CORA Cork Open Research Archive
Cartlann Taighde Oscailte Chorcaí

Title	Computerized decision support systems for multimorbidity care - an urgent call for research and development
Authors	Grace, Audrey;O'Donoghue, John;Mahony, Carolanne;Heffernan, Tony;Molony, David;Carroll, Thomas
Publication date	2016-05
Original Citation	Grace, A., O'Donognue, J., Mahony, C., Heffernan, T., Moloney, D. and Carroll, T. (2016) 'Computerized Decision Support Systems for Multimorbidity Care - An Urgent Call for Research and Development', in: Cruz-Cunha, M. M., Miranda, I. M., Martinho, R. and Rijo, R. (eds)., Encyclopedia of E-Health and Telemedicine, Hershey, Pennsylvania: IGI Global, pp. 486-494. isbn: 9781466699793
Type of publication	Book chapter
Link to publisher's version	https://www.igi-global.com/book/encyclopedia-health-telemedicine/141916 - 10.4018/978-1-4666-9978-6.ch038
Rights	© 2016 by IGI Global. All rights reserved. No part of this publication may be reproduced, stored or distributed in any form or by any means, electronic or mechanical, including photocopying, without written permission from the publisher. Product or company names used in this set are for identification purposes only. Inclusion of the names of the products or companies does not indicate a claim of ownership by IGI Global of the trademark or registered trademark.
Download date	2026-11-14 15:19:30
Item downloaded from	https://hdl.handle.net/10468/6567



University College Cork, Ireland
Coláiste na hOllscoile Corcaigh

Encyclopedia of E-Health and Telemedicine

Maria Manuela Cruz-Cunha
Polytechnic Institute of Cávado and Ave, Portugal & Algoritmi Research Centre, Portugal

Isabel Maria Miranda
Câmara Municipal de Guimarães, Portugal

Ricardo Martinho
Polytechnic Institute of Leiria, Portugal & CINTESIS - Center for Research in Health Technologies and Information Systems, Portugal

Rui Rijo
Polytechnic Institute of Leiria, Portugal & INESCC - Institute for Systems and Computers Engineering at Coimbra, Portugal & CINTESIS - Center for Research in Health Technologies and Information Systems, Portugal

Medical Information Science Reference
An Imprint of IGI Global

Published in the United States of America by
Medical Information Science Reference (an imprint of IGI Global)
701 E. Chocolate Avenue
Hershey PA, USA 17033
Tel: 717-533-8845
Fax: 717-533-8661
E-mail: cust@igi-global.com
Web site: http://www.igi-global.com

Copyright © 2016 by IGI Global. All rights reserved. No part of this publication may be reproduced, stored or distributed in any form or by any means, electronic or mechanical, including photocopying, without written permission from the publisher. Product or company names used in this set are for identification purposes only. Inclusion of the names of the products or companies does not indicate a claim of ownership by IGI Global of the trademark or registered trademark.

Library of Congress Cataloging-in-Publication Data

Names: Cruz-Cunha, Maria Manuela, 1964- editor. | Miranda, Isabel Maria, 1954- editor. | Martinho, Ricardo, 1974- editor. | Rijo, Rui, editor.
Title: Encyclopedia of E-health and telemedicine / Maria Manuela Cruz-Cunha, Isabel Maria Miranda, Ricardo Martinho, and Rui Rijo, editors.
Description: Hershey, PA : Medical Information Science Reference, 2016. | Includes bibliographical references and index.
Identifiers: LCCN 2015051069| ISBN 9781466699786 (hardcover) | ISBN 9781466699793 (ebook)
Subjects: LCSH: Medical care--Technological innovations--Encyclopedias. | Medical informatics--Encyclopedias.
Classification: LCC R858 .E518 2016 | DDC 610.28503--dc23 LC record available at http://lccn.loc.gov/2015051069

British Cataloguing in Publication Data
A Cataloguing in Publication record for this book is available from the British Library.

All work contributed to this book is new, previously-unpublished material. The views expressed in this book are those of the authors, but not necessarily of the publisher.

For electronic access to this publication, please contact: eresources@igi-global.com.

