reporting that is fit for purpose and use: A qualitative study of COVID-19 dashboards in the WHO European Region from the perspective of their developers

Background

Public reporting in the context of a pandemic is a core government function and critical to foster accountability, trust and transparency, and to support individuals to make informed, risk-minimizing behaviour changes. Since the outbreak of COVID-19, activity has surged worldwide to develop dashboards as dynamic, visual tools for communicating COVID-19 data. However, without careful selection of indicators and data collection, analysis and visualization, dashboards have the potential to mislead, misinform, and incite panic, or simply to be ignored.

In the first half of 2020, our international research network of Healthcare Performance Intelligence Professionals (HealthPros)[1], launched a global study of COVID-19 dashboards. The study assessed 158 dashboards from 53 countries in July 2020. It also explored what makes a dashboard actionable, where actionability refers to a dashboards potential to inform decision-making. Seven features common to highly actionable dashboards were identified[2].

To date, the experiences of dashboard developers (teams)—the actors responsible for a dashboard's development—have predominately been captured through anecdotal descriptions, rather than structured evaluations of their development process. Recognizing the sustained importance of COVID-19 dashboards as a tool for pandemic reporting, opportunities for learning, exchanging experiences and co-designing recommendations for better preparedness in future public health crises is of critical importance.

Aims

To describe the development of actionable COVID-19 dashboards from the perspective of their developers, including facilitating and hindering factors faced, and jointly identify lessons learned and recommendations for strengthening actionable public reporting in the context of a pandemic.

---

[1] Marie Skłodowska-Curie Innovative Training Network for Healthcare Performance Intelligence Professionals running 2018-2022. The network sets out to train a cohort of 14 HealthPros Fellows. The network's consortium spans partners in Canada, Denmark, Germany, Hungary, Italy, the Netherlands, and United Kingdom. For more information on the HealthPros network, visit: https://www.healthpros-h2020.eu/.

[2] Ivanković D, Barbazza E et al. Features Constituting Actionable COVID-19 Dashboards: Descriptive assessment and expert appraisal of 158 public, web-based COVID-19 dashboards. J Med Internet Res 2021;32(2):e25682.

Research questions

1. How can the development process of COVID-19 dashboards be described? Where this description includes decisions taken around the aim and audience, indicators selected, data sources used, links to policy measures, geographic breakdowns, population disaggregation, and use of visualizations[3].
2. What facilitating and/or hindering factors were faced in the development of COVID-19 dashboards?

Scope

To scope our investigation, we have put focus on *COVID-19 dashboards* that meet the following criteria: (i) reporting of key performance indicators related to COVID-19; (ii) use of some form of visualization (tables, maps, graphs); (iii) availability in an online, web-based format; (iv) reporting on COVID-19 in the scope of the 53 countries of the WHO European Region at the national level; and (v) developed by a government or appointed public authority with the responsibility to report pandemic-related information. See Annex 1 for the list of target dashboards identified.

Approach

A qualitative study designed in two phases: (i) descriptive evaluation using semi-structured interviews with dashboard developers (individuals and/or their teams); and (ii) co-design of lessons learned and recommendations using workshop(s) with participants from phase (i).

Study phases and timing

Phase one: Semi-structured interviews with dashboard developers (April and May 2021)

At-distance interviews will be conducted by a member(s) of the study team in the preferred language of informants based on the working languages of the study team. Interviews are expected to last 60 minutes and will be structured around the two research questions to describe the dashboard's development process and enabling and hindering factors faced. A detailed interview topic guide will be provided in advance.

Phase two: Co-design workshop(s) with dashboard developers (June 2021)

Workshop(s) with participating dashboard developers will be convened in June 2021 to validate the analysis of findings resulting from phase one and to explore lessons learned for

---

[3] This description reflects the seven features of highly actionable dashboards: (1) know the audience and their information needs; (2) manage the type, volume and flow of displayed information; (3) report data sources and methods clearly; (4) link time trends to policy decisions; (5) provide data 'close to home'; (6) breakdown the population into relevant sub-groups; and (7) use story-telling and visual cues. Refer to the article for the description in full: https://www.jmir.org/2021/2/e25682/.

strengthening pandemic-related public reporting moving forward. The workshops are also an opportunity for developers to directly exchange with one another, making this phase both a learning and networking opportunity.

Working languages

All study materials will be available in English and Russian. Interviews can be conducted in the preferred language of the interviewee, limited to the working languages of the study team: English, Russian, German, French, Bosnian, Croatian, Dutch, Italian, Montenegrin, Portuguese, Serbian, Slovenian, Spanish.

Profile of key informants

Target key informants include individuals in senior strategic, operational, analytical or technical positions related to the development and running of COVID-19 dashboards in the WHO European Region. Informants ideally have involvement with the dashboard from its inception and have had oversight or influence over decisions related to its aim, content, data sources, display and dissemination. Interviews can be conducted jointly with one or more member of a dashboard's team at the informant's discretion.

Dissemination and policy implications of results

It is the intention of the study team to submit the findings for peer-reviewed publication. Key informants will be noted in the acknowledgements unless requested otherwise. Dissemination is also foreseen to include a public webinar in fall 2021. Further details will follow. The study's findings are expected to inform jointly developed lessons learned for actionable reporting using dashboards in the context of a public health crisis.

Funding

This study is funded through the European Union's Horizon 2020 research and innovation programme under grant agreement No. 765141.

Study team and contact details

This study is developed by HealthPros in collaboration with the WHO Regional Office for Europe. The full study team includes HealthPros consortium members from the University of Amsterdam, OptiMedis AG, Corvinus University of Budapest, Scuola Superiore Sant'Anna, University of Oxford and University of Surrey. Contact details for the core study team are provided below.

Are you interested to participate?

Are you involved in the strategic development and/or operations a public, web-based COVID-19 dashboard and interested to participate in this study? Alternatively, are you aware of the experts in your country that are? If so, please get in touch using this link to connect with the study team.

Join our Launch Event 30th March 2021

COVID-19 public reporting from the perspective of dashboard developers

Tuesday March 30th | 12:00–13:00 (Copenhagen) | Zoom | English and Russian

Please also join a public webinar where we will launch this study and present results from recent COVID-19 dashboard and health information system studies.

Target COVID-19 national dashboards in WHO European Region Member States

The following lists COVID-19 dashboards identified in WHO European Region Member States that meet the study's inclusion criteria of a public, web-based COVID-19 dashboard, reporting on the national level and developed by the government, ministry of health or a delegated public authority with the responsibility of publicly reporting COVID-19 dashboard. In some countries, more than one dashboard may meet these criteria. This list is not exhaustive nor definitive of the dashboards sought and can be adjusted based on the advice and expertise of country-specific informants.

Appendix 2: Brief interview topic guide

1. Development process and team

- Briefly, please describe the development process of your dashboard, specifically key milestones from its inception to its launch as well as any main changes that have taken place over the course of 2020 to present-day.
- Describe the members of the team that work on the dashboard on a regular basis, specifically, the competencies (profile) of these individuals, key experts, organizations or stakeholders collaborated with and any significant changes to the team over time.

2. Description of the dashboard's key features[4]

- **Purpose and users.** Was the purpose of the dashboard defined from the start? Who was considered the intended user? Have any measures to track the use of the dashboard been taken?
- **Information (indicators).** What was the process for deciding which indicators to report on? Who was involved in that process? How was the ordering and clustering of indicators decided on?
- **Data sources and methods.** How were the sources of data selected? What permissions to gain access were involved? What data would you have liked to have had access to?
- **Reporting data over time.** To what extent were infection control policy measures (eg, mandatory use of masks) reported on the dashboard to show their effect over time? Why or why not was this done?
- **Geographic breakdowns.** How has the geographic breakdown of data (eg, national, regional, municipal, post code-level) changed over time? Did more granular data become available? In your opinion, what breakdowns are missed and why?

---

[4] The features highlighted for discussion draw from our previous study on a global sample of COVID-19 dashboards. Find the full article here: https://pubmed.ncbi.nlm.nih.gov/33577467/.

- **Population breakdowns.** What population breakdowns were applied (eg, sex, age, ethnicity)? How did these change over time? In your opinion, what breakdowns are missed? Why?
- **Visualizations and explanations.** How were displays decided upon (eg, charts, tables, graphs)? How have you used visual cues and explanations on the data and trends to improve readability? Have you tested the readability/user experience of the dashboard?

3. Summary of key barriers and enabling factors and lessons learned

- In your opinion, what has been the most advantageous factor supporting the development and running of the dashboard? What was the most challenging factor and/or greatest barrier faced in the development and running of the dashboard?
- With the benefit of hindsight, what would you do differently? What advice would you offer to other countries to best prepare for public reporting in the context of a public health crisis?
- What are your plans for the dashboard for the remainder of 2021?

Appendix 3: Sample details

#	COUNTRY (LINK)	ARCHIVE	ORGANIZATION	GROUP	INTERVIEW LANGUAGE	INTERV-IEWER(S)	INFORMANTS		
							#	M	F
1	Albania	https://archive.vn/i4S1W	National Agency for Information Society	Other	English	EB, DI	1		1
2	Andorra	https://archive.ph/vPeLT	Government of Andorra	Other	English	Written	1	1	
3	Armenia	https://archive.vn/3g3Qx	Armed—e-Health Unified Information System	CIS	English	EB, ZY	4	3	1
4	Belgium	https://archive.vn/wip/3WRK6	Sciensano	EU15	English	DI	1[a]	1	
5	Croatia	https://archive.vn/huMXY	MediaVal	EU13	Croatian	DI	3	2	1
6	Czechia	https://archive.vn/yQjkA	Masaryk University	EU13	English	DI	1	1	
7	Denmark	https://archive.ph/XVna1	Statens Serum Institute	EU15	English	EB, DI	3	3	
8	Estonia	https://archive.ph/RKunh	Health and Welfare Information Systems Centre (TEHIK)	EU13	English	EB, DI	2	1	1
9	Finland	https://archive.ph/EqoyQ	Finish Institute for Health and Welfare (THL)	EU15	English	EB, DI	2	1	1
10	Germany	https://archive.ph/hrRd2	Robert Koch-Institut	EU15	German	VB, OG	2	1	1
11	Iceland	https://archive.vn/144Xg	Directorate of Health	Other	English	EB, DI	1		1
12	Ireland	http://archive.today/JAjRL	Government of Ireland and Ordnance Survey Ireland	EU15	English	OBF, EB, DI	3	1	2
13	Italy	https://archive.ph/u8tzO	Agenzia Nazionale per i Servizi Sanitari Regionali (AGENAS)	EU15	Italian/English	MP, EB, DI, NK	5	5	
14	Kazakhstan	https://archive.vn/8WpFu	National Public Health Center and Datanomix	CIS	Russian	ZY	2	1	1
15	Kosovo	https://archive.vn/wip/twFeg	National Institute of Public Health	Other	English	DI	1[a]	1	
16	Latvia	https://archive.vn/Bluro	Centre for Disease Prevention and Control of Latvia (CDPC, SPKC)	EU13	English	Written	3	1	2
17	Lithuania	https://archive.ph/90EEv	Statistics Lithuania	EU13	English	EB, DI	2	1	1

#	COUNTRY (LINK)	ARCHIVE	ORGANIZATION	GROUP	INTERVIEW LANGUAGE	INTERV-IEWER(S)	INFORMANTS		
18	Luxembourg	https://archive.vn/Bascs	Government of Luxembourg	EU15	French	CW	1		1
19	Malta	https://archive.vn/gltow	Ministry of Health	EU13	English	EB, DI	2	2	
20	Montenegro	https://archive.vn/r8wd4	Institute of Public Health	Other	Montenegrin	MP, DI	3	2	1
21	Netherlands	https://archive.vn/6wjkz	Rijksoverheid; the National Government of the Netherlands	EU15	English/ Dutch	VB, EB, DI, NK	4	3	1
22	Poland	https://archive.ph/O89Hr	Ministry of Health	EU13	English	EB, ZY	1	1	
23	Portugal	http://archive.today/uZfSO	Ministry of Health/ Directorate General of Health	EU15	Portuguese	OBF	2	2	
24	Republic of Moldova	https://archive.vn/Gr5f3	Ministry of Health, the National Agency for Public Health	CIS	English	ZY	2	1	1
25	Romania	https://archive.vn/FuQz3	Code for Romania	EU13	English	DI, ZY	3	1	2
26	Slovakia	https://archive.vn/6CELh	National Health Information Center, Ministry of Health	EU13	English	DI	8	2	6
27	Slovenia	https://archive.vn/npXDO	National Institute of Public Health (NIJZ)	EU13	Slovenian	MP	3		3
28	Spain	https://archive.ph/KUoWX	Ministry of Health, Consumption and Social Welfare	EU15	English	EB, BM	3	1	2
29	Switzerland	https://archive.vn/GzzvU	Federal Office of Public Health (FOPH)	Other	English/ French	CW	3	1	2
30	Turkey	https://archive.ph/gdPFQ	Ministry of Health	Other	English	EB, MP	1	1	
31	Ukraine	https://archive.ph/ugzj6	National Security and Defense Council	CIS	English	EB, ZY	2	1	1
32	United Kingdom	https://archive.ph/Md5ID	Public Health England	EU15	English	DI, BM	2	1	1
33	United Kingdom–Scotland	https://archive.ph/K4hIF	Data and Intelligence Network, Public Health Scotland	EU15	English	EB, DI	4	3	1
				Totals			**80**	**45**	**35**

Notes: M: male; F: female; EU15: Members of the European Union before May 2004; EU13: Members of the EU after May 2004; CIS: Commonwealth of Independent States; Other: other WHO European Region member states and/or territories not captured by other groups. aSame informant.

Appendix 4: Overview of dashboard characteristics

COUNTRY/ TERRITORY	APPOINTED DEVELOPING ORGANISATION TYPE	LAUNCH DATE	TYPOLOGY OF CONTENT[a]				OPEN DATA[c]	SOFTWARE
			Spread/ death	Health system	Vaccination	Other[b]		
Albania	Gov/ministry	March 2020	X	X			Yes	In-house solution
Andorra	Gov/ministry	October 2020	X	X			No	In-house solution
Armenia	Other	May 2020	X				No	In-house solution
Belgium	Public health	March 2020	X	X	X		Yes	Google Data Studio
Croatia	Other	March 2020	X	X			Yes	In-house solution
Czechia	Other	February 2020	X	X	X		Yes	Google Data Studio
Denmark	Public health	April 2020	X	X	X[d]		Yes	Esri ArcGIS
Estonia	Gov/ministry	March 2020	X	X	X	X	Yes	Tableau
Finland	Public health	March 2020	X		X[d]		Yes	Esri ArcGIS
Germany	Public health	March 2020	X				Yes	Esri ArcGIS
Iceland	Gov/ministry	March 2020	X	X	X		Yes	Infogram
Ireland	Gov/ministry	March 2020	X	X	X		Yes	Esri ArcGIS
Italy	Gov/ministry	October 2020	X	X			No	In-house solution
Kazakhstan	Public health	April 2020	X				No	Qlik Sense
Kosovo	Public health	Early 2021	X	X			No	Google Data Studio
Latvia	Public health	March 2020	X	X			Yes	Infogram; Esri ArcGIS
Lithuania	Gov/ministry	November 2020	X		X		Yes	Esri ArcGIS
Luxembourg	Gov/ministry	March 2020	X	X	X		No	Qlik Sense
Malta	Gov/ministry	August 2020	X		X		Yes	Infogram
Montenegro	Public health	March 2020	X				No	Infogram
Netherlands	Gov/ministry	May 2020	X	X	X	X	Yes	In-house solution
Poland	Gov/ministry	Early 2021	X		X[d]		Yes	Esri ArcGIS
Portugal	Gov/ministry	March 2020	X	X	X		No	Esri ArcGIS
Republic of Moldova	Gov/ministry	March 2020	X				No	Esri ArcGIS
Romania	Other	March 2020	X		X		Yes	In-house solution
Slovakia	Gov/ministry	March 2020	X	X	X		Yes	In-house solution
Slovenia	Public health	Early 2021			X		No	Microsoft Power BI
Spain	Public health	February 2020	X		X		Yes	In-house solution
Switzerland	Other	November 2020	X	X	X		Yes	In-house solution
Turkey	Gov/ministry	March 2020	X	X			No	In-house solution
Ukraine	Gov/ministry	October 2020	X	X	X		No	In-house solution
UK	Public health	March 2020	X		X		Yes	In-house solution
UK, Scotland	Public health	April 2020	X	X	X		Yes	Tableau

Note: all data are as of the date of interview. Gov: government. UK: United Kingdom. [a]Refers to complete, anonymised datasets available directly from the dashboard, without additional permissions or requests. [b]Spread and death: cases, deaths, testing, reproduction rates, self-quarantine, etc. Health system: hospitalisations; admissions to intensive care units (ICU); hospital, ICU and ventilator capacity; personal protective equipment; etc. Vaccination: vaccination, first and second dose. [c]Other: behavioural insights and social and economic impact. [e]Dedicated dashboard.

