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Evaluating the Effectiveness of Clinical Decision Support Systems: The Case of Multimorbidity Care

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Abstract. General Practitioners (GPs) and healthcare systems, worldwide, are overwhelmed by the growing number of patients with multimorbidity, particularly in light of the additional complexity and costs involved in treating these patients. While it has been proven that clinical decision support systems (CDSS) play a key role in supporting healthcare decisions, there is little research into their role in the case of multimorbidity. This study examines practice systems currently used in Ireland and evaluates their effectiveness in such circumstances. The findings uncover a number of deficiencies, including: (1) the lack of provision of integrated medical guidelines for multiple chronic diseases within the CDSS, (2) the inability to centralise the patient rather than the disease, (3) the difficulty in seamlessly integrating CDSS into the patient consultation, and (4) the lack of adequate training of GPs on how best to use CDSS in multimorbidity decision making. The study underlines the need for further research into CDSS and multimorbidity, and highlights some of the key issues that must be addressed in order to improve how CDSS support the care of multimorbid patients.

Keywords: Clinical Decision Support Systems; Decision-Making; Multimorbidity; Chronic Disease; Information Systems; Sensibility;

1. Introduction

As the life expectancy of the world population continues to grow, chronic disease is becoming a greater burden on already over stretched healthcare systems (Smith et al., 2010b). Multimorbidity is defined as the coexistence of two or more chronic diseases in an individual (Smith and O'Dowd, 2007). While clinical decision support systems (CDSS) have been found to be effective at both reducing clinical decision errors (Cantrill, 2010) and improving healthcare process measures across diverse settings (Bright et al., 2012), the effects of CDSS interventions in multimorbidity care are under investigated (cf. Smith et al., 2012b). Indeed, existing healthcare systems are mainly configured for individual diseases rather than multimorbidity (cf. Barnett et al., 2012). However, it has been argued that this should change and that care of multimorbid patients should incorporate an integrated view of the patients' multiple conditions (Stange, 2005).

Within an Irish context, the Irish Minister for Health, Dr. James Reilly, has announced an initiative to transfer the management of chronic disease from hospitals in Ireland to primary care (Wall, 2012). However, an extensive qualitative study into primary care in Ireland reveals that many GPs already feel overwhelmed when trying to manage multimorbid patients (Smith et al., 2010a). In light of the increased complexity that multimorbidity adds to the decision-making process, an investigation into how well current CDSS support Irish GPs in such circumstances appears essential.

This study examines Irish General Practitioner (GP) attitudes regarding current practice systems in the case of multimorbidity. It draws on the sensibility framework (Feinstein, 1987) in order to assess the effectiveness of CDSS for multimorbidity support in Irish primary healthcare centres. The study employs a multi-method approach that includes both a survey instrument and a focus group. The aim of the study is to investigate if these systems provide sufficient support to GPs when dealing with patients with multimorbidity; and to explore potential opportunities whereby CDSS might better support decision making in such circumstances.

This paper begins by describing the challenges facing healthcare decision makers in primary care settings in light of the growing number of patients with multiple chronic conditions. Next, we examine the impact of CDSS on healthcare decision making and review both the advantages and disadvantages of CDSS that have been uncovered in previous empirical studies. We then discuss the sensibility framework used within the study and briefly describe our multimethod approach. Subsequently, we outline the results of the study. We conclude by discussing the key findings of the study and highlighting the implications of this study for future research in this area.

2. Increase in Multimorbidity and its Impact on Healthcare Decision-Making in Primary Care Settings

Advances in preventative and curative medicine as well as increasing life expectancy in the developed world have contributed to increasing multimorbidity (Smith et al., 2010a). The prevalence of multimorbidity is particularly high in primary care and increases significantly as people age (Fortin et al., 2005). Indeed, patients with multimorbidity often have frequent primary care visits as well as hospital visits, with enormous costs for the individuals and for the healthcare system involved (Boyd et al., 2005).

This higher number of consultation visits for multimorbid patients can also result in them having lower 'continuity of care' than other patients (Salisbury et al., 2011). Continuity of care is commonly considered as seamless care, or a connected series of healthcare visits (Haggerty et al., 2003). It is a combination of *Information Continuity* (having all the necessary information when treating the patient) and *Management Continuity* (the ability to coordinate actions with other healthcare providers to meet the healthcare plan in a timely fashion) (Haggerty, 2012).