Computerized Decision Support Systems for Multimorbidity Care:
An Urgent Call for Research and Development

Audrey Grace
University College Cork, Ireland

John O'Donoghue
Imperial College, UK

Carolanne Mahony
University College Cork, Ireland

Tony Heffernan
The Cork Road Clinic, Ireland

David Molony
The Red House Family Practice, Ireland

Tommy Carroll
The Medical Centre, Ireland

INTRODUCTION

Multimorbidity is defined as the coexistence of two or more chronic illnesses in an individual (Smith & O'Dowd, 2007). General Practitioners (GPs) and healthcare systems, worldwide, are overwhelmed by the growing number of patients with multimorbidity (Kenning, Fisher, Bee, Bower, & Coventry, 2013; Smith, O'Kelly, & O'Dowd, 2010). Yet, healthcare itself and its associated software systems are primarily configured to support healthcare providers in managing individual diseases rather than multimorbidity (Barnett et al., 2012). Moreover, there have been calls for new interventions to promote the provision of high quality care that meets the needs of people with multimorbidity (cf. Hobbs, Baker, & Davies, 2015; Marengoni et al., 2011; Mason et al., 2014; Mercer, Smith, Wyke, O'Dowd, & Watt, 2009; Muth et al., 2013).

This chapter highlights the potential benefits of one such intervention – that is the deployment of computerized decision support systems (CDSS) which are specifically designed to support multimorbidity care. The chapter begins by reviewing the impact of growing numbers of patients with multiple chronic conditions, particularly in a primary care setting. It then draws on extant literature to consider the benefits of CDSS, particularly those benefits that could be applicable to the multimorbidity context. Subsequently, the chapter emphasizes the urgent need for further research and development in this area if we are to exploit the potential offered by CDSS for multimorbidity care. It proposes the required features of a CDSS for multimorbidity support (in light of the potential benefits identified) and concludes by underlining some of the key challenges that must be overcome in order to increase the likelihood of success in such an endeavor.

DOI: 10.4018/978-1-4666-9978-6.ch038

Copyright © 2016, IGI Global. Copying or distributing in print or electronic forms without written permission of IGI Global is prohibited.

BACKGROUND

Advances in preventative and curative medicine as well as increasing life expectancy in the developed world have contributed to increasing multimorbidity (Smith et al., 2010). For example, an extensive cross-sectional study which extracted data on 40 morbidities from a database of 1,751,841 people registered with 314 medical practices in Scotland found that 42.2% of all patients had one or more morbidities and 23.2% were multimorbid (Barnett et al., 2012). Indeed, healthcare globally is faced with the need to cope with rising costs, aging populations and chronic disease (Kenning et al., 2013; Wills, Sarnikar, El-Gayar, & Deokar, 2010). In a study of 99,997 patients across 182 general practices in England, the majority of consultations were found to involve patients with multimorbidity (Salisbury, Johnson, Purdy, Valderas, & Montgomery, 2011).

Patients with multimorbidity often have frequent healthcare visits and frequent hospital admissions with enormous costs for the individuals and for the healthcare provider involved (C. M. Boyd et al., 2005). The healthcare costs for individuals with at least 3 chronic diseases accounted for 89% of Medicare's annual budget in the US (Anderson & Horvath, 2004). The treatment of chronic illness patients in Europe was estimated to account for 70-80% of health care expenses in countries such as Denmark and comprise 8 of the top 11 causes of hospital admission in the UK (WHO, 2006).

Furthermore, it is widely accepted that the care of these patients is complex (Muth et al., 2013; Smith, Soubhi, Fortin, Hudon, & O'Dowd, 2012) and that this care should incorporate an integrated view of the patients' multiple conditions (Stange, 2005). The majority of clinical practice guidelines and healthcare software systems address single diseases and their evidence is regularly based on studies which excluded patients with other diseases – but these guidelines may have undesirable effects when applied to patients with multimorbidity (C. M. Boyd et al., 2005; Fortin, Bravo, Hudon, Vanasse, & Lapointe, 2005; Murphy, Fahey, & Smith, 2014).