General discussion

Introduction

This thesis has assessed the actionability of healthcare performance indicators in a series of seven studies (Table 1). In the pursuit of greater value in healthcare, the implementation of *learning healthcare systems* has become a common ambition in recent times across health systems worldwide. This entails a growing need for performance indicators that are actionable. The imperative to prioritise the actionability of indicators has also been facilitated by the increasingly data-rich and technology-enabled nature of current healthcare systems. What is more, the COVID-19 pandemic has put a spotlight on the real costs of failing to optimise the secondary use of actionable health data for decision-making in health systems. This applies both in the sphere of routine, essential services like primary care and in the response to the pandemic itself.

Given that context, this thesis has been guided by the aim of exploring *actionability* and its constructs of *fitness for purpose* and *fitness for use,* both conceptually and in practice. Part I sought a more nuanced understanding of the two constructs. Parts II and III went on to investigate real-world applications of healthcare performance indicators in the context of primary health care (PHC) and the COVID-19 pandemic. Both areas of application are of critical public health importance globally. PHC is an area where the development of performance indicators and the use of aggregated data for the strengthening of systems has been prioritised for decades [1]. In contrast, the COVID-19 response illustrates a public health event where developments took place in real time, under the strain of a pandemic and its information urgency. The response was characterised by the immediate development and presentation of performance indicators through the novel use of dashboards [2,3]. In researching these two heterogenous areas of application, focus was put to explore the respective purposes of using indicators across the micro–meso–macro contexts of healthcare systems. Such processes were characterised by aspects such as the types of data sources and data visualisation, be it in frameworks or dashboards, that were put to use in the various contexts.

This final chapter summarises the main findings across the previous seven chapters. Methodological considerations with respect to the validity and generalisability of findings are presented, and the findings are then interpreted and placed in the broader context of the field of healthcare performance measurement. Finally, applications of the findings are discussed in their implications for future research and policy.

Table 1. Recalling the main objectives and research questions of this thesis

PART	OBJECTIVE	CHAPTER	MAIN RESEARCH QUESTION
I	To explore the conceptualisation of actionability of performance indicators	1	What characterises fitness for purpose and fitness for use?
II	To explore the actionability of PHC performance indicators and data sources	2	How can actionable PHC performance intelligence be generated across countries?
		3	What are the uses of electronic medical records in PHC for performance measurement?
		4	What makes primary care prescribing data actionable for improving quality of care?
III	To explore the actionability of COVID-19 dashboards in terms of their features, changes and development process	5	How can COVID-19 dashboards be described and what makes them actionable?
		6	Does the actionability of COVID-19 dashboards increase over time?
		7	How can the process of developing COVID-19 dashboards be described?

Main findings

Part I: Conceptualising actionability

Chapter 1 set out to develop a more refined understanding of fitness for purpose and use. A multiphase research approach was applied, consolidating the literature on the topic, as well as the insights of thought leaders and data users through a series of semi-structured interviews [4]. The conclusion was that fitness for purpose can be specified by a range of uses beyond the aggregate micro–meso–macro contexts of healthcare systems. Each purpose of use was found to correspond with different decision-making tasks and, in effect, information needs of the target users. Hence, considerations with respect to why information is needed (its *purpose*), for whom (the intended *users*), and in which context of the health system (*micro, meso or macro levels*) are of key importance for gauging whether an indicator is fit for purpose.

Second, an indicator's fitness for use was found to be captured by three main types of considerations. These pertain to an indicator's *technical qualities,* such as its ease of interpretation or whether it measures what matters; the *intended context of use*, which is influenced by the information infrastructure, governance, workforce capacity and culture; and the handling of an indicator across *managerial cycles*, extending from the initial selection of indicators through the steps of obtaining data, applying analysis methods, displaying findings, and reaching decision-makers. Hence, the existence and development of data sources, of performance frameworks, of ways to visualise data (as in dashboards), and the means of embedding of indicators into managerial cycles constitute important focuses in analysing whether an indicator is fit for use. The study in **Chapter 1** concluded by emphasising that an indicator's fitness for purpose and fitness for use must be appraised together in order to reliably gauge its actionability.

Part II: Exploring actionability applied to primary health care

In Part II, three studies were conducted to explore actionability in relation to PHC – first to develop a framework for its measurement, and then to assess actionability within the scope of indicators sourced from different types of primary care data. In **Chapter 2**, an approach was developed to generate actionable PHC performance intelligence across countries, specifically in the European Region of the World Health Organization (WHO). The study built on an existing systematic review on primary care [5] and drew on European health policies and mappings of available PHC data sources [6,7]. Through the multistage approach applied, a performance framework was developed, organised in the classical model of structure–process–outcomes. The framework clustered the measurement of PHC into six domains: primary care structures, model of primary care, care contact, primary care outputs, health system outcomes, and health outcomes. A further 26 subdomains and 63 features of primary care were also identified. To increase the sensitivity of the tool to the European context, a care continuum was developed using a set of 12 health conditions as tracers. A total of 139 indicators were then mapped to the classification. For each indicator, a range of potential data sources were identified from existing national and international information systems. The resulting framework and its broad suite of indicators had the potential to be customised in terms of the specific uses of the performance intelligence that would be generated if the framework were applied to individual country contexts.

Recognising primary care electronic medical records (EMRs) as a rich data source to measure and improve quality, in **Chapter 3** the current uses of EMRs were investigated, as well as additional considerations to further their potential, in the Canadian PHC context [8]. Using a case study design and a descriptive assessment, six initiatives were identified that drew on EMR data for secondary use in performance measurement. The cases comprised one multi-jurisdictional and five jurisdiction-specific initiatives in the provinces of British Columbia, Manitoba and Ontario. EMR data uses were found to be applied predominately at the micro-level for PHC physician and team performance improvement, with some usage for organisational or network-wide improvement at the meso-level. Indicator sets varied in number, but they shared an emphasis on chronic disease management and on prevention and screening, and to a lesser extent on medication management. Common challenges to be overcome to further the use of EMR data were identified in relation to governing, resourcing and data implementation for performance measurement.

In the data-rich context of the Netherlands, **Chapter 4** explored the secondary uses of primary care prescribing data for improving quality of care [9]. The investigation was anchored around three types of prescribed drugs that were employed as tracers: antibiotics, benzodiazepines and opioids. Three main sources of data were found to be in use for improving prescribing in primary care: clinical data in the electronic health records of general practices; pharmacy data in community pharmacy databases; and claims data from insurance companies. While the secondary use of pharmacy and claims data was found to be well established across the micro, meso and macro-levels, the coupling of these data with electronic health record data from general practice was limited. The study also found important differences in the types of prescribing information needed by the micro, meso and macro contexts. The extent to which current indicators could address those differing needs varied by prescription type. Five main themes were identified as focus areas for optimising the secondary uses of prescribing data: (1) measuring what matters, (2) expanding data linkages, (3) improving data quality, (4) facilitating data sharing and (5) optimising fit-for-use analysis.

Part III: Exploring actionability applied to COVID-19 dashboards

Three studies explored actionability in the context of the COVID-19 pandemic, specifically in relation to the use of online information dashboards. First, **Chapter 5** set out to describe the features of existing COVID-19 dashboards and to appraise features that support their actionability. A descriptive assessment was conducted to a sample of 158 dashboards from 53 countries worldwide in the early stages of the pandemic (July 2020), scoring the dashboards using nominal group technique [10]. The study found that most dashboards had been developed by government authorities and were national in their scope. The primary purpose and intended audience of the majority of dashboards were unstated or only implied. As regards *what* the dashboards specifically reported, epidemiological indicators were nearly universally included. However, indicators focusing on the social and economic impact of the pandemic or on behavioural insights were only infrequently included, even though those types of pandemic information were expressly recommended by the WHO [11]. Notably, about one quarter of dashboards did not report their data sources. In examining *how* the data was analysed, the study found that dashboards predominately reported time trends and breakdowns by two geographic levels and by age and gender. An average of two types of displays were used, mainly graphs and maps, and colour coding was the most common visual support to aid interpretation.

Through expert scoring of the sampled dashboards, the actionability of dashboards was appraised to identify common features of highly actionable dashboards. Actionable COVID-19 dashboards were found to (1) know their audience and its information needs; (2) manage the type, volume and flow of displayed information; (3) report data sources and methods clearly; (4) link time trends to policy decisions; (5) provide data that were 'close to home'; (6) break down populations into relevant subgroups; and (7) use storytelling and visual cues. The study concluded that, although there was no single approach to developing a dashboard, the full potential of dashboards in the pandemic's early stages remained largely untapped.

Chapter 6 built further on the findings of the previous chapter by examining changes to COVID-19 dashboards over time, based on a re-appraisal of the dashboards in the Canadian subsample in November 2020 [12]. Comparisons between the two time points revealed that subtle improvements had been made. These related predominantly to data provision (specificity of geographic breakdowns, range of indicators reported, and explanations of data sources or calculations) and to advancements enabled by the technologies in use (customisation of time trends and interactive or visual chart elements). Some improvements to the actionability of the dashboards were also seen, especially in features involving local-level data provision, time-trend reporting and indicator management. No improvements were found in communicative elements (clarity of purpose and audience), while storytelling techniques to narrate trends remained largely absent from dashboards. Further attention was needed to both technical *and* organisational aspects of dashboard development. Potential organisational improvements included more clarity about mandates and accountability, which would enable dashboard teams to develop and maintain more purpose-driven dashboards.

Finally, the development stories of national COVID-19 dashboard teams were investigated in **Chapter 7**. The purpose was to bridge the gap in pan-European collaboration and to remedy the lack of systematic evidence to capture the process of developing dashboards [13]. Semi-structured group interviews were conducted in a sample of 33 national teams from across the WHO European Region. The study revealed more similarities than differences in dashboard development. Urgency, intense workload, limited human resources, data and privacy constraints, and public scrutiny were common descriptors of the initial dashboard development stage across teams. Six main themes and fifteen subthemes were identified in relation to developmental barriers and enablers, whereby recurrent barriers for some teams might serve as enablers for others. The themes pertained to (1) the pre-pandemic context (data infrastructure, privacy regulations); (2) the pandemic itself (urgency, leadership, mandates); (3) people and processes (human resources, partnerships, processes); (4) software (availability, functionality); (5) data (availability and quality, data culture, automation); and (6) the users (target groups, information needs, user experience and expectations).

With this benefit of hindsight, lessons about the dashboard development process were identified around five themes: (1) *simplicity* (essential information only, straightforward interpretations, clear explanations); (2) *trust* (acknowledgement of errors, use of open data, prioritisation of data security and privacy); (3) *partnership* (engagement of the right people, securing high-level endorsement, listening to your audience); (4) *software and data* (wise choice of software, automation when possible, quality data); and (5) *change* (learning from others, adapting with the situation, embedding dashboards into reporting ecosystems). The study found that the relative underpreparedness of countries to develop dashboards was offset by more agile and pragmatic processes developed in the face of the information urgency. A further conclusion was that, moving forward, the full potential of dashboards requires investments both at team level and at the national and pan-European levels.

Methodological considerations

The chapters of this thesis comprise a series of systematic research studies applying a range of qualitative methods. The methodological limitations specific to each study were presented in their respective chapters. Here the *validity* of the findings in terms of the appropriateness of study designs, data sources and processes for the analysis in question [14], and on their *generalisability*, the potential to extend the findings beyond the contexts studied [15], are reflected upon.

Validity considerations

In the absence of existing tools applicable to the research questions, the development of study-specific tools was needed. To do so, the findings of **Chapter 1** were applied in subsequent chapters. Study-specific tools were reviewed by experts and/or piloted prior to their use. As **Chapter 1** findings were incorporated into research tools, they were also complemented by existing definitions, concepts and models, such as the notion of micro–meso–macro contexts [16], Donabedian's structure–process–outcome model [17], and Lasswell's model for mass communication [18]. Although at the time of study there was a lack of applicable tools to describe and assess COVID-19 dashboards, that field has since developed further. Other studies have also applied Lasswell's model (eg, [2,19]), exploring dashboards by each element of 'Who (says) What (to) Whom (in) Which Channel (with) What Effect' [18]. There are similarities between the tool developed here and those in other approaches (eg, [20,21]), although some other tools have examined a narrower range of elements. For example, an expert review of government COVID-19 dashboards in the US context [20] focused on a dashboard's content (What) and their function and visual design (How).

In **Chapters 2 and 4**, the tracer method was applied to anchor the studies [22]. The use of tracers was deemed a suitable approach for tailoring the investigation to pertinent areas of interest in PHC. In the former chapter, that meant selecting 12 health conditions as tracers that would define the scope of the selection of indicators that were to be mapped to the framework developed to monitor the impact, performance and capacity of PHC. In the latter chapter, tracers were used to focus the study on three commonly prescribed types of drugs: antibiotics, benzodiazepines and opioids. As a consequence, the findings are true to the tracers applied but may not capture the nuances of other possible tracers. The tool developed in **Chapter 2** ultimately affords the flexibility to accommodate different tracer conditions, depending on the tool's specific context of use.

Because these were exploratory studies, capturing data across healthcare system levels (micro–meso–macro) and types was prioritised. The studies therefore consistently sought to engage a range of perspectives. In total more than 200 informants were met with for the seven studies conducted. These included academics, regional and national policy-makers, healthcare professionals, healthcare managers, dashboard teams, representatives of professional and patient associations, and health information system vendors. An alternative approach might have focused on a particular context, such as by investigating each research question at the micro-level from the perspective of healthcare professionals. Exploring the system as a whole took precedence, however, in order to reach an understanding of actionability, both conceptually and in practice, that would be consistent with the reality of healthcare systems.

To ensure a sufficient mix of perspectives, different panels were designed as a method to group informants in the studies. The sampling strategies were not exhaustive and were to the exclusion of some relevant system actors, such as patients, who were beyond the scope of the studies. The representativeness of the actors included was also not exhaustive. For example, the clinical perspective was predominately that of doctors, to the exclusion of nurses and allied healthcare providers. The patterns and experiences identified will therefore require additional testing with larger samples in order to make observations specific to particular actors. Additionally, in order to capture a diverse range of perspectives, semi-structured interviews were conducted in all studies. Participation was always voluntary. This implies that the data do not necessarily reflect general experience, but rather may capture viewpoints from people with a particular interest in the topic, possibly expressing strong opinions.

For the purpose of assessing actionability in dashboards used to report COVID-19 information, in **Chapters 5 and 6**, experts were used as a proxy for the intended users of dashboards. In the majority of dashboards sampled, the often unstated but implied or presumed users were the general public. As an initial exploration of actionability, the perspective of experts on healthcare performance intelligence was the one most closely associated with the research aims. The nominal group technique was applied, as a well-established method for exploring group judgments [23]. The thus identified features of highly actionable dashboards therefore reflect the perspective of experts and should not be inferred to be that of the general public.

In addition to capturing different perspectives, the studies were not limited to a specific type of healthcare system or context. A number of measures were taken to ensure diversified samples, including the use of a range of sampling strategies (purposive and quota sampling) and techniques (manual searches or engagement of the study teams and existing international networks). To enhance the comparability of multi-country samples in the studies on COVID-19 dashboards, data collection was conducted at consistent points in time and digitally archived it for record-keeping purposes (**Chapters 5 and 6**). Large study teams were also set up to ensure data collection in the original language of the dashboard reporting.

Generalisability considerations

The studies in this thesis were conducted with international samples (**Chapters 1, 2, 5 and 7**) or country-specific samples, in the contexts of Canada (**Chapters 3 and 6**) and the Netherlands (**Chapter 4**). Hence, the generalisability of findings is considered in relation to these differing samples and settings.

Multi-country studies

The multi-country studies drew data from high- and middle-income countries, primarily from the WHO European Region and the Member States of the Organisation for Economic Co-operation and Development (OECD). Such research settings are generally well positioned in terms of available resources, increasingly digitised health data, and growing attention to secondary data uses [24,25]. The 53 Member States of the WHO European Region have continuously restated high-level policy commitments to prioritise PHC [26,27], while also holding claim as the 'birthplace of primary health care', with the adoption of the Alma-Ata Declaration of 1978 [28]. The WHO European Region also has a long tradition of prioritising the strengthening of health systems and good governance [29,30]. In practice, this has included investments in health system performance assessment, focused on the secondary use of data to strengthen the systems [31-33]. The region has also collectively defined common principles on the processing of data as stipulated in the European Union's General Data Protection Regulation (GDPR).

Consequently, the findings of the multi-country studies may not be generalisable to settings that are less well resourced, and which are at different stages of data availability and health information system maturity. Those contexts may also be characterised by different practices towards system governance and management, including different mixes of stakeholders and assigned mandates, and a potentially greater presence of international donors and agencies, in comparison with the countries sampled. Beyond the available data sources, low- and middle-income country contexts may face different priority areas for improvement in the sphere of PHC [34]. In relation to reporting in the scope of the COVID-19 pandemic, other regions, such as Southeast Asia, may also have experiences with data privacy and sharing that differ from the European experience captured here [35].