It is perhaps with 'increasing costs' and 'continuity of care issues' in mind that there is currently a drive in Ireland to encourage multimorbid patients to be treated in primary care instead of in hospital environments (cf. Wall, 2012). This initiative will lead to an increase in both the number and significance of healthcare decisions that have to be made by the primary care provider – the GP. However, studies have shown that GPs already feel under pressure when making healthcare decisions with multimorbid patients due to the complexity of dealing with the multiple conditions (c.f. Smith et al., 2010a).

Clinical decision-making is inherently complex and requires both a knowledgeable practitioner and relevant information inputs that must be used to identify and manage a patient's healthcare needs (Fortier et al., 2005). When issues of multimorbidity are introduced, some of which are co-dependent, the complexity begins to multiply. Both GPs and patients must deal with issues such as (1) increased visits, (2) complicated care plans, (3) long-term disease and treatment monitoring, (4) behaviour modification and (5) patient self-management (Roshanov et al., 2011).

This task is made more difficult by the time pressures which are placed on consultations (cf. Moayyeri et al., 2011). GPs are often under pressure to make decisions quickly. This pressure stems not only from time critical medical decisions, but also from the increased number of patients and the limited amount of time they can allow for each patient. A longitudinal study spanning twelve years and 392 consultations found that the length of patient visits did not vary significantly, irrespective of the healthcare condition (or multiple conditions) being discussed (Tai-Seale et al., 2007).

When medical professionals are placed in situations of high pressure, high complexity and low certainty, they are more likely to apply cognitive approaches such as heuristics ('rules of thumb'), or pattern matching (cf. Croskerry, 2002, Cioffi and Markham, 1997). These techniques are used by many decision makers in the trade-off between cognitive effort and analytical accuracy (cf. Conlisk, 1996, Payne et al., 1992). However they can provide a false sense of certainty (Kamal and Burkell, 2011) and this can lead to medical errors (Croskerry, 2002).

Section 4 outlines the potential of Clinical Decision Support Systems (CDSS) to support and/or improve such decision making.

3. The Impact of CDSS

Clinical Decision Support Systems (CDSS) have been defined as systems that aid directly in clinical decision-making and that use characteristics of individual patients to generate patient-specific assessments which are subsequently presented to clinicians for consideration (Hunt Dl, 1998). CDSS have a critical role to play in primary care and have been shown to improve practitioner performance in 64% of studies (Garg et al., 2005). Kawamoto et al. (2005) identify a number of features that are of particular importance within a CDSS. These include automatic provision of decision support in clinician workflow and provision of decision support at time and location of decision (i.e. real-time decisions).

Ireland has a strong proliferation of software systems within primary care practices with 90% of GP practices use primary care systems (c.f. ICGP, 2012, PCAST, 2010). Five specific primary care systems are accredited for use in Ireland by the Irish Congress of General Practitioners (ICGP, 2012), though a small number of practices use non-accredited systems. While some initiatives (e.g. Health Atlas Ireland[1]) attempt to integrate and consolidate health information in Irish healthcare, some deficiencies still exist in this area. These include, for example, the ability to transfer medical records electronically between practices, digitising older records and integrating GP systems with hospital systems.

While CDSS were originally seen as a challenge to professional decision-making (Fortier et al., 2003), they have now been found to be effective at both reducing clinical decision errors (Cantrill, 2010) and improving healthcare process measures across diverse settings (Bright et al., 2012). CDSS have also been shown to improve physician adherence to guidelines because they reduce the complexity involved (Goud et al., 2010). CDSS can add value by

[1] Health Atlas Ireland is an award winning web application portal supporting Health Service Planning and Monitoring. It is an open-source mapping, database and statistical system. The system integrates geographic information, health event datasets and statistical components.

informing rather than completely automating the decision making process (cf. Hesse and Shneiderman, 2007).