In relation to primary care in particular, GPs regularly encounter patients with multimorbidity, yet many practitioners feel overwhelmed when trying to manage these patients (Smith et al., 2010). In a qualitative study that explores the views and attitudes of Irish GPs and pharmacists who manage patients with multimorbidity in primary care, "GPs described a strategy of treating simpler and more manageable (acute) conditions in preference to opening the Pandora's box of multimorbidity" (Smith et al., 2010).

Furthermore, the model of care for multimorbidity is changing from a disease approach to patient-centered holistic care, with primary care as the key integrator/coordinator of various professions and organizations (Fraccaro, Arguello Casteleiro, Ainsworth, & Buchan, 2015). It is not surprising, therefore, that extant research has found that GPs would welcome decision support when dealing with multimorbid patients (cf. Grace et al., 2013; Schuling, Gebben, Veehof, & Haaijer-Ruskamp, 2012).

CDSS AND THEIR RELEVANCE TO MULTIMORBIDITY

In the clinical context, CDSS have been defined as 'any electronic system designed to aid directly in clinical decision making, in which characteristics of individual patients are used to generate patient specific assessments or recommendations that are then presented to clinicians for consideration (Kawamoto, Houlihan, Balas, & Lobach, 2005).

While CDSS have shown great promise for reducing medical errors and improving patient care (Kawamoto et al., 2005), evidence that clearly demonstrates the positive effects of CDSS on clinical and

economic outcomes remains surprisingly sparse. This may be, in part, because CDSS have sometimes been seen as a challenge to professional decision-making (Fortier, Jagannathan, Michel, Dluhy, & Oneill, 2003). It may also be because of the relative difficulty of implementing randomized controlled trials in real clinical settings as well as the logistics of measuring the direct clinical effect of CDSS (Bright et al., 2012). Another barrier to successful CDSS evaluation is its broad definition adopted by the research community which encompasses a diverse range of interventions and functions (Moja et al., 2014).

Nevertheless, for some time, healthcare organisations have been turning to CDSS to address ongoing healthcare deficiencies and inadequate quality of healthcare, including preventable medical errors and adverse healthcare events (Kawamoto et al., 2005). For example, there is empirical evidence that demonstrates the effectiveness of CDSS for improving health care process measures across diverse settings (cf. Berner, 2007; Bright et al., 2012). Of particular interest to this discussion is the fact that CDSS have been found to play a critical role in primary care and have shown to improve practitioner performance in 64% of studies (Garg et al., 2005).

Moreover, previous studies have found a number of advantages of CDSS which could be applicable to the multimorbidity context. For example, CDSS have been found to have a favorable effect on the quality/safety medication prescribing and to decrease the rate of prescription errors (cf. Bright et al., 2012; Kaushal, Shojania, & Bates, 2003). Multimorbid patients often require multiple drugs to be administered to them simultaneously and they are particularly susceptible to the hazards of polypharmacy (Cynthia M Boyd & Fortin, 2010).

Previous studies have also shown that CDSS help to increase clinician adherence to guideline or protocol based care (Chaudhry et al., 2006; P. S. Roshanov et al., 2013) and reduce clinical decision errors (cf. Cantrill, 2010). Because multimorbidity involves clinical complexity and requires multiple guidelines to be followed simultaneously (cf. Cynthia M Boyd & Fortin, 2010; Schuling et al., 2012), this would be particularly beneficial. However, this would not be a simple case of listing the guidelines for each disease that the patient has and removing overlaps. Integration and prioritization of such guidelines would be necessary and would be extremely challenging (Cynthia M Boyd & Fortin, 2010; Grace et al., 2013). CDSS that systematize clinical practice guidelines without considering the interactions of different conditions and care processes may lead to harmful clinical actions (Fraccaro et al., 2015).