Country-specific studies

In the case of PHC (Part II), the secondary uses of EMR data were first investigated in the Canadian context in **Chapter 3**. Canada presented an interesting setting with regard to the trajectory of rolling out EMRs. Each of Canada's 13 provinces or territories have taken different approaches to implementing EMRs, and with varied levels of prioritisation [36]. A piecemeal approach to the adoption of EMRs in PHC is not a uniquely Canadian phenomenon. The private practice model of primary care settings has afforded space for a heterogenous mix of EMR vendors in many contexts, as was also found in the Netherlands (**Chapter 4**). In most countries, the standardisation of EMR records for the secondary use of data is likewise an endeavour still in progress. Even countries with sophisticated secondary uses of health data in some respects, like Denmark and the Netherlands, still face challenges in extending such uses to primary care data. Denmark, while a leader in digitising data, still struggles to use primary care sources for quality improvement purposes [37]. As was also found to a certain extent in the Canadian context, the Danish challenge relates to governance, as seen in barriers regarding data ownership and requirements for data sharing across private general practice providers. Hence, it can be concluded that the findings on Canadian developments in enhancing secondary uses of EMR data for performance measurement may be considered generalisable to other countries, even those with more sophisticated levels of digitisation in primary care.

The Canadian context was also explored in the case of COVID-19 dashboards in **Chapter 6**. That study's findings on improvements in data availability and dashboard technology in Canada are consistent with experiences in other country-specific dashboard trajectories. For example, reports on dashboard development in the Netherlands [19] and Ireland [38] have described similar improvements with time. In the Canadian context, the challenge to strengthening communicative features like the clarity of a dashboard's intended purpose and users was attributed to limitations of a more organisational nature. A lack of national stewardship for health data, setting out a clear direction and common objective across jurisdictions, has been identified as a key challenge in Canada [39]. This finding is considered comparable with other country contexts where both national and jurisdiction-specific actors hold public health reporting mandates. These include the United States (eg, [40-43]), Australia (eg, [44,45]) and the United Kingdom (eg, [46,47], countries where both national and jurisdiction-specific COVID-19 dashboards were identified during the research for **Chapter 5**.

Chapter 4 examined the secondary uses of primary care prescribing data for quality improvement in the Dutch context. The available electronic data sources identified – clinical data in the electronic records of general practices, pharmacy data in community pharmacy databases, and claims data from health insurers – are likely comparable with sources in other countries at similar stages of digitisation. This is especially true of countries that have fully rolled out electronic prescribing, like Denmark, Finland and the United Kingdom [25]. Increasing attention is being devoted to the secondary use of prescribing data to measure and drive improvements with respect to drug prescribing [48]. The national medical drug utilisation systems in most countries still base their information on insurance claims data, with only a few examples emerging in Australia, Japan and the United States where the data were drawn from electronic health records [48]. Hence, the Dutch focus and experience in prioritising data linkages between electronic prescriptions and clinical records, as illustrated in **Chapter 4**, is considered to be generalisable to other countries that are optimising the secondary uses of primary care prescribing data.

Reflection on key findings

The following observations can be made when reflecting across the seven studies of this thesis.

The fitness for purpose of healthcare performance indicators and their fitness for use require more explicit articulation in the handling of indicators across the two healthcare areas explored

The findings of this thesis have underscored the absence of fitness for purpose in the handling of healthcare performance indicators. Despite the differentiation of uses of performance indicators found in **Chapter 1**, the specificity of the intended use and target decision-maker was found as a recurrent gap. In the studies related to PHC, the uses of indicators appear more developed in clinical settings and at the national-level, to the absence of more meso-level focuses. In the case of COVID-19 dashboards, the intended use and users was more implied than made explicit. It was also found this was not necessarily an effect of urgency, as more communicative features did not improve with time (**Chapter 6**). In both cases there was also disconnect from the intended decision-maker.

In regard to fitness for use, the studies applied to the COVID-19 pandemic capture a clearer focus on fitness for use considerations relative to the field of PHC. This can be attributed in part to the focus put to the delivery of performance information via dashboards, as thinking about and being concerned with the actual use of data was critical to the pandemic. In PHC, despite years of high-level policy prioritisation of performance measurement, the *delivery* of information to target users has arguably remained an afterthought. Until recently, reporting of performance measurement information in PHC, like other areas of healthcare, has continued to be largely analogy, paper-based formats. This may be related in part to the slower roll-out of electronic data sources in PHC which has kept attention on the availability and quality of data, rather than a focus on optimising its secondary uses.

Data sources should be attuned with the intended purpose of use and both applications make a case for the importance of combining data from different sources for more actionable information

There are strengths and limitations for different individual data sources, be it clinical, administrative, or survey data among other source, which has important implications for thinking about fitness for purpose and use. This was reflected in the studies applied to PHC like in **Chapter 2** where the availability of data weighed on the suitability of indicators for international comparisons, but also in the country-specific studies, like in the Netherlands, where no singular data was found to be optimal for optimising primary care prescribing. In

Part III, the importance of drawing from multiple data sources for reporting on the COVID-19 pandemic was also found across the three studies conducted.

That is, in both application areas, the potential of data to tell a more complete story and increase in value when different sources are combined was a recurrent theme. In the case of the pandemic, the importance of data from outside of the healthcare system was also emphasised. Over time, data from more innovative sources including wastewater data, Google mobility data, flights and commercial activity, and publicly reported data, were also used to report on the status of the pandemic. The importance of drawing from multiple data sources, as well as aggregating these sources when possible, also applies to PHC. As the cornerstone of services delivery, measurement should draw from a range of sources, including pharmacies, laboratories, secondary care, and social care. In both areas of application, lingering uncertainty around data privacy and unresolved considerations about data ownership and data flows related to governance issues were apparent and require prioritisation to truly leverage the potential of available data.

Accelerating the use of actionable healthcare performance indicators could benefit from learning across the two application areas in regard to the development and processes of using indicators

The two areas of healthcare explored in this thesis have vastly differing developmental trajectories, as described from the outset. In the case of PHC, slow progress in the field of performance measurement has been attributed to a range of causes, from underinvestment in indicators to drive improvement in health performance [49], to a slow pace of digitalisation relative to other areas of healthcare [25,50], and heterogenous models that have presented challenges for standardisation [27,51]. This path is in sharp contrast to measurement in the sphere of COVID-19. In the case of the pandemic, obstacles like a lack of indicators, strained data sources, and non-existent standards were met with pragmatic solutions given the acuteness and severity of the situation.

While the COVID-19 pandemic had the effect of urgency as an accelerant, the lessons learned from the process have applications to PHC, together with other healthcare areas. For example, **Chapter 7** demonstrated the potential to resolve perceived obstacles in developing COVD-19 dashboards in large part through leadership, clarity of mandates, and streamlined and agile internal organisational processes. In the studies applied to PHC, the same principles of good governance were found as needed inputs to accelerate progress. Similarly, the development of COVID-19 dashboards highlighted the importance and value of working across sectors. The ubiquitous use of dashboards was found to be a reflection of the readiness of software solutions that was provided by software vendors. PHC has arguably been slower to adopt such partnerships and uptake innovations, benefiting from a trickle-down effect of new solutions in healthcare when it comes to performance measurement, rather than the starting point.

Common to the process in both areas was the importance of a diverse range of competencies. Gaps in professional competencies were a recurrent theme among COVID-19 dashboard teams at the outset, with few in-house dashboard teams prior to the pandemic. These teams would go on to expand and included business intelligence and analytics experts, geographic information systems (GIS) specialists, user experience researchers and communication professionals, information specialists, communication specialists, among others still. In PHC, performance measurement and the uses of indicators has relied in large part on healthcare professionals as ad hoc champions, rather than established roles like data and in-practice change management specialist. Nonetheless, the importance of established roles to support the use of measurement was a recurrent theme, like identified in the initiatives using EMR data for performance measurement in the Canadian context in **Chapter 3**.

Implications for research

On the basis of the studies contained in this thesis, several recommendations for future research can be formulated. First, in order to build further on the findings, researchers could explore different methods including quantitative study designs, and data sources. In large part, the studies presented here have engaged stakeholders through semi-structured interviews with explorative and descriptive aims. Other methods to collect data from the perspective of users could include surveys or focus groups, representing larger samples of target end-users (eg, primary care physicians and nurses, regional health authorities, national policy-makers). Mixed methods and experimental study designs may also be suitable for further exploring the use and impact of healthcare performance indicators. In the scope of COVID-19 dashboards, there is a growing field of research to evaluate their use from the perspective of their users, including healthcare professionals and policy-makers (eg, [52,53]). Importantly, further research should include efforts to capture the perspective of the general public.

Second, two potential adaptations of the theoretical model applied could be explored. For one, this research has explored a range of uses of healthcare performance indicators across decision-making contexts in healthcare systems. An alternative approach could be to explore a specific use of healthcare performance indicators to appreciate the nuances related to indicators for this cause. Second, the approach taken here has engaged a range of potential data users to explore their experiences using indicators in practice. Their role in the developmental stage was not captured. As the findings underscore the importance of clarity regarding the intended users of indicators, studies to explore current co-creative processes in place and means to strengthen inclusive development processes could be applied.

Third, this thesis has revealed a need for further research and development with regard to indictors and instruments that evaluate the use and impact of indicators in practice. In the case of dashboards, for instance, built-in website analytics have predominately been relied on to quantify use. Statistics include the number of dashboard visits and revisits or registrations for a newsletter [54-56]. While such metrics may apply in the field of online commerce (from which they are drawn), they offer limited insights in the sphere of public health, where the responses and actions to be identified are less transactional [56]. That is, the intended outcomes in the public health sphere relate to the ways that dashboard users apply the provided information to their health-related decision-making. In the case of the pandemic, this includes behaviour and lifestyle changes. Research is needed to develop indicators and tools for evaluating dashboard usage, patterns of use, and success factors. As innovative tools like dashboards are applied to other areas, which could include PHC, indicators for measuring how information is put to use in practice will be increasingly relevant.

Fourth, the studies in this thesis have shown a need for more systematic approaches to explore and understand the information needs of users, in order to devise more purpose-driven healthcare performance indicators. Tools are now available for engaging experts in the development and selection of indicators (eg, [57-59]), but their focus is still predominately on the quality of the indicator itself, rather than on considerations of fitness for purpose and fitness for use. The effect of this was made clear in the studies conducted on PHC, as in **Chapter 4**, where primary care prescribing indicators were found to be insufficiently tailored to the information needs of actors. In the early stages of the COVID-19 pandemic, dashboard developers pointed to a lack of time as a key barrier to engaging the public in the development process. Catering the dashboard reporting to the needs of user groups has been described as an afterthought [60]. The study reported in **Chapter 7** found an absence of agile ways to engage with and receive feedback from users, with many dashboard teams describing unstructured processes such as phone calls and emails directed to the team in unmanageable volumes. The gap could be addressed by research into methods for co-creating valid and reliable indicators which are also actionable.

The potential for reporting in healthcare using innovative tools like dashboards appears to have expanded for the foreseeable future. More research is therefore needed into how to optimise the delivery of healthcare performance indicators as an innovative ecosystem of products. While there is a field of research that investigates the importance and impact of data visualisations (see eg [61,62]), studies are still lacking that examine visualisations in more complex presentations like dashboards [63]. There is a need for testing dashboards in segmented audiences, to understand when dashboards work and for whom. This would be especially relevant for the general public, whose exposure to dashboards was limited prior to the pandemic [64].

Applications for policy

Several considerations for policy can be drawn from the findings of this thesis. At the time of writing, the COVID-19 pandemic was still ongoing. Just as in its earlier stages, the pandemic has demanded a continuously evolving approach to the public reporting of healthcare performance data. A future in which routine reporting using dashboards is no longer necessary will require appropriate planning. The presence of 'stale dashboards', whose data have not been updated for some time, carries its own risks. They can lead to misinformation, for instance, as readers may not understand at first glance that the information is out of date, and they may incorrectly interpret it [63]. Failing to handle a future smooth transition away from dashboards could erode trust. Mandated public health authorities responsible for reporting COVID-19 data need to develop strategies to sunset dashboards or adjust their intended purpose, such as expanding their use into areas like resilience and recovery plans. In either case, it will be critical to clearly communicate the intended changes in usage, and also to appropriately archive the data, once dashboards have outlived their originally intended purpose of use.

Yet dashboards also have potential for other uses beyond the pandemic [38]. Other application areas include information in relation to cancer, seasonal flu or patient safety. Great potential also exists for the use of dashboards in PHC. Dashboard-like displays of PHC performance measurement for international comparisons are already available in the Vital Signs Profiles provided by the Primary Health Care Performance Initiative [65]. The study reported **Chapter 3** observed that dashboards were also in use at the micro-level in initiatives identified in British Columbia [66] and Ontario [67]. Expansion of the range of uses of dashboards as tools for delivering PHC information back to users needs to be prioritised and further diversified. Strong audience segmentation should be a guiding principle here, based on a clearly defined purpose of use and understanding of users' information needs [64]. As dashboards are applied to PHC reporting, their use should be coupled with a portfolio of other communication and user engagement strategies, similar to the use of these in pandemic reporting [54].

Throughout this thesis, the studies have signalled the importance of intensified collaboration, in particular across countries and healthcare sectors. Cross-national efforts in the European region are needed to advance the development of common data standards, indicator sets and methodologies for the betterment of national and pan-European reporting. As seen in **Chapter 2**, this could help countries to resolve persisting data gaps in PHC and support them as they work to apply the new global monitoring framework [68]. As a component of preparedness planning for future health crises, cross-national collaboration may also help countries to resolve uncertainties with respect to common privacy regulations and enable them to exchange lessons and approaches in ways that were not possible during the acute stages of the COVID-19 pandemic.

Collaboration is also needed across sectors. Some of the potential features of highly actionable dashboards identified in **Chapter 5** were found in **Chapter 7** to have gone unaddressed for technical reasons. For example, narration of information is a powerful mode of communication, and narrative dashboard features have been found to simplify information, yet most dashboards still had a sole emphasis on quantitative information display. **Chapter 7** found that this was caused in part by limitations in software design, which was unable to accommodate text-based narratives [64]. Action to resolve existing gaps between available technology and software solutions, so as to enable their use in healthcare, could be undertaken through well-planned cross-sector collaborations.

The studies in this thesis emphasise a need for continued investments in national data sources. To fully leverage the information potential of electronic health data, work is still to be done to ensure sources that are integrated and interoperable. The digitisation of health alone is not enough [69]. The importance of harmonising data from different sources was underscored in the context of COVID-19 [70]. The pandemic signalled that hospital, clinical, commercial and home-generated sources needed to be reconciled and standardised. Addressing this can help unlock the value in the various data captured. The same applies in the case of PHC, where the actionability of different types of data across settings – be it physicians' offices, pharmacies, laboratories, secondary care or social care – is optimised when these sources can be leveraged together. Importantly, the studies discussed here show that optimising the fitness for use of data requires strong governance, including a clearly defined vision and strategic direction. A collaborative culture, and agreements for sharing data between organisations, with clearly mandated roles and responsibilities, are needed. These can also help to manage overly zealous concerns about data privacy, which can hinder data sharing and foster misguided senses of ownership and data hoarding in organisation-specific databases. Systems with high levels of secondary data use, as the United Kingdom, Finland, and Denmark [71], may offer inspiration for efforts to steward data systems towards their fitness for use.

In proactively transforming data infrastructure towards more actionable uses, investments are also needed in professionals to support the necessary processes and data uses. The continued training of healthcare performance intelligence professionals is needed for a healthcare workforce equipped with the necessary expertise to make effective use of available healthcare performance data. Beyond dedicated professionals trained in the field of healthcare performance intelligence, ensuring professionals across the healthcare system are also supported and have access to training related to data, performance measurement, and use of evidence in decision-making is also needed. These competencies will play an important role in achieving a shift in professional culture to instil a sense of continuous learning and improvement [72].

Conclusions

Actionable healthcare performance indicators are crucial in working towards learning health systems that ensure value-based healthcare. To obtain additional value from the available data-rich and technology-enabled health information systems, business as usual in performance measurement will not suffice. A fundamental change is needed in the approach taken to the handling of healthcare performance indicators. Such a shift will require awareness of the importance of linkages between measurement, governance and management, and the use of measurement in decision-making processes. The persisting dissociation between indicators and specific strategic goals has left performance measurement unfit to serve its basic function of providing directions for improvement. The missing link between measurement and governance and management, coupled with a fixation on selecting indicators that are valid and reliable, has diverted the focus away from the importance of prioritising the *purposes and uses* of the indicators.