However, some have argued that introducing technology into the medical environment can produce negative effects, such as: (1) information overload (Kang et al., 2010), (2) cross compatibility issues (Friedewald and Raabe, 2011, Iakovidis, 2009) (3) data protection issues (Friedewald and Raabe, 2011) and (4) usability problems (Bhachu et al., 2008). Others have suggested that earlier findings were contaminated by involving doctors who were undergoing training and therefore didn't have a choice regarding their involvement with the system, regardless of its quality (cf. Cantrill, 2010).

Nevertheless, CDSS have been found to enable GPs and patients to make more informed decisions (cf. Vedel et al., 2012). They have also been shown to facilitate GPs and patients in reaching consensus (cf. Goud et al., 2010). This is vital in the current climate where patients are increasingly looking for more information and more involvement in their healthcare decisions (Chewning et al., 2011, Kiesler and Auerbach, 2006).

Despite the apparent advantages of CDSS, there is a dearth of research which explores the effects of introducing a CDSS to support decision making in the case of multimorbidity. A recent systematic review of extant research in the area reveals that previous interventions for improving outcomes in patients with multimorbidity in primary care have not considered CDSS. Interventions already studied include: (1) professional (e.g. education design); (2) financial (e.g. financial incentives to providers to reach treatment targets); (3) organisational (e.g. case management) ; (4) patient oriented (e.g. patient education); and (5) regulatory (e.g. changes to local or national regulations) (Smith et al., 2012a).

Clearly, there is a need for further research in this area. Consequently, this study draws on the sensibility framework (Feinstein, 1987) in order to assess the effectiveness of CDSS for multimorbidity support in Irish primary healthcare centres. The next section introduces the Sensibility framework and discusses the suitability of this framework for assessing the effectiveness of CDSS for multimorbidity support.

4. Sensibility: A framework for Evaluating CDSS

Sensibility is a framework first used by Feinstein (1987) to test medical instruments and medical guidelines. Original dimensions of sensibility include: (1) comprehensibility; (2) replicability; (3) suitability of scale (whether the scale measures what it purports to); (4) ease of use; (5) face validity; (6) content validity; and (7) scale purpose (Feinstein, 1987). These seven dimensions were simplified by Rowe and Oxman (1993) to create a check list with 4 key measures of sensibility. These are: (1) objectivity; (2) discriminative power; (3) content; and (4) appropriateness. Although the sensibility framework originates outside the information systems discipline, many of the concepts of sensibility are

applicable to information systems. Indeed, it has been proven to provide a practical and effective way of evaluating the effectiveness of CDSS in the case emergency medicine (cf. Graham et al., 2008). It provides an aggregate of properties that make up the common sense aspects of an instrument (Graham et al., 2008); and thus, can be used to investigate the key elements which are important to the success of the instrument – in this case the use of a CDSS to support a GP in multimorbidity healthcare decisions (see Figure 1).

The first measure of the sensibility framework is *Objectivity*. This is a vital element of healthcare decision-making. This aspect examines the availability of information to the GP, support for subjective decisions and the potential for GP bias. While subjective decisions will always be a necessary element of medicine, the goal of a CDSS is to provide the necessary information combined with objective guidelines to aid the process.

The second measure of the sensibility framework is *Discriminative Power*. This investigates if the CDSS is capturing adequate information in the right categories to enable the GP to make an informed decision. Without sufficient categories, GPs are forced to input the information into free text fields which are unstructured. This information cannot easily be used for calculations or analysis and perhaps more importantly, cannot readily support decision making at an optimal level.

The third measure, *Content* looks at the features of the CDSS, how information is captured and how information is processed. This measure questions the focus of the CDSS by examining comprehensiveness versus redundancy. By trying to capture everything, the resulting system can have too many features which are unnecessary (redundant) and time consuming. This aspect also considers if the content extends beyond the relevant domain and if content is weighted.

The final measure of the sensibility framework is *Appropriateness.* This measure examines the basic elements of the CDSS to see if the system is 'fit' to support decision-making within its specific context (in this case, GP decision support when dealing with multimorbid patients in primary care settings). It considers the usability of the system; the clarity and simplicity of the system; the ability of the system to provide the decision maker with adequate instructions; as well as the overall applicability of the system. If a system is found not to be appropriate, then the other three aspects of sensibility will be irrelevant.