CDSS helps to facilitate communication between providers and patients (cf. Moja et al., 2014). Such systems add value by informing rather than completely automating the decision making process (Farwell, 1984; Hesse & Shneiderman, 2007) and to be successful, they must be partnered with the human element to complete the process (Farwell, 1984). When a physician and a patient are faced with alternative treatments, they may seek help to choose among them (e.g. the estimation of prognosis for cure or risk of complications), but it is them and not the CDSS who must decide among the treatments available (Musen, Middleton, & Greenes, 2014). Indeed, it is particularly notable that recent evidence suggests that CDSS are more likely to be successful if they provide advice for patients in addition to practitioners (P. S. Roshanov et al., 2013).

Doctor/patient communication is important to all patients, but is particularly critical and challenging in the case of multimorbidity. This is because the presence of simultaneous care plans for multiple conditions leads to confusion and, in turn, generates safety hazards (Fraccaro et al., 2015). Clearly communicated plans that are patient centered and that blend clinical care with self-management are essential in multimorbidity (Bayliss, Ellis, & Steiner, 2007; Grace et al., 2013). Indeed, according to Reuben and Tinetti (2012), the patient centered goal oriented approach to making healthcare decisions has several advantages including:

1. It frames the discussion in terms of individually desired rather than universally applied health states;
2. It simplifies decision making for patients with multiple conditions by focusing on outcomes that span conditions and aligning treatments toward common goals;
3. It prompts patients to articulate which health states are important to them and their relative priority; and
4. If they jointly agree what health states are most desired, patients and clinicians can agree on steps that can be taken to achieve these goals and monitor progress in reaching them.

In addition to doctor/patient communication and decision making, CDSS could also facilitate communication and decision making of others involved in the patient's care. Indeed, it has been argued that greatest impact of a software system is its "ability to create linkages, not its ability to process internal data into information" (Warkentin, Bapna, & Sugumaran, 2001, p. 152). The nature of multimorbidity is such that it typically involves a large number of healthcare professionals and this creates a combinatorial explosion of communication interfaces, often resulting in the patient having difficulty in understanding and recalling guidance (Eichner & Blumenthal, 2003). Other common problems arising from the large number of individuals involved in multimorbidity care are duplication of tests and harmful decisions made on the basis of incomplete or incorrect information (Haggerty, 2012; Kuperman, 2011).

FUTURE RESEARCH AND DEVELOPMENT DIRECTIONS

While CDSS for chronic disease management has been extensively studied (cf. P. Roshanov et al., 2011), the study of CDSS designed specifically to support decision making in the case of multimorbidity remains largely unexplored.

For example, Smith *et al.* (2012) carried out a systematic review of extant interventions for enhancing multimorbid care in primary care settings and found that, to date, efforts have been made to improve outcomes in patients with multimorbidity by focusing largely on five key interventions. These include:

1. Professional interventions (e.g. education design);
2. Financial interventions (e.g. financial incentives to providers to reach treatment targets);
3. Organizational interventions (e.g. case management);
4. Patient oriented interventions (e.g. patient education); and
5. Regulatory interventions (e.g. changes to local or national regulations).

A more recent systematic review also clearly shows that the adoption of CDSS in multimorbidity is under investigated (Fraccaro et al., 2015). Given the potential benefits of CDSS within this context (as outlined in the previous section), there is no doubt that this is an avenue now worth pursuing in earnest.

CDSS for Multimorbidity: Required Features

A systematic review of randomized control trials has identified several general features as being of particular importance within any CDSS (Kawamoto et al., 2005). These are:

1. Decision support provided automatically as part of clinician workflow;
2. Decision support delivered at a time and location of decision making;

3. Actionable recommendations provided; and
4. Computer based.

A more recent study of the features of effective CDSS in 162 randomized trials (P. S. Roshanov et al., 2013) found that CDSS are more likely to be successful if they:

1. Are standalone rather integrated into other systems – for example, within electronic health records/charts or within order entry systems;
2. Provide advice for patients in addition to practitioners; and
3. Require practitioner to give explanations for overriding advice.