The studies presented in this thesis have provided insights for a richer conceptualisation of actionability and its constructs of fitness for purpose and fitness for use. Once applied, the considerations identified here can offer guidance for thinking about indicators in light of their intended purpose, users and context of use, as well as for the management of that process. The investigations here on the use of healthcare performance indicators in the context of PHC and the COVID-19 pandemic have provided further practical insights. Focus was put to exploring the *purposes* of using indicators respectively across the micro–meso–macro context of healthcare systems, as well as on identifying potential types of data sources and data visualisation, be it in frameworks or in dashboards. Such purposes characterise the respective development processes in the contexts of application. The results of this research highlight a range of resources for strengthening actionability. These include a framework for measuring PHC across countries, considerations for using different primary care data sources, features for optimising dashboards, and lessons about the process of dashboard development that could apply both in a pandemic context and beyond. Ultimately, the findings are an initial exploration into actionability. Only through the continued prioritisation of measurement, governance and management, and the use of measurement in practice, can the real potential of healthcare performance indicators be realised – to ensure performance indicators that work.

References

1. World Health Organization. A vision for primary health care in the 21st century: Towards universal health coverage and the Sustainable Development Goals. Geneva: World Health Organization; 2018.
2. Zhang Y, Sun Y, Padilla L, Barua S, Bertini E, Parker AG. Mapping the landscape of COVID-19 crisis visualizations. Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems; Yokohama, Japan: Association for Computing Machinery; 2021.
3. Budd J, Miller BS, Manning EM, Lampos V, Zhuang M, Edelstein M, et al. Digital technologies in the public-health response to COVID-19. Nature Medicine. 2020;26(8):1183–92.
4. Barbazza E, Klazinga NS, Kringos DS. Exploring the actionability of healthcare performance indicators for quality of care: a qualitative analysis of the literature, expert opinion and user experience. BMJ Qual Saf. 2021;30(12):1010.
5. Kringos DS, Boerma WG, Hutchinson A, van der Zee J, Groenewegen PP. The breadth of primary care: a systematic literature review of its core dimensions. BMC Health Serv Res. 2010;10:65.
6. OECD. Strengthening health information infrastructure for health care quality governance. Paris: OECD; 2013.
7. WHO Regional Office for Europe. Availability of national health services delivery data across the WHO European Region: scanning survey results. Copenhagen: WHO Regional Office for Europe; 2018.
8. Barbazza E, Allin S, Byrnes M, Foebel AD, Khan T, Sidhom P, et al. The current and potential uses of Electronic Medical Record (EMR) data for primary health care performance measurement in the Canadian context: a qualitative analysis. BMC Health Serv Res. 2021;21(1):820.
9. Barbazza E, Verheij R, Ramerman L, Klazinga N, Kringos D. Optimising the secondary use of primary care prescribing data to improve quality of care: a qualitative analysis. BMJ Open. 2022;12(7):e062349.
10. Ivanković D, Barbazza E, Bos V, Brito Fernandes Ó, Jamieson Gilmore K, Jansen T, et al. Features constituting actionable COVID-19 dashboards: descriptive assessment and expert appraisal of 158 public web-based COVID-19 dashboards. J Med Internet Res. 2021;23(2):e25682.
11. WHO Regional Office for Europe. Strengthening and adjusting public health measures throughout the COVID-19 transition phases. Copenhagen: WHO Regional Office for Europe; 2020.
12. Barbazza E, Ivanković D, Wang S, Gilmore KJ, Poldrugovac M, Willmington C, et al. Exploring changes to the actionability of COVID-19 dashboards over the course of 2020 in the Canadian context: descriptive assessment and expert appraisal study. J Med Internet Res. 2021;23(8):e30200.
13. Barbazza E, Ivanković D, Davtyan K, Poldrugovac M, Yelgezekova Z, Willmington C, et al. The experiences of 33 national COVID-19 dashboard teams during the first year of the pandemic in the WHO European Region: a qualitative study. Digit Health. 2022;8:1–16.

14. Leung L. Validity, reliability, and generalizability in qualitative research. J Family Med Prim Care. 2015;4(3):324–7.

15. Hays DG, McKibben WB. Promoting rigorous research: generalizability and qualitative research. Journal of Counseling & Development. 2021;99(2):178–88.

16. Plochg T, Klazinga NS. Community-based integrated care: myth or must? Int J Qual Health Care. 2002;14(2):91–101.

17. Donabedian A. The quality of care. How can it be assessed? JAMA. 1988;260(12):1743–8.

18. Lasswell HD. The structure and function of communication in society. The Communication of Ideas. 1948;37(1):136–9.

19. Bos V, Jansen T, Klazinga NS, Kringos DS. Development and actionability of the Dutch COVID-19 dashboard: descriptive assessment and expert appraisal study. JMIR Public Health Surveill. 2021;7(10):e31161.

20. Fareed N, Swoboda CM, Chen S, Potter E, Wu DTY, Sieck CJ. U.S. COVID-19 State government public dashboards: an expert review. Appl Clin Inform. 2021;12(2):208–21.

21. Monkman H, Martin SZ, Minshall S, Kushniruk AW, Lesselroth BJ. Opportunities to improve COVID-19 dashboard designs for the public. Stud Health Technol Inform. 2021;286:16–20.

22. Kessner D, Kalk C, Singer J. Assessing health quality: the case for tracers. N Engl J Med. 1973;288.

23. Van de Ven AH, Delbecq AL. The nominal group as a research instrument for exploratory health studies. Am J Public Health. 1972;62(3):337–42.

24. OECD. Health in the 21st Century: putting data to work for stronger health systems. Paris: OECD; 2019.

25. Oderkirk J. Readiness of electronic health record systems to contribute to national health information and research. Paris: OECD; 2017.

26. Regional Committee for Europe. Seventy-first Regional Committee for Europe: virtual session, 13–15 September 2021: resolution: realizing the potential of primary health care: lessons learned from the COVID-19 pandemic and implications for future directions in the WHO European Region. Copenhagen: WHO Regional Office for Europe; 2021.

27. Declaration of Astana. The Global Conference on Primary Health Care. Astana, Kazakhstan; 2018.

28. UNICEF, World Health Organization. Declaration of Alma Ata: International Conference on Primary Health Care, Alma Ata, USSR, 6–12 September 1978. Geneva: World Health Organization; 1978.

29. WHO Regional Office for Europe. Implementation of the Tallinn Charter: Final report. Copenhagen: WHO Regional Office for Europe; 2015.

30. Regional Committee for Europe. Sixty-fifth Regional Committee for Europe: Vilnius, 14–17 September 2015: resolution: priorities for health systems strengthening in the WHO European Region 2015–2020: walking the talk on people centredness. Copenhagen: World Health Organization. Regional Office for Europe; 2015.

31. Papanicolas I, Rajan D, Karanikolos M, Figueras J. Assessing health system performance for UHC: rationale and approach. In: Papanicolas I, Rajan D, Karanikolos M, Soucat A, Figueras J, editors. Health system performance assessment: a framework for policy analysis. Health Policy Series, No. 57. Geneva: World Health Organization; 2022.

32. Paoli F, Schmidt I, Wigzell O, Ryś A. An EU approach to health system performance assessment: building trust and learning from each other. Health Policy. 2019;123(4):403–7.

33. Perić N, Hofmarcher-Holzhacker MM, Simon J. Health system performance assessment landscape at the EU level: a structured synthesis of actors and actions. Arch Public Health. 2017;75:5.

34. Veillard J, Cowling K, Bitton A, Ratcliffe H, Kimball M, Barkley S, et al. Better measurement for performance improvement in low- and middle-income countries: The Primary Health Care Performance Initiative (PHCPI) Experience of conceptual framework development and indicator selection. Milbank Q. 2017;95(4):836–83.

35. Amit AML, Pepito VCF, Gutierrez B, Rawson T. Data sharing in Southeast Asia during the first wave of the COVID-19 pandemic. Front Public Health. 2021;9:662842.

36. Chang F, Gupta N. Progress in electronic medical record adoption in Canada. Can Fam Physician. 2015;61.

37. OECD. OECD reviews of health systems: Primary care in Denmark. Paris: OECD; 2017.

38. Gleeson J, Kitchin R, McCarthy E. Dashboards and public health: the development, impacts, and lessons from the Irish government COVID-19 dashboards. Am J Public Health. 2022;112(6):896–9.

39. Expert Advisory Group. Pan-Canadian health data strategy: towards a world-class health data system. Ottawa: Public Health Agency of Canada; 2022.

40. Centers for Disease Control and Prevention. Coronavirus disease 2019 (COVID-19): CDC; 2020. Available from: https://www.cdc.gov/coronavirus/2019-ncov/cases-updates/index.html archived at https://archive.ph/TExg1.

41. California State Government. Tracking COVID-19 in California; 2020. Available from: https://covid19.ca.gov/state-dashboard/, archived at http://archive.vn/u41FC.

42. Colorado Department of Public Health and Environment, Colorado State Emergency Operations Center. Colorado COVID-19 data; 2020. Available from: https://covid19.colorado.gov/data, Archived at http://archive.today/I3yam.

43. Florida Department of Health. Florida's COVID-19 Data and Surveillance Dashboard; 2020. Available from: https://fdoh.maps.arcgis.com/apps/opsdashboard/index.html#/8d0de33f260d444c852a615dc7837c86.

44. Government of Australia. Coronavirus (COVID-19) health alert: Australian Government; 2020. Available from: https://www.health.gov.au/news/health-alerts/novel-coronavirus-2019-ncov-health-alert Archived at https://archive.ph/fQSn7.

45. Victoria State Government. Surveillance of notifiable conditions: Coronavirus COVID-19 in Victoria: Victoria State Government; 2020. Available from: https://archive.ph/9Moo0.

46. Public Health England. Coronavirus (COVID-19) in the UK; 2020. Available from: https://coronavirus.data.gov.uk archived at http://archive.vn/q5ilb.

47. Public Health Scotland. COVD-19 in Scotland: Public Health Scotland; 2022. Available from: https://public.tableau.com/app/profile/phs.covid.19/viz/COVID-19DailyDashboard_15960160643010/Dailyupdate.

48. OECD. Improving medication safety through collective, real-time learning. Paris: OECD; Under review.

49. WHO Regional Office for Europe. Primary Health Care Advisory Group First Meeting Report. Copenhagen: WHO Regional Office for Europe; 2017.

50. The Commonwealth Fund. 2019 Commonwealth Fund international health policy survey of primary care physicians. New York, NY: The Commonwealth Fund; 2019.

51. Kringos D, Boerma W, Bourgueil Y, Cartier T, Dedeu T, Hasvold T, et al. The strength of primary care in Europe: an international comparative study. Br J Gen Pract. 2013;63(616):e742–50.

52. Fazaeli S, Khodaveisi T, Vakilzadeh AK, Yousefi M, Ariafar A, Shokoohizadeh M, et al. Development, implementation, and user evaluation of COVID-19 dashboard in a third-level hospital in Iran. Appl Clin Inform. 2021;12(5):1091–100.

53. Patterson JR, Shaw D, Thomas SR, Hayes JA, Daley CR, Knight S, et al. COVID-19 Data utilization in North Carolina: qualitative analysis of stakeholder experiences. JMIR Public Health Surveill. 2021;7(9):e29310.

54. Thorpe LE, Gourevitch MN. Data dashboards for advancing health and equity: proving their promise? Am J Public Health. 2022;112(6):889–92.

55. Verhulsdonck G, Shah V. Lean data visualization: considering actionable metrics for technical communication. J Bus Tech Commun. 2020;35(1):57–64.

56. Ivankovic D, Barbazza E, Klazinga N, Kringos D. Comment on Verhulsdonck and Shah's "lean data visualization: considering actionable metrics for technical communication". J Bus Tech Commun. 2021;36(1):105–13.

57. de Koning J, Burgers J, Klazinga N. Appraisal of indicators through research and evaluation (AIRE). Amsterdam: University of Amsterdam; 2008.

58. Jones P, Shepherd M, Wells S, Le Fevre J, Ameratunga S. Review article: what makes a good healthcare quality indicator? A systematic review and validation study. Emerg Med Australas. 2014;26(2):113–24.

59. McGlynn EA. The outcomes utility index: will outcomes data tell us what we want to know? Int J Qual Health Care. 1998;10(6):485–90.

60. Peeples L. Lessons from the COVID-19 data wizards. Nature. 2022;603(7902):564–7.

61. Rowley J. The wisdom hierarchy: representations of the DIKW hierarchy. J Inf Sci. 2007;33(2):163–80.

62. Peters E, Dieckmann N, Dixon A, Hibbard JH, Mertz CK. Less is more in presenting quality information to consumers. Med Care Res Rev. 2007;64(2):169–90.

63. Crisan A. The importance of data visualization in combating a pandemic. Am J Public Health. 2022;112(6):893–5.

64. Dasgupta N, Kapadia F. The future of the public health data dashboard. Am J Public Health. 2022;112(6):886–8.

65. Primary Health Care Performance Initative. Vital signs profiles: PHCPI; 2022. Available from: https://improvingphc.org/vital-signs-profiles.

66. Health Data Coalition. Welcome to the Health Data Coalition; 2022. Available from: https://hdcbc.ca/.

67. OntarioMD. EMR quality dashboard proof of concept: phase 2 report. Toronto: OntarioMD; 2019.

68. WHO. Primary health care measurement framework and indicators: monitoring health systems through a primary health care lens. Geneva: World Health Organization; 2022.

69. Brand B, LaVenture M, Lipshutz JA, Stephens WF, Baker EL. The information imperative for public health: a call to action to become informatics-savvy. J Public Health Manag Pract. 2018;24(6).

70. Dixon BE, Dearth S, Duszynski TJ, Grannis SJ. Dashboards are trendy, visible components of data management in public health: sustaining their use after the pandemic requires a broader view. Am J Public Health. 2022;112(6):900-3.

71. Boyd M, Zimeta M, Tennison J, Alassow M. Secondary use of health data in Europe. Open Data Institute; 2021.

72. McGuire MJ. Building learning health care systems in primary care. Qual Manag Health Care. 2019;28(4):252–3.

Appendices

Summary

Healthcare performance measurement aims to quantify the work of healthcare professionals, organisations, and systems at-large. The use of performance measurement in decision-making for improvement plays a key role in working towards learning health systems. Learning takes place across healthcare systems and includes decision-making related to processes of care in the clinical context (micro-level); the context of organisations, including networks and specialities (meso-level); and the policy context of system decision-making (macro-level). Importantly, decision-makers in each context also differ, ranging from individual healthcare professionals, teams and managers to insurers, professional associations, inspectorates, academia, the public, and regional and national health authorities.

Performance measurement is operationalised through the use of healthcare performance indicators. Given their importance, much attention has been put to support the selection of indicators that are, at a minimum, valid and reliable. However, the focus put to selecting indicators that are scientifically strong has contributed to a shift in focus away from indicators rooted in a clear conception of their intended use. As a consequence, healthcare performance indicators and the performance intelligence they generate, often lie outside, rather than embedded within the systems of governance and the managerial cycles involved. As systems become more data-rich and technology-enabled, the importance to harness this potential or risk the consequences of performance measurement that fails to add value, has put a spotlight on the use of healthcare performance indicators that are *actionable*.

This thesis aimed to explore actionability and its constructs of *fitness for purpose* and *fitness for use* both conceptually and in practice. The findings of this thesis are intended to augment existing theories about fitness for purpose and use, while also providing practical insights for major system actors – clinicians, healthcare managers, policy-makers – about working with healthcare performance measurement to improve quality across healthcare systems. Towards practical insights, two real-world applications of healthcare performance indicators were explored in the context of: (1) primary health care (PHC); and (2) the COVID-19 pandemic.

The thesis was guided by three main objectives, and these informed the organisation of the seven research questions investigated:

- Part I: To explore the conceptualisation of actionability of performance indicators.
- Part II: To explore the actionability of performance indicators and data sources in primary health care (PHC).
- Part III: To explore the actionability of COVID-19 dashboards in terms of their features, changes and development process.

In Part I, **Chapter 1** set out to develop a more refined understanding of fitness for purpose and use. The study found fitness for purpose can be specified by a range of uses beyond aggregate micro-meso-macro contexts of healthcare systems. Each purpose of use was found to correspond with different decision-making tasks, and in effect, information needs of the target user. An indicator's fitness for use was found to be captured by three main types of considerations. These pertain to an indicator's technical qualities, such as the ease of interpretation or ability to measure what matters, the intended context of use, being influenced by the information infrastructure, governance, workforce capacity, and culture, and its handling across managerial cycles, extending from the selection of indicators to accessing data, applying methods of analysis, displaying findings, and reaching decision-makers. The study concluded by emphasising an indicator's fitness for purpose and fitness for use should be appraised together to gauge actionability.