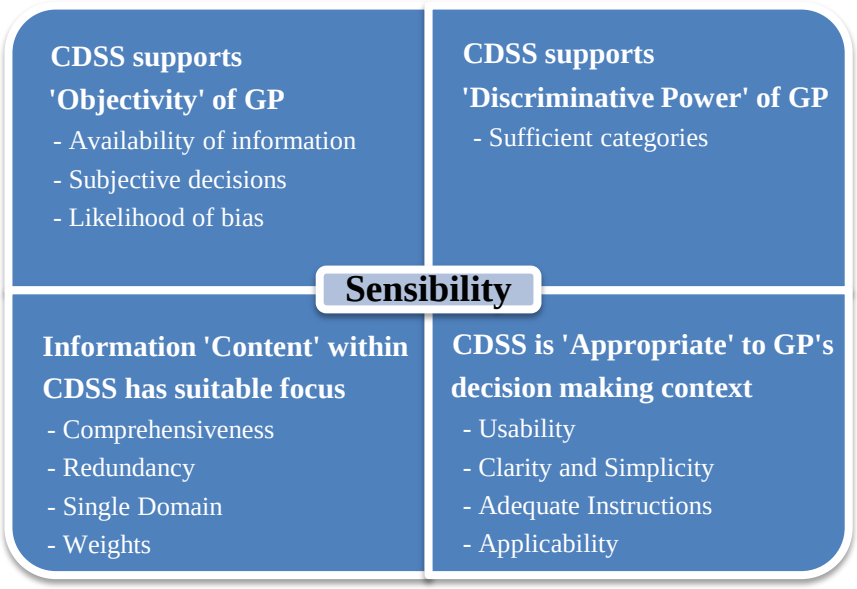


Figure 1. Sensibility Measures - Adapted from Rowe and Oxman (1993)

The following section describes how the sensibility framework was utilised to guide empirical data gathering in this study.

5. Methodology

As a measure, sensibility can be tested either qualitatively or quantitatively (cf. Rowe and Oxman, 1993). The study, thus, employed a multi-method approach to data gathering. It combined a semi-structured web-based survey and a focus group with GPs from a number of practices in order to collect a sufficient quantity of data to achieve our research objective.

The semi-structured survey instrument was informed by the dimensions of the sensibility framework and was pilot tested by GPs from two practices. This ensured that it was unambiguous to those who would be taking the survey (cf. Remenyi and Williams, 1995). The survey contained a mixture of likert scale questions, multiple choice questions and open-ended questions. We received 59 complete responses, which cover four out of the five systems that are accredited for use in GP practice surgeries in Ireland (ICGP, 2012), plus one additional legacy system. This enabled us to evaluate GP opinion of the overall capability of the current GP practice software to act as a CDSS in the case of multimorbidity care.

Focus groups are a method of group interview which capitalises on communication and interaction between participants in order to generate data (Kitzinger, 1995). Although focus groups are a widely recognised and used method of social research, they are still underused in IS research (Stahl et al., 2011). The focus group in this study included representatives from three different GP practices, one practice manager and one IT expert, who is responsible for designing and managing one of the accredited practice software packages in Ireland.

The duration of the focus group session was approximately one and a half hours and was moderated by one of the senior researchers on the research team. Another member of the research team was also in attendance. The initial questions were based on the results of the survey. Focus group participants were asked to provide more details and/or opinions surrounding the interim results/findings from the survey. Open questions prompted additional insights/contributions to the discussion. This afforded the research team the opportunity to further analyse and refine the findings from the survey instrument, as well as to openly discuss particular aspects of sensibility in detail.

With respect to the coding of the data gathered, the semi-structured survey contained a number of open questions that needed to be coded. The elements of the sensibility framework were used as seed categories for this coding. Two different coders analysed the responses separately. A similar process was undertaken with the transcription from the focus group. Once the coding was complete, the coders then came together to discuss and consider potential differences in codes that had arisen.

The following section describes the results of our analysis.

6. Sensibility of CDSS in the Case of Multimorbidity Healthcare

The following sub-sections combine the rich insights gained from both the survey responses and the focus group to reveal the findings of the study in terms of each of the four measures of the sensibility (i.e. Objectivity, Discriminative Power, Content and Appropriateness). The discussion focuses on both the strengths and weaknesses of the decision support provided to GPs by the current systems when caring for multimorbid patients.