In light of the earlier discussion in this chapter about the challenges posed by multimorbidity specifically and the relevance of CDSS to at least tackling if not addressing some of these challenges, the following features should also be incorporated in any CDSS for multimorbidity support:

- Tracks patient medications and prompts for regular reviews of these medications (to mitigate against a prescribing cascade where drugs are prescribed to treat the adverse effects of other drugs).
- Prompts for all status information/tests needed for a particular patient (to enable review of all chronic conditions for a patient simultaneously and eliminates duplicate tests).
- Uses an open architecture (to support electronic updates and interoperability with existing electronic health records and other healthcare software systems).
- Produces an integrated healthcare plan that integrates guidelines across multiple conditions and considers interactions between pathologies and treatments (to facilitate a more holistic, patient centered plan that incorporates all of their conditions).
- Allows customization/prioritization of healthcare plan to incorporate patient goals/preferences and to enable targets to be set that have been jointly agreed with the patient (to increase patient concordance by enabling multimorbid patients to play a more active role in setting their own targets).
- Enables healthcare plan to be remotely accessed and updated by patient (to facilitate patient reflection on agreed plan/targets and to support self-management of conditions).
- Provides remote access to allow collaboration with 3rd parties – for example, healthcare specialists and family carers (to facilitate collaboration between all involved in the care of the patient and to support continuity of care).

Key Challenges

In order to increase the chances of successfully developing and deploying a patient-centered multimorbidity CDSS, there are a number of challenges that must be addressed. Not least of these will be the integration of clinical practice guidelines for multiple chronic illnesses. Interactions between diseases in multimorbidity have barely been touched upon to date (Weiss et al., 2014). Interoperability with existing healthcare software systems will also be a key challenge.

Consideration will have to be given to regulatory and legal requirements for any new CDSS for multimorbidity care. Within a European context, these include:

1. Good Automated Manufacturing Practice incorporating both ISO:9001 and IEC62304;
2. Patient rights legislation including 'The Mental Health Act 2001', 'The Health Act 2005', and 'Medical Practitioners Act 2007'.

Given that there is no widely accepted model for computer use in the clinical consultation (cf. de Lusignan & Chan, 2008), another key challenge will be to integrate such a system into the everyday work practices of 'very busy' clinicians. Well thought out mobilization and training plans will be critical to the successful adoption of any CDSS for multimorbidity care.

REFERENCES

Anderson, G., & Horvath, J. (2004). The growing burden of chronic disease in America. *Public Health Reports*, *119*(3), 263–270. doi:10.1016/j.phr.2004.04.005 PMID:15158105

Barnett, K., Mercer, S. W., Norbury, M., Watt, G., Wyke, S., & Guthrie, B. (2012). Epidemiology of multimorbidity and implications for health care, research, and medical education: A cross sectional study. *Lancet*, *380*(9836), 37–43. doi:10.1016/S0140-6736(12)60240-2 PMID:22579043

Bayliss, E. A., Ellis, J. L., & Steiner, J. F. (2007). Barriers to self-management and quality-of-life outcomes in seniors with multimorbidities. *Annals of Family Medicine*, *5*(5), 395–402. doi:10.1370/afm.722 PMID:17893380

Berner, E. S. (2007). *Clinical Decision Support Systems*. Springer. doi:10.1007/978-0-387-38319-4

Boyd, C. M., Darer, J., Boult, C., Fried, L. P., Boult, L., & Wu, A. W. (2005). Clinical practice guidelines and quality of care for older patients with multiple comorbid diseases: Implications for pay for performance. *Journal of the American Medical Association*, *294*(6), 716–724. doi:10.1001/jama.294.6.716 PMID:16091574

Boyd, C. M., & Fortin, M. (2010). Future of multimorbidity research: How should understanding of multimorbidity inform health system design. *Public Health Reviews*, *32*(2), 451–474.

Bright, T. J., Wong, A., Dhurjati, R., Bristow, E., Bastian, L., Coeytaux, R. R., & Musty, M. D. et al. (2012). Effect of Clinical Decision-Support Systems A Systematic Review. *Annals of Internal Medicine*, *157*(1), 29. doi:10.7326/0003-4819-157-1-201207030-00450 PMID:22751758

Cantrill, S. V. (2010). Computers in patient care: The promise and the challenge. *Queue*, *8*(8), 20.