In Part II, three studies were conducted to explore actionability in relation to PHC. In **Chapter 2**, an approach to generate actionable PHC performance intelligence across countries, specifically in the WHO European Region, was developed. Through a multi-stage approach, a performance framework organised in the classical approach of structure-process-outcomes resulted. The framework clusters the measurement of PHC across six domains: primary care structures, model of primary care, care contact, primary care outputs, health system outcomes, and health outcomes. Twenty-six subdomains and 63 features of primary care were also identified. To increase the sensitivity of the tool to the European context, a care continuum was developed using a set of 12 tracer conditions. The study mapped a total of 139 indicators to the classification. For each indicator, a range of potential data sources from existing (inter)national information systems were identified. The resulting framework and its broad suite of indicators has the potential to be customised based on the specific uses of the performance intelligence generated when applied to individual country contexts.

In **Chapter 3**, recognizing primary care Electronic Medical Records (EMRs) as a rich data source to measure and improve quality, the current uses of EMRs and considerations to further their potential in the Canadian PHC context was explored. Using a case study design and descriptive assessment, six initiatives drawing on the secondary use of EMR data for performance measurement were found. The cases included one multi-jurisdictional and five jurisdiction-specific initiatives in British Columbia, Manitoba, and Ontario. EMR data uses were found to be predominately applied at the micro-level for PHC physician and team performance improvement, with some use for meso-level organisation/network-wide improvement. Indicator sets varied in number, though shared emphasis on chronic disease management and prevention/screening, and to a lesser extent medication management. Common challenges to be overcome in order to further the use of EMR data were identified in relation to governing, resourcing, and implementing EMR data for performance measurement.

In **Chapter 4**, in the data-rich context of the Netherlands, the secondary uses of primary care prescribing data for improving quality of care was explored. The investigation was anchored around three tracer prescription types: antibiotics, benzodiazepines, and opioids. Three main sources of data for improving prescribing in primary care were found to be in use: clinical data in the electronic health records of general practices; pharmacy data in community pharmacy databases; and claims data of insurers. While the secondary use of pharmacy and claims data was found to be well-established across levels, the use of these data together with electronic health record data was found to be limited. The study also found important differences in the types of prescribing information needed by micro-meso-macro context, though the extent to which current indicators address these varies by prescription type. Five main themes were found as areas for optimising data use: (1) measuring what matters, (2) increasing data linkages, (3) improving data quality, (4) facilitating data sharing, and (5) optimising fit for use analysis.

In Part III, three studies were conducted to explore actionability in the context of the COVID-19 pandemic in relation to the use of dashboards. In **Chapter 5**, a sample of 158 dashboards from 53 countries worldwide were assessed in the early stages of the pandemic (July 2020) to describe and to appraise features contributing to their actionability. We found most dashboards had been developed by government authorities and were national in their scope though the primary purpose and intended audience for the majority of dashboards was unstated or implied. Epidemiological indicators were nearly universally reported on, in contrast to the infrequent reporting of indicators related to social and economic impact and behavioural insights. Notably, data sources were not reported by approximately a quarter of the dashboards. The study also found the dashboards predominately used time trends and breakdowns by two geographic levels and by age and sex to analyse the data. On average, the dashboards also used two types of displays, mainly graphs and maps, with colour-coding being the most common visual support to aide interpretation.

Actionable COVID-19 dashboards were found to: (1) know their audience and information needs; (2) manage the type, volume, and flow of displayed information; (3) report data sources and methods clearly; (4) link time trends to policy decisions; (5) provide data that are “close to home”; (6) break down the population into relevant subgroups; and (7) use storytelling and visual cues. It was concluded that while there is no single approach to developing a dashboard, the full potential of dashboards in the pandemic’s early stages was largely untapped and introducing the seven features identified may enhance their actionability.

In **Chapter 6**, building on the approach and findings of **Chapter 5**, changes to COVID-19 dashboards, over time were explored. To do so, the Canadian sample of dashboards assessed in **Chapter 5** were appraised again in November 2020 (N=26). The comparison between the two time points revealed subtle improvements had been made, predominantly related to data provision and advancements enabled by the technologies employed. The study also found some improvements to the actionability of the dashboards, especially in regard to features involving local-level data provision, time-trend reporting, and indicator management. No improvements were found for communicative elements (clarity of purpose and audience), while the use of storytelling techniques to narrate trends remained largely absent from the dashboards. It was concluded further attention to both technical *and* organisational aspects of dashboard development remained needed, where the latter includes clearer mandates and accountability for dashboard teams to develop and maintain purpose-driven dashboards.

Finally, in **Chapter 7**, observing a lack of scientific evidence capturing the process of developing COVID-19 dashboards and gap in cross-country collaboration, the development stories of national teams were investigated. Semi-structured group interviews with a sample of 33 national COVID-19 dashboard teams from across the WHO European Region were conducted. The study revealed more similarities than differences in the development of dashboards across the sample. The urgency, intense workload, limited human resources, data and privacy constraints, and public scrutiny were common descriptors of the initial development stage across dashboard teams. Investigating common barriers or enablers, six main themes and fifteen subthemes were identified as recurrent barriers for some dashboard teams, yet enablers for others. The themes pertained to the pre-pandemic context, pandemic itself, people and processes, software, data, and users. With the benefit of hindsight, lessons about the process were identified around five themes relating to simplicity, trust, partnership, software and data, and change. The study found that the relative under-preparedness of countries to develop dashboards was compensated for by more agile and pragmatic processes given the information-urgency faced. The study also concluded the full potential of dashboards moving-forward requires investment at team, national, and pan-European level.

The findings of this thesis are considered valid and generalisable with the following considerations in mind. For one, in the absence of existing tools, study-specific tools were developed and applied, in large part drawing on the findings of **Chapter 1**. To increase validity, these results were validated with experts prior to their use and have been complemented by existing definitions, concepts, and theories. Second, the tracer method was applied to increase the specificity of findings in **Chapters 2 and 4** but as a consequence, the nuances of other possible tracers may not be captured. Similarly, as exploratory studies, priority was put to capture the constructs of fitness for purpose and use across healthcare systems and hence, the nuances of each context (micro, meso and macro-levels) may not be captured. Lastly, capturing different perspectives was prioritised throughout this thesis, though these perspectives were limited to major healthcare system actors – clinicians, healthcare managers, policy-makers – and were to the exclusion of other important actors, including patients.

With regards to the generalisability of findings, the results of multi-country studies were considered generalisable to other developed country contexts, sharing a similar availability of resources, digitalisation of health data, and attention put to its secondary uses. Findings in the Canadian context with regards to EMRs were considered characteristic of the development of the digitalisation of PHC in other country contexts. Changes to COVID-19 dashboards in the Canadian context were also found to mirror the experiences of other country contexts, where data and technology improved with time, yet more organisational features continued to require further attention. Similarly, findings from the Netherlands regarding the current uses of primary care prescribing data were found comparable with other developed countries at similar stages of digitalisation.

To conclude, this thesis proposed three recommendations reflecting the key findings across the seven studies. First, the studies of the thesis signalled the uses of healthcare performance indicators and their intended users require more explicit articulation across both of the healthcare areas (PHC and COVID-19 dashboards) explored. In regard to fitness for use considerations, this was more developed in the field of COVID-19 dashboards and is an area for further emphasis in PHC. Second, data sources should align with the intended purpose of use, though both applications make a case for the importance of combining data from different sources for more actionable information. Lastly, despite the differing trajectories of development, there are a number of similarities in the areas of importance between the two application areas explored which offer insights for accelerating actionability, in particular in the field of PHC.

To further this field of work, research is needed in the following areas: exploring related research questions using different methods, including quantitative study designs, and data sources; testing adaptations to the theory applied which may include exploring specific uses of indicators or their development in co-creative processes with their intended users; developing indictors and instruments that evaluate the use and impact of healthcare performance indicators in practice; systematizing approaches to explore and understand the information needs of users; and optimising the delivery of healthcare performance indicators as an innovative ecosystem of products that includes the use of dashboards.

Other recommendations for policy-makers include: strategizing the continued use of COVID-19 dashboards as their intended purpose of use continues to change over the course of the pandemic; extending the range of uses of dashboards as a tool for delivering PHC information back to users, together with other potential applications of dashboards as a reporting tool; intensifying collaboration, in particular across countries and sectors; and, continuing investments in national data sources and the professional competencies needed to support these processes.

Now more than ever are the real costs and consequences of failing to optimise the secondary use of health data understood. This understanding should be leveraged as the momentum needed to apply the findings of this thesis for the use of indicators rooted in an understanding of their fitness for purpose and use. Only through the continued prioritisation of measurement, governance and management, and use of measurement in practice, can the real potential of healthcare performance indicators be realised, for performance measurement that it actionable. That is, performance indicators that *work*.

Samenvatting

Prestatiemeting in de gezondheidszorg is bedoeld om het werk van zorgprofessionals, organisaties en systemen in het algemeen in maat en getal weer te geven. Deze informatie kan worden gebruikt bij het nemen van beslissingen ter verbetering van de prestaties en het functioneren van de zorg. Toepassing van prestatie-informatie draagt bij aan de ontwikkeling van een lerend gezondheidssysteem. Leren vindt plaats in het gehele zorgstelsel en omvat besluitvorming met betrekking tot zorgprocessen in een klinische context (microniveau); de management context van organisaties, inclusief netwerken en specialismen (mesoniveau); en de beleidscontext van besluitvorming op systeem niveau (macroniveau). Belangrijk is dat besluitvormers op elk van de drie niveau's ook verschillen, variërend van individuele zorgprofessionals, teams en managers tot verzekeraars, beroepsverenigingen, inspecties, de academische wereld, het publiek en regionale en nationale gezondheidszorgsautoriteiten.

Prestatiemeting wordt geoperationaliseerd door het gebruik van prestatie-indicatoren in de zorg. Gezien het belang hiervan wordt veel aandacht besteed aan het ondersteunen van de selectie van indicatoren die op zijn minst valide en betrouwbaar dienen te zijn. De focus op het selecteren van indicatoren die wetenschappelijk sterk zijn ('evidence based'), heeft er echter toe bijgedragen dat minder aandacht wordt besteed aan de vereisten die voortkomen uit het beoogde gebruik. Als gevolg hiervan sluiten prestatie-indicatoren in de gezondheidszorg en de prestatie-informatie die ze genereren, vaak slecht aan op de gerelateerde bestuurssystemen en managementcycli. Naarmate zorgsystemen meer data-rijk en door technologie ondersteund worden, neemt het belang om dit potentieel beter te benutten toe, en wordt de aandacht gevestigd op het gebruik van prestatie-indicatoren in de gezondheidszorg die *bruikbaar* ('actionable') zijn. Omdat de Engelse term 'actionability' niet goed vertaald kan worden naar het Nederlands, zullen we deze Engelse term hanteren in dit hoofdstuk. Hetzelfde geldt voor de Engelse termen 'fitness for purpose' en 'fitness for use'.

Dit proefschrift was gericht op het onderzoeken van actionability van prestatie-indicatoren en hun geschiktheid voor een *bepaald doel* ('fitness for purpose') en *geschiktheid voor gebruik* ('fitness for use'), zowel conceptueel als in de praktijk. De bevindingen van dit proefschrift zijn bedoeld om bestaande theorieën over 'fitness for purpose and use' aan te vullen, terwijl ze ook praktische inzichten bieden voor belangrijke systeemactoren - clinici, zorgmanagers, beleidsmakers - over het werken met prestatiemeting in de gezondheidszorg om de kwaliteit in alle zorgsystemen te verbeteren. Hiervoor werden twee praktijkgerichte toepassingen van prestatie-indicatoren in de gezondheidszorg onderzocht: (1) eerstelijnszorg; en (2) de COVID-19-pandemie.

Het proefschrift had drie hoofddoelen, en deze vormden de basis voor de indeling van de zeven onderzochte onderzoeksvragen:

- Deel I: Verkennen van de conceptualisering van de actionability van prestatie-indicatoren.
- Deel II: Onderzoek naar de actionability van prestatie-indicatoren en databronnen in de eerstelijnszorg.
- Deel III: De actionability van COVID-19-dashboards onderzoeken met betrekking tot kenmerken, veranderingen en ontwikkelingsproces.

In Deel I werd in **Hoofdstuk 1** uiteengezet hoe tot een meer verfijnd begrip van fitness for purpose and use te komen. Uit de studie bleek dat fitness for purpose kan worden gespecificeerd door een reeks toepassingen die verder gaan dan de geaggregeerde micro-meso-macrocontexten van zorgstelsels. Elk gebruiksdoel bleek overeen te komen met verschillende besluitvormingsopdrachten en specifieke informatiebehoeften van de beoogde gebruiker. De fitness for use van een indicator bleek te worden bepaald door drie typen overwegingen. Deze hebben betrekking op de technische kwaliteit van een indicator, zoals het gemak van interpretatie of het vermogen om te meten wat belangrijk is, de beoogde gebruikscontext, beïnvloeding door de informatie-infrastructuur, governance, personeelscapaciteit en cultuur, en de inbedding in managementcycli, van de selectie van indicatoren tot toegang tot gegevens, het toepassen van analysemethoden, het weergeven van bevindingen en het bereiken van besluitvormers. De studie concludeerde dat de fitness for purpose and use van een indicator, samen moeten worden beoordeeld om de actionability van een indicator te bepalen.

In Deel II wordt verslag gedaan van drie studies naar de actionability in relatie tot de eerstelijnszorg. In **Hoofdstuk 2** werd een benadering ontwikkeld om actionable informatie over de eerstelijnszorg-prestaties te genereren in verschillende landen, met name in de Europese regio van de WHO. Door middel van een meertrapsbenadering is een prestatiekader ontstaan dat is georganiseerd naar de klassieke indeling van structuur-proces-uitkomsten. Het raamwerk clustert de meting van de eerstelijnszorg over zes domeinen: eerstelijnszorgstructuren, model van eerstelijnszorg, zorgcontact, eerstelijnszorgresultaten, gezondheidssysteemresultaten en gezondheidsuitkomsten. Zesentwintig subdomeinen en 63 kenmerken van de eerstelijnszorg werden geïdentificeerd. Om de toepasbaarheid van de tool voor de Europese context te vergroten, wordt het zorgcontinuüm beschreven met behulp van een set van 12 tracercondities. Het onderzoek bracht in totaal 139 indicatoren in kaart bij de finale classificatie. Voor elke indicator is een reeks potentiële gegevensbronnen uit bestaande (inter)nationale informatiesystemen geïdentificeerd. Het resulterende raamwerk en de brede reeks indicatoren kunnen worden aangepast op basis van het specifieke gebruik van de prestatie-informatie die wordt gegenereerd wanneer toegepast in een specifiek land.

In **Hoofdstuk 3**, waarin de eerstelijns elektronische medische dossiers (EPD's) werden erkend als een rijke gegevensbron om de kwaliteit te meten en te verbeteren, werden het huidige gebruik van EPD's en mogelijkheden om hun potentieel in de Canadese eerstelijnszorg te vergroten, onderzocht. Met behulp van een systematische beschrijving van case-studies werden zes initiatieven gevonden die gebaseerd waren op het secundaire gebruik van EPD-gegevens voor prestatiemeting. De cases omvatten een Canada brede en vijf provinciale initiatieven in British Columbia, Manitoba en Ontario. EPD-gegevens bleken voornamelijk gebruikt te worden op microniveau voor verbetering van de prestaties van eerstelijns-artsen en teams, en in mindere mate voor verbetering van de organisatie/het netwerk op mesoniveau. Indicatorensets varieerden in aantal indicatoren, met een gedeelde nadruk op het management van chronische aandoeningen en preventie/screening, alsmede in mindere mate medicatiemanagement. Er werden gemeenschappelijke uitdagingen geïdentificeerd die moeten worden overwonnen om het gebruik van EPD-gegevens te bevorderen. Deze uitdagingen hebben betrekking op het beheer van data, de middelen en de implementatie van EPD-gegevens voor prestatiemeting.

In **Hoofdstuk 4**, in de datarijke context van Nederland, werd het secundaire gebruik van geneesmiddelen voorschrijfgegevens in de eerste lijn voor het verbeteren van de kwaliteit van zorg onderzocht. Het onderzoek was gebaseerd op drie soorten tracerrecepten: antibiotica, benzodiazepines en opioïden. Er bleken drie belangrijke gegevensbronnen in gebruik om het voorschrijven in de eerste lijn te verbeteren: klinische gegevens in de EPD's van huisartsenpraktijken; gegevens in databases van openbare apotheken; en declaratiegegevens van zorgverzekeraars. Hoewel het secundaire gebruik van apotheek- en verzekeraar gegevens goed ingeburgerd bleek te zijn op alle niveaus, bleek het gebruik van deze gegevens samen met EPD's beperkt. De studie vond ook belangrijke verschillen in de soorten voorschrijfinformatie die nodig zijn binnen de micro-meso-macro-context, hoewel de mate waarin de huidige indicatoren deze dekken verschilt per type voorschrift. Er werden vijf hoofdthema's gevonden voor het optimaliseren van datagebruik: (1) meten wat er toe doet, (2) het vergroten van datakoppelingen, (3) het verbeteren van de datakwaliteit, (4) het faciliteren van het delen van data, en (5) het optimaliseren van de gebruiksgeschiktheid.