6.1.1 Supporting Objectivity of the GP

This measure of sensibility is an important one for a decision maker as it includes key elements of information availability and bias. With respect to **bias**, only 24% of respondents feel that their system is too rigid and does not allow for individual clinical judgement when dealing with multimorbid patients. In relation to **availability of information**, over 79% of GPs are confident of their ability to retrieve general information using their existing systems. They

consider the system to be a "*great [for] prompting when necessary for things that need to be done…lots of different options".*

In addition, the results of the study reveal that 62% of GPs are confident that their systems ensure that pertinent historical information is not lost, with some respondents noting that patient history is only useful if kept up to date by the individual GPs. This historical information not only reduces cognitive effort in decision-making, but also improves 'information continuity' of care (see Section 2). If doctors are treating patients who are not their own, information must be readily available for them to make objective decisions and maintain the greatest level of continuity of care possible.

However, the analysis reveals that 81% of the GPs report using an additional information resource when making a healthcare decision in the case of a multimorbid patient. This points to a significant deficiency in the availability of information within their current systems to aid decision making in such circumstances. While a number of reasons are cited by respondents for seeking alternative sources of information, the majority can be organised into three key categories. These are: (1) to obtain current information on chronic diseases, (2) to obtain information more readily in the decision-making situation; and (3) to support patient education. One GP noted that he uses the internet "*to find the latest up-to-date information and guidelines*". Another GP commented that he finds that information on the internet is "*more easily available and I know how to get it straight away*".

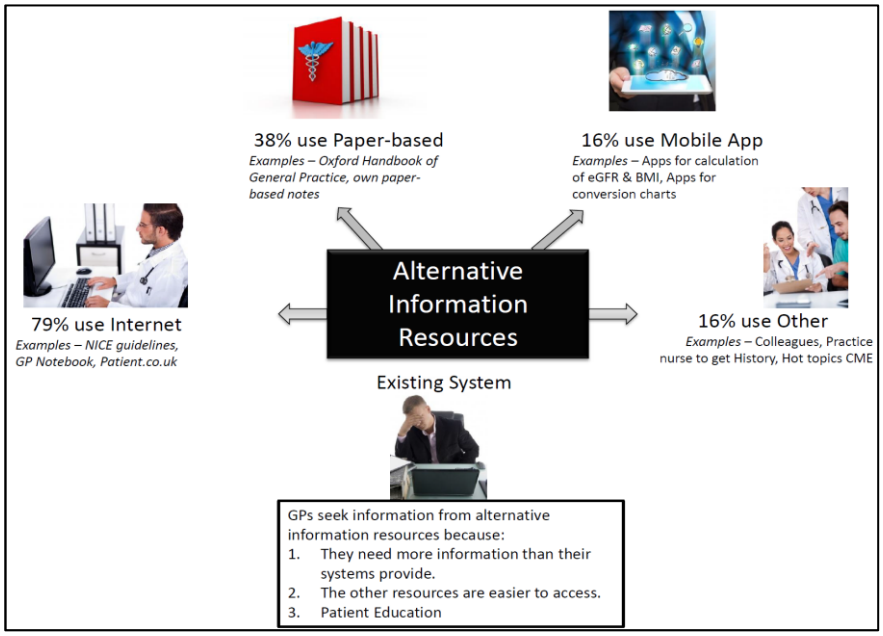


Figure 2. Alternative Sources of Information

The internet is the most popular alternative source of information, with 79% of GPs seeking information online, cf. Figure 2. Websites commonly cited by respondents include: (1) www.nice.org.uk which provides diverse information from drug interactions to the widely used 'Nice' clinical guidelines; (2) www.gpnotebook.co.uk which is an online encyclopaedia of medicine that provides a trusted reference resource for clinicians; and (3) www.patient.co.uk which aims to provide non-medical people with good quality information about health and disease.