Chaudhry, B., Wang, J., Wu, S., Maglione, M., Mojica, W., Roth, E., & Shekelle, P. G. et al. (2006). Systematic review: Impact of health information technology on quality, efficiency, and costs of medical care. *Annals of Internal Medicine*, *144*(10), 742–752. doi:10.7326/0003-4819-144-10-200605160-00125 PMID:16702590

de Lusignan, S., & Chan, T. (2008). The Develoment of Primary Care Information Technology in the United Kingdom. *The Journal of Ambulatory Care Management*, *31*(3), 201–210. doi:10.1097/01.JAC.0000324664.88131.d2 PMID:18574377

Eichner, J., & Blumenthal, D. (2003). *Medicare in the 21st century: building a better chronic care system.* Available at SSRN 555632

Farwell, D. C. (1984). Dss mechanisms for judgmental flexibility: An exploratory survey. *Journal of Management Information Systems*, *1*(2), 72–79. doi:10.1080/07421222.1984.11517705

Fortier, P., Jagannathan, S., Michel, H., Dluhy, N., & Oneill, E. (2003). *Development of a Hand-held Real-time Decision Support Aid for Critical Care Nursing*. Paper presented at the 36th Annual Hawaii International Conference on System Sciences (HICSS'03). doi:10.1109/HICSS.2003.1174355

Fortin, M., Bravo, G., Hudon, C., Vanasse, A., & Lapointe, L. (2005). Prevalence of multimorbidity among adults seen in family practice. *Annals of Family Medicine*, *3*(3), 223–228. doi:10.1370/afm.272 PMID:15928225

Fraccaro, P., Arguello Casteleiro, M., Ainsworth, J., & Buchan, I. (2015). Adoption of Clinical Decision Support in Multimorbidity: A Systematic Review. *JMIR Medical Informatics*, *3*(1), e4. doi:10.2196/medinform.3503 PMID:25785897

Garg, A. X., Adhikari, N. K. J., McDonald, H., Rosas-Arellano, M. P., Devereaux, P., Beyene, J., & Haynes, R. B. et al. (2005). Effects of computerized clinical decision support systems on practitioner performance and patient outcomes: A systematic review. *Journal of the American Medical Association*, *293*(10), 1223–1238. doi:10.1001/jama.293.10.1223 PMID:15755945

Grace, A., Mahony, C., O'Donoghue, J., Heffernan, T., Molony, D., & Carroll, T. (2013). Evaluating the effectiveness of clinical decision support systems: The case of multimorbidity care. *Journal of Decision Systems*, *22*(2), 97–108. doi:10.1080/12460125.2013.780320

Haggerty, J. L. (2012). Ordering the chaos for patients with multimorbidity. *BMJ (Clinical Research Ed.)*, 345. PMID:22960377

Hesse, B. W., & Shneiderman, B. (2007). eHealth Research from the User's Perspective. *American Journal of Preventive Medicine*, *32*(5Supplement), S97–S103. doi:10.1016/j.amepre.2007.01.019 PMID:17466825

Hobbs, F. R., Baker, M., & Davies, D. S. C. (2015). Morbidity matters: Challenges for research. *The British Journal of General Practice*, *65*(633), e215–e216. doi:10.3399/bjgp15X684301 PMID:25824180

Kaushal, R., Shojania, K. G., & Bates, D. W. (2003). Effects of computerized physician order entry and clinical decision support systems on medication safety: A systematic review. *Archives of Internal Medicine*, *163*(12), 1409–1416. doi:10.1001/archinte.163.12.1409 PMID:12824090

Kawamoto, K., Houlihan, C. A., Balas, E. A., & Lobach, D. F. (2005). Improving clinical practice using clinical decision support systems: A systematic review of trials to identify features critical to success. *BMJ (Clinical Research Ed.)*, *330*(7494), 765. doi:10.1136/bmj.38398.500764.8F PMID:15767266

Kenning, C., Fisher, L., Bee, P., Bower, P., & Coventry, P. (2013). Primary care practitioner and patient understanding of the concepts of multimorbidity and self-management: A qualitative study. *SAGE Open Medicine*, *1*(0), 2050312113510001. doi:10.1177/2050312113510001 PMID:26770690