In Deel III zijn drie studies uitgevoerd om de actionability in de context van de COVID-19-pandemie in relatie tot het gebruik van dashboards te onderzoeken. In **Hoofdstuk 5** werd een steekproef van 158 dashboards uit 53 landen wereldwijd beoordeeld in de vroege stadia van de pandemie (juli 2020) om kenmerken te beschrijven en te beoordelen die bijdragen aan hun actionability. Ontdekt werd dat de meeste dashboards waren ontwikkeld door overheidsinstanties en landelijk in hun reikwijdte waren, hoewel het primaire doel en de beoogde doelgroep voor de meeste dashboards niet vermeld was of impliciet aanwezig werd verondersteld. Over epidemiologische indicatoren werd bijna overal gerapporteerd, in tegenstelling tot de beperkte rapportage van indicatoren met betrekking tot sociale en economische impact en gedragsinzichten. Opvallend is dat databronnen door ongeveer een kwart van de dashboards niet worden gerapporteerd.

Uit het onderzoek bleek ook dat de dashboards voornamelijk tijdstrends en uitsplitsingen naar twee geografische niveaus en naar leeftijd en geslacht gebruikten om de gegevens te analyseren. Gemiddeld gebruikten de dashboards ook twee soorten displays, voornamelijk grafieken en kaarten, waarbij kleurcodering de meest gebruikelijke visuele ondersteuning was om de interpretatie te vergemakkelijken.

Actionable COVID-19-dashboards kenmerkten zich door: (1) hun doelgroep en informatiebehoeften te kennen; (2) beheer van het type, het volume en de stroom van weergegeven informatie; (3) gegevensbronnen en methoden duidelijk rapporteren; (4) tijdtrends koppelen aan beleidsbeslissingen; (5) gegevens verstrekken die “dicht bij huis” zijn; (6) de populatie in relevante subgroepen verdelen; en (7) ‘storytelling’ technieken en visuele aanwijzingen gebruiken. Er werd geconcludeerd dat hoewel er geen eenduidige benadering is voor het ontwikkelen van een dashboard, het volledige potentieel van dashboards in de vroege stadia van de pandemie grotendeels onbenut was en dat de introductie van de zeven geïdentificeerde functies hun actionability zou kunnen vergroten.

In **Hoofdstuk 6**, voortbouwend op de aanpak en bevindingen van **Hoofdstuk 5**, werden veranderingen in de COVID-19-dashboards in de loop van de tijd onderzocht. Om dit te doen, is de Canadese steekproef van dashboards die in **Hoofdstuk 5** is beoordeeld, in november 2020 opnieuw geëvalueerd (N=26). De vergelijking tussen de twee tijdstippen bracht aan het licht dat er subtiele verbeteringen waren aangebracht, voornamelijk met betrekking tot gegevensverstrekking en vorderingen die mogelijk werden gemaakt door de gebruikte technologieën. De studie vond ook enkele verbeteringen in de actionability van de dashboards, met name met betrekking tot gegevensverstrekking op lokaal niveau, tijdtrendrapportage en indicatorbeheer. Er werden geen verbeteringen gevonden voor communicatieve elementen (explicitering van doel en publiek), terwijl het gebruik van storytelling-technieken om trends te vertellen grotendeels afwezig bleef in de dashboards in Canada. Er werd geconcludeerd dat verdere aandacht voor zowel technische als organisatorische aspecten van dashboardontwikkeling nodig bleef, waarbij dit laatste duidelijkere mandaten en verantwoordelijkheden omvat voor dashboardteams voor het ontwikkelen en het onderhouden van doelgerichte dashboards (fit for purpose and use).

Tot slot, in **Hoofdstuk 7**, werden de ontwikkelingsverhalen van nationale teams onderzocht, waarbij een gebrek aan wetenschappelijk bewijs werd vastgesteld voor het ontwikkelen van COVID-19-dashboards en een hiaat in de samenwerking tussen landen. Er werden semi-gestructureerde groepsinterviews gehouden met een steekproef van 33 nationale COVID-19-dashboardteams uit de hele Europese regio van de Wereldgezondheidsorganisatie. Het onderzoek bracht meer overeenkomsten dan verschillen aan het licht in de ontwikkeling van dashboards in de steekproef. De urgentie, de hoge werkdruk, de beperkte personele middelen, de beperkingen op het gebied van beschikbare gegevens en privacy en de publieke controle waren veelvoorkomende kenmerken van de initiële ontwikkelingsfase van dashboardteams. Bij het onderzoeken van gemeenschappelijke belemmerende en bevorderende factoren werden zes hoofdthema’s en vijftien subthema’s geïdentificeerd als terugkerende belemmerende factoren voor sommige dashboardteams, maar bevorderende factoren voor anderen. De thema’s hadden betrekking op de pre-pandemische context, de pandemie zelf, mensen en processen, software, data en gebruikers. Achteraf zijn lessen over het proces geïdentificeerd rond vijf thema’s met betrekking tot eenvoud, vertrouwen, samenwerking, software en data en verandering. Uit het onderzoek bleek dat de relatieve onvoorbereidheid van landen om dashboards te ontwikkelen werd gecompenseerd door flexibele en pragmatische processen, gezien de informatie-urgentie waarmee ze te maken hadden. De studie concludeerde ook dat het volledige potentieel van dashboards in de toekomst investeringen vereist op team-, nationaal en pan-Europees niveau.

De bevindingen van dit proefschrift worden als valide en generaliseerbaar beschouwd met de volgende overwegingen in gedachten. Ten eerste werden, bij afwezigheid van bestaande instrumenten, studiespecifieke instrumenten ontwikkeld en toegepast, grotendeels gebaseerd op de bevindingen van **Hoofdstuk 1**. Om de validiteit te vergroten, werden deze resultaten voorafgaand aan het gebruik gevalideerd door experts en aangevuld met bestaande definities, concepten en theorieën. Ten tweede werd de tracermethode toegepast om de specificiteit van de bevindingen in **Hoofdstukken 2 en 4** te vergroten, maar als gevolg daarvan kunnen de nuances van andere potentiële tracers mogelijk niet worden vastgelegd. Evenzo werd als verkennende studies prioriteit gegeven aan het vastleggen van de constructies van fitness for purpose and use in zorgstelsels en daarom kunnen de nuances van elke context (micro-, meso- en macroniveaus) mogelijk niet worden vastgesteld. Tenslotte kreeg het vastleggen van verschillende perspectieven in dit proefschrift prioriteit, waarbij deze perspectieven vooral gericht waren op het gebruik van prestatieinformatie door clinici, zorgmanagers en beleidsmakers. Andere belangrijke actor perspectieven in de gezondheidszorg, waaronder patiënten, zijn niet specifiek onderzocht.

Met betrekking tot de generaliseerbaarheid van bevindingen, werden de resultaten van studies uit meerdere landen beschouwd als generaliseerbaar naar andere landen, wanneer deze een vergelijkbare beschikbaarheid van middelen, digitalisering van gezondheidsgegevens en aandacht voor secundaire toepassingen ervan delen. Bevindingen in de Canadese context met betrekking tot EPD’s werden als illustratief beschouwd voor de ontwikkeling van de digitalisering van de eerstelijnszorg in andere landen. Veranderingen in COVID-19-dashboards in de Canadese context bleken ook een afspiegeling te zijn van de ervaringen in andere landen, waar gegevens en technologie met de tijd verbeterden, maar meer organisatorische kenmerken verdere aandacht vroegen. Evenzo bleken de bevindingen uit Nederland met betrekking tot het huidige gebruik van voorschrijfgegevens in de eerste lijn vergelijkbaar met andere ontwikkelde landen met een vergelijkbare mate van digitalisering.

Concluderend stelde dit proefschrift drie aanbevelingen voor die de belangrijkste bevindingen van de zeven onderzoeken weerspiegelen. Ten eerste signaleerden de studies van het proefschrift dat het gebruik van prestatie-indicatoren voor de gezondheidszorg en hun beoogde gebruikers een meer expliciete articulatie van actionability vereist in beide onderzochte zorggebieden (eerstelijnszorg- en COVID-19-dashboards). Met betrekking tot overwegingen van fitness for use, was dit meer ontwikkeld op het gebied van COVID-19-dashboards en blijft dit een aandachtspunt voor verdere ontwikkeling in de eerstelijnszorg. Ten tweede moeten gegevensbronnen aansluiten bij het beoogde gebruiksdoel. Voor beide toepassingsgebieden wordt gepleit voor het combineren van gegevens uit verschillende bronnen om te komen tot meer actionable informatie. Ten slotte zijn er, ondanks de verschillende ontwikkelingstrajecten, een aantal overeenkomsten op belangrijke punten tussen de twee onderzochte toepassingsgebieden welke inzichten bieden voor het versnellen van de actionability, met name op het gebied van eerstelijnszorg.

Om dit werkveld verder te ontwikkelen, is onderzoek nodig op de volgende gebieden: het onderzoeken van gerelateerde onderzoeksvragen met behulp van verschillende methoden, waaronder kwantitatieve onderzoeksdesigns en gegevensbronnen; het testen van aanpassingen aan de toegepaste theorie, waaronder het verkennen van specifieke toepassingen van indicatoren of hun ontwikkeling in co-creatie processen met de beoogde gebruikers; het ontwikkelen van indicatoren en instrumenten die het gebruik en de impact van prestatie-indicatoren in de zorg in de praktijk evalueren; systematiseren van benaderingen om de informatiebehoeften van gebruikers te verkennen en te begrijpen; en het optimaliseren van de ontwikkeling van prestatie-indicatoren voor de gezondheidszorg als een innovatief ecosysteem van producten inclusief het gebruik van dashboards.

Andere aanbevelingen voor beleidsmakers zijn onder meer: strategische inzet van COVID-19-dashboards, aangezien hun beoogde gebruiksdoel in de loop van de pandemie is blijven veranderen; uitbreiding van het gebruiksbereik van dashboards als hulpmiddel om gebruikers te voorzien van eerstelijnszorg-informatie, samen met andere mogelijke toepassingen van dashboards als rapportagehulpmiddel; intensivering van de samenwerking, met name tussen landen en sectoren; en voortdurende investeringen in nationale gegevensbronnen en de professionele competenties die nodig zijn om deze processen te ondersteunen.

Meer dan ooit worden de werkelijke kosten en gevolgen van het niet optimaliseren van het secundaire gebruik van gezondheidsgegevens zichtbaar. Dit inzicht moet worden benut als het momentum dat nodig is om de bevindingen van dit proefschrift toe te passen voor het gebruik van indicatoren die zijn geworteld in hun fitness for purpose and use. Alleen door de voortdurende prioritering van meten, het inbedden van prestatie-informatie in managementcycli, en het gebruik van prestatiemetingen in de praktijk, kan het echte potentieel van prestatie-indicatoren in de gezondheidszorg worden gerealiseerd. Dat zijn prestatie-indicatoren die *werken*.

PhD portfolio

PhD candidate	Erica Stukator Barbazza
Supervisor	Prof. Dr. N. S. Klazinga (AMC-UvA)
Co-supervisor	Dr. D. S. Kringos (AMC-UvA)
PhD period	October 2018–July 2022

TRAINING	YEAR	ECTS[a]
General courses		
First HealthPros Training Week (topics: career development; project management; gender in research; development of performance indicators; handling the media), Academic Medical Center, University of Amsterdam, Amsterdam, the Netherlands	2018	1.5
Second HealthPros Training Week (topics: registry-based performance indicators; scientific presentations and open science publications; bioethics; performance composite indicator hackathon), Aalborg University, Aalborg, Denmark	2019	1.5
Third HealthPros Training Week (topics: novel statistical techniques for analysing the potential of performance indicators; proposal writing), Optimedis AG, Hamburg, Germany	2019	1.5
Fourth HealthPros Training Week (topics: benchmarking for improving quality of care; setting goals and priorities in health care performance evaluation systems; skills and tools for entrepreneurship and technology management), Sant'Anna School of Advanced Studies, online	2020	1.5
Fifth HealthPros Training Week (topics: health informatics and information governance; essential levels of health information for evidence-based performance evaluation; health care policy, systems structures and functions; organizational behaviour and management), University of Oxford, online	2020	1.5
Sixth HealthPros Training Week (topics: performance indicators and health economics; value-based purchasing of services and insurance in the health and social care sectors), Corvinus University of Budapest, online	2021	1.5
Specific courses		
World of Science, Academic Medical Centre Graduate School, University of Amsterdam, Amsterdam, the Netherlands	2018	0.3
International Comparison of Healthcare Systems, Netherlands Institute for Health Services (NIHES), Utrecht and Rotterdam, the Netherlands	2018	1.5
Building engaging teams in primary care, Harvard Medical School Centre for Primary Care, Nanterre, France	2019	0.3
Basic Manuscript Editing, University of Chicago, online	2020	1
Medical Copyediting, University of Chicago, online	2021	1
Intermediate Manuscript Editing, University of Chicago, online	2021	1
Editing Electronically, University of Chicago, online	2021	1

TRAINING	YEAR	ECTS[a]
Advanced Editing, University of Chicago, online	2022	1
Short Career Advice Programme, ProActief, University of Amsterdam, online	2022	0.3
Secondments and apprenticeships		
Netherlands Institute for Health Services Research, September–December 2019, Utrecht, the Netherlands	2019	NA
Canadian Institute for Health Information and University of Toronto, January–April 2020, Toronto, Canada	2020	NA
International Journal for Quality in Health Care (IJQHC) and IJQHC Communications Editorial Apprenticeship Programme, February 2021–January 2022, online	2021–22	10
Workshop moderation		
Consensus workshop on survey of health practitioners in Montenegro, 17 December 2018, Podgorica, Montenegro	2018	0.3
Final workshop of European Commission Programme on Primary Care in Flanders, 9 October 2019, Brussels, Belgium	2019	0.3
Citizen Panel for Performance Accountability for the Irish Health System, 7 December 2019, Dublin, Ireland	2019	0.3
IAmSummer School International Federation of Medical Students' Associations and University of Amsterdam, 7 July 2021, Amsterdam, the Netherlands	2021	0.2
Leading for Quality session at International Society for Quality in Health Care (ISQua) Virtual Conference, 8–10 July 2021, online	2021	0.2
Presentations at workshops, meetings, or webinars		
Update presentations at biannual HealthPros consortium meetings	2018–22	1
"Tool for monitoring impact, performance and capacity of primary health care (PHC-IMPACT)" at Consensus workshop on survey of health practitioners in Montenegro, 17 December 2018, Podgorica, Montenegro	2018	0.3
"Overview and data collection for the Primary Health Care Impact, Performance and Capacity Tool," at Inter-programmatic meeting on PHC-IMPACT and SRMNCAH monitoring tools in the European Region, 7 June 2019, Copenhagen, Denmark	2019	0.3
"Summary of key elements of relevant primary care reforms," at Final workshop of European Commission Programme on Primary Care in Flanders, 9 October 2019, Brussels, Belgium	2019	0.3
"How is primary care prescribing data used? An investigation in the Dutch context," at the Dutch Data Expert Community Meeting, 19 November 2019, Utrecht, the Netherlands	2019	0.3
"What to know and how to be informed about how Ireland's health system is doing," co-presenter at Citizen Panel for Performance Accountability for the Irish Health System, 7 December 2019, Dublin, Ireland	2019	0.3
"Investigating the current and potential use of primary health care EMR data for performance measurement across Canadian jurisdictions: Preliminary findings" at Webinar Lecture Series, North American Observatory on Health Systems and Policies, 28 April 2020, online	2020	0.3
"A HealthPros perspective to COVID-19: Our research agenda for performance intelligence in times of crisis," at Department of Public and Occupational Health meeting, 8 June 2020, online	2020	0.2