The next most popular source of information used by GPs aside from their GP practice system is paper-based information (38% of respondents) - for example, the Handbook of General Practice, GPs own written notes. 16% of respondents describe regularly using Mobile Applications - for example, for calculating Body Mass Index, while another 16% cite a range of other sources – for example, colleagues or the practice nurse, etc.

6.1.2 Supporting Discriminative Power of the GP

There is only one element within this measure of sensibility and that is **sufficient categories,** cf. Figure 1. In relation to this measure, a number of GPs criticise the coding mechanism (i.e. means of grouping data) within their current systems: *"The coding of chronic diseases is a nightmare. [It] offers free text facility but that's no use."*

One GP notes that her system does not distinguish between how information is coded for one chronic disease versus another – *"[For example Diabetes, Asthma, COPD….there should be an [online] questionnaire to follow for each of these…so you could follow templates to follow up on each of these and these values could then be audited easily in the future".* Another GP explained: *"[Within my system] I am unable to perform a search for patients with any [particular] chronic disease…this must be arduously carried out by searching for the commonly used medications that patients with certain chronic illnesses may be using".*

The study finds that issues with coding within a particular system not only to make it more difficult to access information stored on the system, but also serve as a disincentive for GPs to use the system in the first place: *"Coding system is too bulky and cumbersome…there's a disincentive to use it."*

6.1.3 Focus of Information Content

The two primary elements of this measure which emerge as being significant within this study are ***comprehensiveness*** and ***redundancy.*** Although 81% of GPs are happy with how their systems perform when dealing with conditions other than the patients multiple chronic diseases, there is a lack of

consensus over the ability of these systems to balance comprehensiveness and redundancy in the case of multimorbidity.

In systems where guidelines were present, the results of the study illustrate that balancing comprehensive checklists and guidelines for multiple chronic illnesses against excess of redundant elements for individual diseases is a difficult balancing act. Some respondents welcome the checklists as a method for ensuring they did "*not miss important points of information*".

However, others find that in an attempt to be comprehensive, the systems add either confusion: *"[There are]multiple information sources, [which cause] conflict of treatment paths"*; or time and cognitive effort: *"[The system has] tailor made sequences that prompt questions but these are for individual diseases….the "checklist" for an individual disease is too long - e.g. Diabetes. So if a diabetic also has arthritis, an alcohol problem or depression, by the time I sort those out I am really not in the humour for another 20 item checklist..."*

6.1.4 Appropriateness to Decision Making Context

The final measure of sensibility deals with whether the system is fit for purpose. With respect to this measure, while only 55% of GPs like the way their systems present information **(clarity and simplicity)**, 76% of GPs feel that their existing systems have good **usability** or view their systems as "*easily navigable"***.** However, many GPs are of the view that there is insufficient training on how these systems should be used. One GP commented: *"I find it all useful and user friendly, but there's not enough training or time to use all of the features."*

This issue is also highlighted during the focus group discussion. The general consensus of the group is that the usability of the system (one of the key elements of the Appropriateness measure) is often down to whether individual users use the system correctly or not: "*There's a saying in the computer industry…GIGO [Garbage In, Garbage Out]. And there's a problem that I have seen, even in a single practice. Say you will have one GP who enters in a standard fashion that is easily readable by a locum or anyone coming in while another GP does it a different way, because there is no standardisation…and he doesn't do the proper diagnosis entries and doesn't do a note or something…So it's not the computer system, it's how that it is used [that is important]".*

With respect to **adequate instructions** and **applicability**, surprisingly, this study reveals that many GPs do not view their systems as a CDSS for patients with multimorbidity. These GPs report that their systems lack adequate protocols or guidelines to support decision making in this situation. One particular GP comments that there were *"no protocols in place on the IT system"* and that instead he had turned to "*recognised management guidelines on the internet [to provide decision support]".* Another GP feels that any questions centred on decision-making or GP-Patient interaction are "*non-IT related….. but [instead are] relationship based with the patient...the system simply records*

same". Yet another commented that their system has *"no space for centralising the patient rather than the diseases"*.

The study also reveals that a number of GPs are concerned about the current and future impact of the CDSS on the consultation process. The prospect of developing more features and the inclusion of further protocols and guidelines in their systems makes some GPs uneasy about the impact that this may have on interactions with patients. One GP fears that further development of his system might lead to more *"pop-up boxes with constant reminders/checks that you have to keep clicking off"*.