TRAINING	YEAR	ECTS[a]
"Are COVID-19 dashboards fit for purpose and use? Preliminary results of a review on the actionability of 158 public, web-based COVID-19 dashboards," co-presenter at Dutch Ministry of Health internal meeting, 12 October 2020, online	2020	0.2
"What makes COVID-19 dashboards actionable? A descriptive assessment and expert appraisal of 158 public, web-based COVID-19 dashboards," co-presenter at the Population Health Information Research Infrastructure (PHIRI) Project Meeting, 28 October 2020, online	2020	0.2
"What makes COVID-19 dashboards actionable? A descriptive assessment and expert appraisal of 158 public, web-based COVID-19 dashboards," co-presenter at Canadian Red Cross Technical Meeting, 8 December 2020, online	2020	0.2
"Learning from COVID-19 dashboard developers: Webinar launching new study on the development of COVID-19 dashboards in the WHO European Region," co-presenter at WHO Regional Office for Europe and HealthPros COVID-19 dashboard webinar series, 30 March 2021, online	2021	0.3
"Pandemic public reporting that is fit for purpose and use: A healthcare performance intelligence lens to COVID-19 dashboards," co-presenter at Behavioural Insights Network Netherlands (BIN NL), 31 March 2021, online	2021	0.2
"Pandemic public reporting that is fit for purpose and use: Lessons from studies on the actionability of COVID-19 dashboards," co-presenter at PANDEM-2 and HealthPros Joint Meeting, 18 May 2021, online	2021	0.1
"COVID-19 dashboard developers' workshop: Reporting back on interview findings," co-presenter at WHO Regional Office for Europe and HealthPros COVID-19 dashboard webinar series, 23 June 2021, online	2021	0.3
"Developing a Health System Performance Assessment (HSPA) Framework in Ireland," co-presenter at HSPA Launch Event, 10 September 2021, online	2021	0.3
"The past, present and future of COVID-19 dashboards," co-presenter at WHO Regional Office for Europe and HealthPros COVID-19 dashboard webinar series, 9 December 2021, online	2021	0.3
"What happens to my paper once submitted? Insights and other lessons from a year as a journal Editorial Apprentice," co-presenter at Quality of Care Section meeting, Department of Public and Occupational Health, 17 May 2022, online	2022	0.2
Presentations at conferences		
"Creating performance intelligence for primary health care strengthening in Europe" at 14th European Forum for Primary Care Conference, 30–1 October 2019, Nanterre, France	2019	0.5
"Exploring the actionability of healthcare performance indicators for quality of care: What makes an indicator fit for purpose and use?" at Sixth Global Symposium on Health Systems Research, Health Systems Global, 13 January 2021, online	2021	0.5
"How is primary care prescribing data used? An explorative study in the Dutch context," at ISQua Virtual Conference, 8–10 July 2021, online	2021	0.5
"Developing and using healthcare performance intelligence: Experiences from the HealthPros initiative," co-presenting at ISQua Virtual Conference, 8–10 July 2021, online	2021	0.5
"What makes COVID-19 dashboards actionable? Lessons learned from international and country-specific studies of COVID-19 dashboards with dashboard developers in WHO European Region," co-presenting at 14th European Public Health Conference, 11 November 2021, online	2021	0.5

TRAINING	YEAR	ECTS[a]
“Selecting healthcare performance indicators that are fit for purpose and use for various stakeholders,” co-presenting at Final Conference on HealthPros Findings, 25 March 2022, Utrecht, the Netherlands	2022	0.3
Posters and pre-recorded presentations		
“WHO/CC WHO Collaborating Centre for Quality and Equity in Primary Health Care Systems (NET-94)” at WHO Collaborating Centres Regional Meeting, 2–3 November 2021, online	2021	0.3
“Better COVID-19 dashboards for better decision-making by Canadians: A descriptive assessment and expert appraisal of changes to Canadian COVID-19 dashboards in 2020,” co-presenter at Annual CAHSPR Conference, 19–21 May 2021, online	2021	0.3
“Investigating the current and potential health care EMR data for performance across Canadian jurisdiction,” at Annual CAHSPR Conference, 19–21 May 2021, online	2021	0.3
“Three years in three minutes,” at Final Conference on HealthPros Findings, 25 March 2022, online	2022	0.3
“The experiences of 33 national COVID-19 dashboard teams during the first year of the pandemic: A qualitative study,” (contributor) at AcademyHealth Annual Research Meeting, Washington, D.C.	2022	0.1
Other conferences or workshops attended		
Biannual HealthPros Immersion Community Events	2018–22	0.5
Scientific conference: crossroads of policy, research, education and practice in primary health care, 23–24 October 2018, Almaty, Kazakhstan	2018	0.5
Amsterdam Public Health research institute Annual Meeting, 22 November 2018, Amsterdam, the Netherlands	2018	0.3
4th Annual International Symposium on Advancing the Science and Impact of Audit and Feedback, 23 May 2019, Amsterdam, the Netherlands	2019	0.3
Health Datapalooza and National Health Policy Conference, 10–11 February 2020, Washington, D.C. United States	2020	0.5
UpOnDigital: The Update on Ontario Digital Health, 24 February 2020, Toronto, Ontario	2020	0.3

[a] ECTS: European Credit Transfer System; 1 ECTS=28 hours

TEACHING	YEAR	ECTS
Lecturing		
International Comparison of Health Care Systems course Netherlands Institute for Health Sciences, 12–16 November 2018, Utrecht, the Netherlands	2018	0.5
Health Systems Development course at Imperial College London, 19 March 2019, London, United Kingdom	2019	0.5
International Comparison of Health Care Systems course Netherlands Institute for Health Sciences, 19 November 2019, Utrecht, the Netherlands	2019	0.5
Health Systems Development course at Imperial College London, 19 March 2021, online	2021	0.5
First Training Week on PHC Performance Measurement and Management, WHO Collaborating Centre for Quality and Equity in Primary Health Care and WHO European Centre for Primary Health Care, 15 June 2021, online	2021	2
Voice over for e-learning course "Sex and gender in epidemiological research," at Amsterdam UMC, University of Amsterdam, online	2022	0.5
First Training Week on PHC Performance Measurement and Management, WHO Collaborating Centre for Quality and Equity in Primary Health Care and WHO European Centre for Primary Health Care, 5 April 2022, online	2022	5
Health System Research course, Master of Public Health Programme, at Netherlands School of Public & Occupational Health, 7 June 2022, online	2022	0.5
Supervising and mentoring		
Co-supervisor for Master of Public Health thesis, Cleo Baskin, Imperial College London, May–August 2019, Amsterdam, the Netherlands	2019	2
Mentor of two Master of Science students annually for Department of Health Policy Mentorship Programme, London School of Economics and Political Sciences	2020–22	2
Reviewing and editing		
Monthly HealthPros research group peer review meetings, Utrecht, the Netherlands	2018–2022	5
Deputy Assistant Editor, International Journal for Quality in Health Care	2022	2
Reviewer for organisation-specific reports		
Results for Development, "Taking stock of the global primary health care measurement landscape"	2019	0.5
WHO Regional Office for Europe, "Strengthening population health surveillance: a tool for selecting indicators to signal and monitor the wider effects of the COVID-19 pandemic"	2020	0.5
World Bank, "Primary health care in the World Bank from year 2010–2020: the extent and evolution of primary healthcare in the World Bank Health, Nutrition, and Population Portfolio over the Past Decade"	2021	0.5
Organisation for Economic Co-operation and Development (OECD), "Improving medication safety through collective, real-time learning"	2022	0.5

TEACHING	YEAR	ECTS
Reviewer for scientific journals		
The Permanente Journal	2019–21	0.5
Health Policy	2020–21	1
Canadian Medical Association Journal (CMAJ) Open	2021–22	0.5
International Journal for Quality in Health Care (IJQHC) Communications	2021–22	2
Family Medicine and Community Health Journal	2021	0.5
British Medical Journal (BMJ) Open	2022	0.5
Dove Press	2022	0.5
International Journal of Health Policy and Management	2022	0.5

PARAMETERS OF ESTEEM	YEAR
Funding	
Amsterdam Public Health (Quality of Care) travel grant	2020
Team member of other funded projects	
“Support to the reform of integrated primary care in Flanders,” funded by the European Commission Structural Reform Support Agreement No. SRSS/S2019/007	2019
“Performance accountability for the Irish health system,” funded by the European Commission Structural Reform Support No. SRSS/C2019/046	2019–2021
“Strengthening actionable primary health care performance measurement and management: tailored training and mentorship programme,” funded by the WHO Regional Office for Europe	2021
“State of Health in the European Union: Ireland: Country Health Profile 2021,” supported by the European Commission, OECD and European Observatory on Health Systems and Policies	2021
Other	
Interviewee for “The Rise of Pandemic Dashboards,” by Marie Patino of Bloomberg CityLab, 25 September, 2021	2021

List of publications

October 2018–July 2022

Publications included in this thesis

Barbazza E, Klazinga NS, Kringos DS. Exploring the actionability of healthcare performance indicators for quality of care: a qualitative analysis of the literature, expert opinion and user experience. BMJ Qual Saf. 2021;30:1010–20. https://doi.org/10.1136/bmjqs-2020-011247.

Barbazza E, Kringos D, Kruse I, Klazinga NS, Tello JE. Creating performance intelligence for primary health care strengthening in Europe. BMC Health Serv Res. 2019;19(1006). https://doi.org/10.1186/s12913-019-4853-z.

Barbazza E, Allin S, Byrnes M, Foebel AD, Khan T, Sidhom P, Klazinga NS, Kringos DS. The current and potential uses of Electronic Medical Record (EMR) data for primary health care performance measurement in the Canadian context: a qualitative analysis. BMC Health Serv Res. 2021;21(820). https://doi.org/10.1186/s12913-021-06851-0.

Barbazza E, Verheij R, Ramerman L, Klazinga N, Kringos D. Optimising the secondary use of primary care prescribing data to improve quality of care: a qualitative analysis. BMJ Open. 2022;12(7):e062349. https://doi.org/10.1136/bmjopen-2022-062349.

Ivanković D, **Barbazza E**, Bos V, Brito Fernandes Ó, Jamieson Gilmore K, Jansen T, Kara P, Larrain N, Lu S, Meza-Torres B, Mulyanto J, Poldrugovac M, Rotar A, Wang S, Willmington C, Yang Y, Yelgezekova Z, Allin S, Klazinga N, Kringos D. Features constituting actionable COVID-19 dashboards: descriptive assessment and expert appraisal of 158 public web-based COVID-19 dashboards. J Med Internet Res. 2021;23(2):e25682. https://doi.org/10.2196/25682.

Barbazza E, Ivanković D, Wang S, Jamieson Gilmore K, Poldrugovac M, Willmington C, Larrain N, Bos V, Allin S, Klazinga N, Kringos D. Exploring changes to the actionability of COVID-19 dashboards over the course of 2020 in the Canadian context: descriptive assessment and expert appraisal study. J Med Internet Res. 2021;23(8):e30200. https://doi.org/10.2196/30200.

Barbazza E, Ivanković D, Davtyan K, Poldrugovac M, Yelgezekova Z, Willmington C, Meza-Torres B, Bos VLLC, Brito Fernandes Ó, Rotar A, Nuti S, Vainieri M, Carinci F, Azzopardi-Muscat N, Groene O, Novillo-Ortiz D, Klazinga N, Kringos D. The experiences of 33 national COVID-19 dashboard teams during the first year of the pandemic in the WHO European Region: a qualitative study. Digit Health. 2022;8:1–16. https://doi.org/10.1177/20552076221121154.

Other peer-reviewed publications

Ivanković D, Jansen T, **Barbazza E**, Brito Fernandes Ó, Klazinga N, Kringos D. Status of the health information system in Ireland and its fitness to support health system performance assessment: A multimethod assessment based on stakeholder involvement. [Manuscript submitted for publication]. https://doi.org/10.21203/rs.3.rs-1426665/v1.

Jaeger L, Devi T, **Barbazza E**, Neufeld M, Franz C, Marten R, Tello J. Describing and mapping scientific articles on alcohol globally for the period 2010–2021: a bibliometric analysis. BMJ Open. 2022;12:e063365. https://doi.org/10.1136/bmjopen-2022-063365.

Ivanković D, **Barbazza E**, Klazinga N, Kringos D. Comment on Verhulsdonck and Shah's 'Lean Data Visualization: considering actionable metrics for technical communication.' J Bus Tech Commun. 2022;36(1):105–13. https://doi.org/10.1177/10506519211054926.

Brito Fernandes Ó, **Barbazza E**, Ivanković D, Jansen T, Klazinga NS, Kringos DS. Engaging citizens in the development of a health system performance assessment framework: a case study in Ireland. Health Res Policy Syst. 2021;19(148). https://doi.org/10.1186/s12961-021-00798-8.

Kringos DS, Carinci F, **Barbazza E**, *et al*. Managing COVID-19 within and across health systems: why we need performance intelligence to coordinate a global response. Health Res Policy Syst. 2020;18(80). https://doi.org/10.1186/s12961-020-00593-x.

Tello J, **Barbazza E**, Waddell K. Review of 128 quality of care mechanisms: a framework and mapping for health systems stewards. Health Policy. 2020;124,(1):12–24. https://doi.org/10.1016/j.healthpol.2019.11.006.

Tello J, Pardo-Hernandez H, Rodrigues R, Ilinca S, Leichsenring K, Yordi Aguire I, Huber M, **Barbazza E**. A services delivery perspective to the provision of long-term care in Portugal. Public Policy Portuguese Journal. 2020;5(1):8–27.

Shukor AR, **Barbazza E**, Klazinga NS, Kringos DS. A problem-oriented systems approach to primary care system development: development and initial testing of the problem-oriented primary care system development record. BMC Health Ser Res. 2020;20(706). https://doi.org/10.1186/s12913-020-05581-z.

Barbazza E, Yegeubayeva S, Akkazieva B, Tsoyi E, Zheleznyakov E, Tello J. Improving clinical practice in primary care for the prevention and control of noncommunicable diseases: a multi-actor approach to two regional pilot projects in Kazakhstan. Cardiovas Diagn Ther. 2019;9(2):129–39. https://doi.org/10.21037/cdt.2018.01.07.

Editorials

Barbazza E, Crosby D, O'Dowd E, Otchi E. Training the next generation of journal editors: the case for editorial apprenticeship programmes. Int J Qual Health Care. 2022;34(2):1–2. https://doi.org/10.1093/intqhc/mzac036.

Barbazza E, Bak Pedersen H, Birtanov Y, Huber M, Immonen K, Jakab M, Kluge K, Kringos D, Azzopardi-Muscat N, Rawaf S, Stavdal A, Tello J. Ten evidence-based policy accelerators for transforming primary health care in the WHO European Region. Public Health Panorama. 2018;4(4):507–14.

Tello J, **Barbazza E**, Kluge H. Accelerating primary health care on its fortieth anniversary: a must-do to extend coverage to quality services for advancing universal health coverage. Public Health Panorama. 2018;4(4):500–2.

Reports

Barbazza E, Kara P, Larrain N, *et al.* A practical guide towards actionable healthcare performance indicators: Selecting healthcare performance indicators that are fit for purpose and use for various stakeholders. Amsterdam: HealthPros No. 1.3; 2022. Available from: https://www.healthpros-h2020.eu/index.php/output/videos-and-recommendations.

Berchet C, Kringos D, **Barbazza E**, Guanais F. More effective and patient-centred care. In: Realising the Potential of Primary Health Care: OECD Health Policy Studies. Paris: OECD Publishing; 2020. Available from: https://doi.org/10.1787/a92adee4-en.

Kringos D and **Barbazza E**. Review of illustrative country cases in support of the reform of integrated primary care in Flanders. Amsterdam: Amsterdam UMC, Academic Medical Centre, University of Amsterdam; 2019.

Barbazza E, Mosca I, Kringos D. Montenegro: WHO European Primary Health Care Impact, Performance and Capacity Tool (PHC-IMPACT). Copenhagen: WHO Regional Office for Europe; 2019. Available from: https://www.euro.who.int/__data/assets/pdf_file/0009/425196/05_MNE_Report_PHC-IMPACT.pdf.

Tello J, **Barbazza E**, Yelgezekova Z, Kruse I, Klazinga N, Kringos D. (eds). Indicator passports: WHO European Primary Health Care Impact, Performance and Capacity Tool (PHC-IMPACT). Copenhagen: WHO Regional Office for Europe; 2019. Available from: https://www.euro.who.int/__data/assets/pdf_file/0005/421943/Passport-web-171219.pdf.

Tello J, **Barbazza E**, Yelgezekova Z, Kruse I, Klazinga N, Kringos D. (eds). Glossary of terms: WHO European Primary Health Care Impact, Performance and Capacity Tool (PHC-IMPACT). Copenhagen: WHO Regional Office for Europe; 2019. Available from: https://www.euro.who.int/__data/assets/pdf_file/0006/421944/Glossary-web-171219.pdf.

Author contributions

Chapter 1

Reference

Barbazza E, Klazinga NS, Kringos DS. Exploring the actionability of healthcare performance indicators for quality of care: a qualitative analysis of the literature, expert opinion and user experience. BMJ Qual Saf. 2021;30:1010–20.

Contributions

Conception and study design: All authors. Data collection: EB. Analysis: EB. Interpretation: All authors. Drafting of manuscript: EB. Critical review and final approval: All authors.

Chapter 2

Reference

Barbazza E, Kringos D, Kruse I, Klazinga NS, Tello JE. Creating performance intelligence for primary health care strengthening in Europe. BMC Health Serv Res. 2019;19(1006).

Contributions

Conception and study design: EB, DK, NSK, JET. Data collection: EB, DK, IK. Analysis: EB, DK, IK. Interpretation: All authors. Drafting of manuscript: All authors. Critical review and final approval: All authors.

Chapter 3

Reference

Barbazza E, Allin S, Byrnes M, Foebel AD, Khan T, Sidhom P, Klazinga NS, Kringos DS. The current and potential uses of Electronic Medical Record (EMR) data for primary health care performance measurement in the Canadian context: a qualitative analysis. BMC Health Serv Res. 2021;21(820).

Contributions

Conception and study design: All authors. Data collection: EB, SA, MB, TK. Analysis and interpretation: All authors. Drafting of manuscript: EB. Critical review of manuscript and final approval: All authors.

Chapter 4

Reference

Barbazza E, Verheij R, Ramerman L, Klazinga N, Kringos D. Optimising the secondary use of primary care prescribing data to improve quality of care: a qualitative analysis. BMJ Open. 2022;12(7):e062349.

Contributions

Conception and study design: All authors. Data collection: EB, RV, LR. Analysis: EB. Interpretation: All authors. Drafting of manuscript: EB. Critical review and final approval: All authors.

Chapter 5

Reference

Ivanković D, Barbazza E, Bos V, Brito Fernandes Ó, Jamieson Gilmore K, Jansen T, Kara P, Larrain N, Lu S, Meza-Torres B, Mulyanto J, Poldrugovac M, Rotar A, Wang S, Willmington C, Yang Y, Yelgezekova Z, Allin S, Klazinga N, Kringos D. Features Constituting Actionable COVID-19 Dashboards: Descriptive Assessment and Expert Appraisal of 158 Public Web-Based COVID-19 Dashboards. J Med Internet Res. 2021;23(2): e25682.

Contributions

DI and EB contributed equally as first authors. Conception and study design: DI, EB, SA, NK, DK. Tool development: DI, EB. Data collection: DI, EB, VB, OBF, KJG, TS, PK, NL, SL, BMT, JM, MP, AR, SW, CW, YY, ZY. Data analysis: DI, EB, SA, NK, DK. Interpterion: All authors. Drafting of manuscript: DI, EB. Critical review and final approval: All authors.

Chapter 6

Reference

Barbazza E, Ivanković D, Wang S, Jamieson Gilmore K, Poldrugovac M, Willmington C, Larrain N, Bos V, Allin S, Klazinga N, Kringos D. Exploring Changes to the Actionability of COVID-19 Dashboards Over the Course of 2020 in the Canadian Context: Descriptive Assessment and Expert Appraisal Study. J Med Internet Res. 2021;23(8):e30200.

Contributions

EB and DI contributed equally as co-first authors. Conception and study design: EB, DI, SA, NK, DK. Data collection: EB, DI, SW, KJG, MP, CW, NL, VB. Analysis: EB, DI. Interpretation: All authors. Drafting of manuscript: EB, DI. drafted the manuscript. Critical review and final approval: All authors.

Chapter 7

Reference

Barbazza E, Ivanković D, Davtyan K, Poldrugovac M, Yelgezekova Z, Willmington C, Meza-Torres B, Bos VLLC, Brito Fernandes Ó, Rotar A, Nuti S, Vainieri M, Carinci F, Azzopardi-Muscat N, Groene O, Novillo-Ortiz D, Klazinga N, Kringos D. The experiences of 33 national COVID-19 dashboard teams during the first year of the pandemic in the WHO European Region: a qualitative study. Digit Health. 2022;8:1–16.

Contributions

EB and DI contributed equally as co-first authors. Conception and study design: EB, DI, KD, OG, DNO, NK, DK. Tool development: All authors. Data collection: EB, DI, OBF, MP, CW, BMT, VB, ZY, OG, NK. Analysis: EB, DI, NK, DK. Interpretation: All authors. Drafting of manuscript: EB, DI. Critical review and final approval: All authors.

Funding

The studies included in this thesis were funded by the Marie Skłodowska-Curie Innovative Training Network for Healthcare Performance Intelligence Professionals (HealthPros) that received funding through the European Union's Horizon 2020 research and innovation programme under grant agreement Nr. 765141.

Chapter 2 was also financially support by the Government of Kazakhstan through the WHO European Centre for Primary Health Care in Almaty, Kazakhstan.

The funders had no role in the study design, data collection, analyses, interpretation of the data, or decision to submit results.

Acknowledgements

This thesis would not have been possible without the collaboration, guidance and support of many individuals. Thank you to my supervisors, Niek Klazinga and Dionne Kringos, who shepherded me throughout my PhD trajectory with constructive, consistent and calming guidance. To have access to their expertise was a privilege. Their mentorship with equal emphasis to my professional development and well-being was invaluable and admirable. I will aspire to replicate this level of care in all my future roles.

Thank you to the varied teams that have hosted me as part of my research. Particular thanks to the Department of Public and Occupational Health at the Amsterdam University Medical Centers of the University of Amsterdam where I spent the majority of my time during my studies. I am especially grateful for thoughtful discussions, peer reviews and the support and friendship of the Health Care System Development and Evaluation group, led by my supervisors and made up of my peers Véronique Bos, Óscar Brito Fernandes, Damir Ivanković and Mircha Poldrugovac, and many visiting or at-distance researchers.

Thank you to Lotte Ramerman and Robert Verheij at the Netherlands Institute for Health Services Research, in Utrecht, the Netherlands, Sara Allin and Gregory Marchildon at the University of Toronto and Mary Byrnes, Andrea Foebel, Tanya Khan, Kathleen Morris and Patricia Sidhom at the Canadian Institute for Health Information in Toronto, Canada, for welcoming me into their teams and supporting my throughout my secondments. I feel very fortunate to have worked alongside them all and my secondments truly enriched my PhD trajectory.

Thank you to the Marie Skłodowska-Curie Actions scheme of the European Union's Horizon 2020 Programme. The funding support provided through the Innovative Training Network for Healthcare Performance Intelligence Professionals (HealthPros) not only made this research possible but also provided a uniquely rich learning opportunity. Thank you to the HealthPros consortium members for the foresight to apply for this grant and for their commitment throughout.

Thank you to my fellow HealthPros Fellows, Pinar Kara, Mekha Ann Mathew, Nicolas Larraín, Kendall Gilmore, Damir Ivanković, Óscar Brito Fernandes, Sophie Wang, Bernardo Meza-Torres, Claire Willmington, Mircha Poldrugovac and Véronique Bos. I am grateful to have been part of such a dynamic and engaged network and to have learnt and worked alongside them all. A special thank you to my primary HealthPros collaborator, Damir Ivanković. His complementary skillset, enthusiasm for dashboards, and friendship made our shared research a joy and a cherished experience of true teamwork.

Thank you to all the other collaborators and co-authors, in particular the HealthPros network at-large and teams at the World Health Organization and its offices in Almaty, Kazakhstan and Copenhagen, Denmark, for the possibility to co-author studies included in this thesis.

Thank you to my Doctoral Committee members, Eric Moll van Charante, Ronald Cornet, Suzanne Geerlings, Robert Verheij, and Adalsteinn (Steini) Brown, for devoting their time to read and comment on my manuscript and serve as opponents for my PhD defense.

Thank you to my paranymphs, Damir Ivanković and Óscar Brito Fernandes, for the support throughout and in the lead up to my defense.

Thank you to the informants that have participated in interviews throughout this research for the trust, time, candid insights and experiences shared.

Thank you to my early mentors, Neil Fulford, Irene Papanicolas and Juan Tello, for setting me on a path that has led me to such a rewarding field of work.

And finally, thank you to my dearest friends and family in Canada, Denmark and beyond, for being a consistent source of enthusiasm and encouragement from near and far. Your support is always felt. Thank you to Mom and Dad for being my greatest cheerleaders. I owe all my achievements to you. To my Kaia, thank you for teaching me the greatest lesson in love and resilience. To Ollie the mini poodle, thank you for the forced walks and endless cuddles. And thank you to my husband Morten, for being an endless source of balance, love and support.

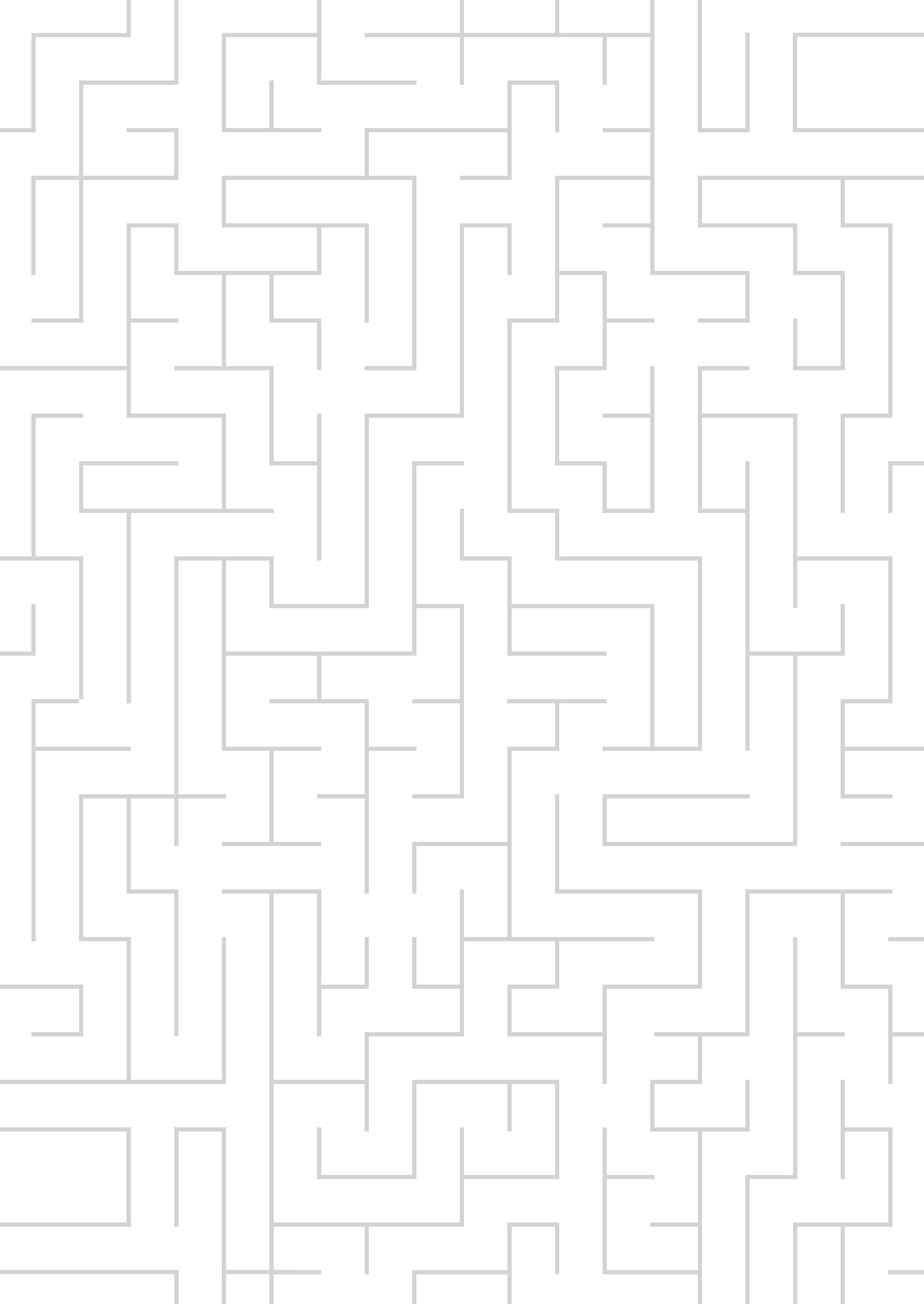
About the author

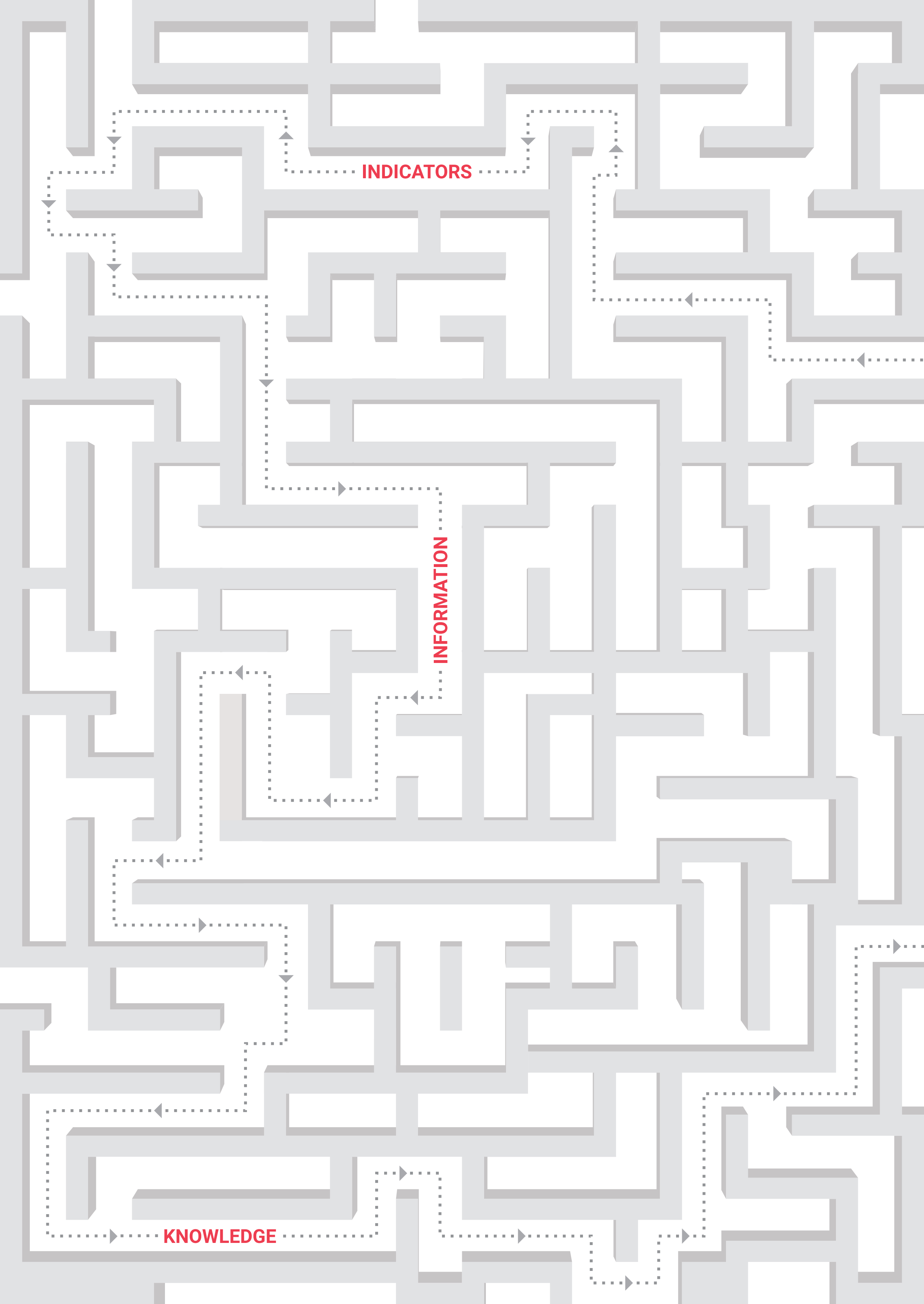
Erica Stukator Barbazza (1989) was born and raised in Toronto, Canada. She completed her undergraduate degree in Health Sciences with a minor in Globalization Studies at Western University in London, Ontario in 2011. To gain an international perspective to her studies, she pursued a Master of Science in International Health Policy from the London School of Economics and Political Sciences in London, United Kingdom in 2012.

As a new graduate, Erica joined the World Health Organization (WHO) Regional Office for Europe in Copenhagen, Denmark. In this role, her work focused on health systems strengthening, specifically, health systems governance and health services delivery. In 2017, she relocated to continue her assignment at the new WHO European Centre for Primary Health Care in Almaty, Kazakhstan. While working with WHO, Erica contributed to the development of a European policy framework on integrated health services delivery and regional tool for measuring primary health care performance. She also supported WHO's country work across Central Asia, specifically in Tajikistan, Kazakhstan, and Kyrgyzstan, as well as in Georgia, Hungary, the Republic of Moldova, and Ukraine.

In 2018, Erica joined the Marie Skłodowska-Curie Innovative Training Network for Healthcare Performance Intelligence Professionals (HealthPros). As a HealthPros fellow, Erica was based at the Department of Public and Occupational Health at the Amsterdam UMC, University of Amsterdam. She also held positions as a visiting researcher with the Netherlands Institute for Health Services Research (Nivel), Canadian Institute for Health Information (CIHI), and University of Toronto. In parallel to her PhD research, Erica contributed to a number of applied policy projects, including in the Flanders Region of Belgium, Ireland, and with the WHO Collaborating Centre for Quality and Equity in Primary Health Care Systems. She has also completed an editorial apprenticeship with the International Journal for Quality in Health Care and certificate in editing from the University of Chicago.

Erica splits her time between her home in Copenhagen, Denmark that she shares with her husband Morten, and Toronto, Canada, where her family and dearest friends live, as well as the numerous places that life takes her and her family.




INDICATORS
INFORMATION
KNOWLEDGE