7. Multimorbidity in Primary Care: The Need for New Decision Support Systems

The aim of this study was to investigate the effectiveness of GP practice systems currently used in Ireland in providing decision support to GPs when treating patients with multimorbidity. The study uncovers a number of areas where these systems are failing to support GP decision-making in the case of multimorbid patients. It augments earlier findings that GPs feel overwhelmed when treating patients with multimorbidity (cf. Smith et al., 2010a).

In particular, the study highlights a deficiency within Irish GP practice systems in providing up-to-date information needed by GPs when treating mutlimorbid patients. Most significantly, many systems do not currently provide treatment guideline information for all relevant chronic diseases. Quite apart from treatment information, the study also uncovers the inadequacy of Irish GP practice systems with respect to handling the requisite chronic disease data for each multimorbid patient in a way that centralises the patient rather than the disease. This makes it very difficult to simultaneously access, and review all relevant chronic disease information related to a particular multimorbid patient.

Another key finding of the study relates to the discriminative power offered by GP practice systems in Ireland in the case of multimorbidity. This was manifest in the difficulty of balancing redundancy and comprehensiveness within these systems. The study, thus, supports earlier work which suggests that interventions which are tailored for single disease may not work for patients with co-morbid conditions (cf. Fortin et al., 2005). Guidelines and templates which are useful when dealing with one condition were found to become time-consuming, repetitive and sometimes complicated when dealing with multiple conditions. GPs emphasised the challenges of monitoring information related to multiple chronic diseases and managing their associated (sometimes conflicting) treatment paths. They emphasised the importance of guidelines to aid their navigation of the various options/treatment paths open to them.

It is perhaps these failings that precipitate the widely held view of Irish GPs that their GP practice systems are useful for recording information, but are incapable of acting as a clinical decision support system (CDSS) for

multimorbidity care. This points to a need for further research to be carried out in order to investigate if these systems could provide a more integrated view of the monitoring and treatment guidelines for multiple chronic diseases – in order to better support decision making regarding appropriate healthcare for multimorbid patients. Such an approach may also facilitate more patient-focused rather than disease focused healthcare decision making.

This research will not be without its challenges, however. The growing numbers of patients with multimorbidity and the associated complexity have led to calls for new skills in primary care (Fortin et al., 2005). Any interventions, including technological interventions, conducted in primary care must be cognisant of the challenges faced by this demographic. For instance, multiple conditions can lead to overlapping or divergent care plans (Roshanov et al., 2011).

Further investigation is also required into what other information GPs require when dealing with multimorbid patients and how best to provide access to this information, depending on its type, location and how often it is updated. This study found that the majority of GPs consult alternative sources of information when making healthcare decisions in this context. Notably, this research must take into account the concerns raised by GPs over the potential negative impact on doctor-patient interaction that can be created by systems which require too much active participation during consultations.

Finally, concerns were also raised by GPs who participated in this research around the adequacy of training provided on how best to use their practice systems. The lack of training was seen to negatively affect the quality of available information on the systems and therefore, represented a key obstacle to the appropriateness of these systems for supporting healthcare decisions. Clearly, any future enhancements to GP practice systems that support decision making in the case of multimorbidity must be partnered with training programmes for GPs on how best to utilise such systems in order to support their decision making.

In conclusion, this study has emphasised the need for further research within the area of Clinical Decision Support Systems (CDSS) and multimorbidity. In particular, the findings of the study uncover a number of the key issues that must be overcome if future CDSS solutions are to more effectively support patient care in the case of multimorbidity. The study provides both researchers and practitioners with a useful starting point to begin designing and developing such solutions. For example, in developing any new CDSS for multimorbid care, treatment guideline information would need to be provided in an integrated way for all chronic diseases; a balance would need to be struck between the adequacy of information available on the system and information overload (i.e. comprehensiveness and redundancy); disruptiveness of the system on the doctor/patient consultation would need to be considered, etc. Therefore, as an outcome of the findings presented in this paper, it is hoped that future research will design, develop and evaluate new improved CDSS solutions and demonstrate their positive impact on patient care over the existing approaches.

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