Kuperman, G. J. (2011). Health-information exchange: Why are we doing it, and what are we doing? *Journal of the American Medical Informatics Association*, *18*(5), 678–682. doi:10.1136/amiajnl-2010-000021 PMID:21676940

Marengoni, A., Angleman, S., Melis, R., Mangialasche, F., Karp, A., Garmen, A., & Fratiglioni, L. et al. (2011). Aging with multimorbidity: A systematic review of the literature. *Ageing Research Reviews*, *10*(4), 430–439. doi:10.1016/j.arr.2011.03.003 PMID:21402176

Mason, B., Nanton, V., Epiphaniou, E., Murray, S. A., Donaldson, A., Shipman, C.,... Munday, D. (2014). 'My body's falling apart.' Understanding the experiences of patients with advanced multimorbidity to improve care: serial interviews with patients and carers. *BMJ Supportive & Palliative Care*.

Mercer, S. W., Smith, S. M., Wyke, S., O'Dowd, T., & Watt, G. C. (2009). Multimorbidity in primary care: Developing the research agenda. *Family Practice*, *26*(2), 79–80. doi:10.1093/fampra/cmp020 PMID:19287000

Moja, L., Kwag, K. H., Lytras, T., Bertizzolo, L., Brandt, L., Pecoraro, V., & Mangia, M. et al. (2014). Effectiveness of computerized decision support systems linked to electronic health records: A systematic review and meta-analysis. *American Journal of Public Health*, *104*(12), e12–e22. doi:10.2105/AJPH.2014.302164 PMID:25322302

Murphy, M. E., Fahey, T., & Smith, S. M. (2014). Computer-based clinical decision support for GP. *Family Practice*.

Musen, M. A., Middleton, B., & Greenes, R. A. (2014). *Clinical decision-support systems. In Biomedical informatics* (pp. 643–674). Springer.

Muth, C., Beyer, M., Fortin, M., Rochon, J., Oswald, F., Valderas, J. M., & Freitag, M. et al. (2013). Multimorbidity's research challenges and priorities from a clinical perspective: The case of'Mr Curran'. *The European Journal of General Practice*, (0): 1–9. PMID:24160250

Reuben, D. B., & Tinetti, M. E. (2012). Goal-Oriented Patient Care — An Alternative Health Outcomes Paradigm. *The New England Journal of Medicine*, *366*(9), 777–779. doi:10.1056/NEJMp1113631 PMID:22375966

Roshanov, P., Misra, S., Gerstein, H. C., Garg, A. X., Sebaldt, R. J., Mackay, J. A., & Haynes, R. B. et al. (2011). Computerized clinical decision support systems for chronic disease management: A decision-maker-researcher partnership systematic review. *Implementation Science; IS*, *6*(1), 92. doi:10.1186/1748-5908-6-92 PMID:21824386

Roshanov, P. S., Fernandes, N., Wilczynski, J. M., Hemens, B. J., You, J. J., Handler, S. M.,... Haynes, R. B. (2013). *Features of effective computerised clinical decision support systems: meta-regression of 162 randomised trials* (Vol. 346). Academic Press.

Salisbury, C., Johnson, L., Purdy, S., Valderas, J. M., & Montgomery, A. A. (2011). Epidemiology and impact of multimorbidity in primary care: A retrospective cohort study. *The British Journal of General Practice*, *61*(582), e12–e21. doi:10.3399/bjgp11X548929 PMID:21401985

Schuling, J., Gebben, H., Veehof, L. J., & Haaijer-Ruskamp, F. (2012). Deprescribing medication in very elderly patients with multimorbidity: The view of Dutch GPs. A qualitative study. *BMC Family Practice*, *13*(1), 56. doi:10.1186/1471-2296-13-56 PMID:22697490

Smith, S., & O'Dowd, T. (2007). Chronic diseases: What happens when they come in multiples? *The British Journal of General Practice*, *57*(537), 268. PMID:17394728

Smith, S., O'Kelly, S., & O'Dowd, T. (2010). GPs' and pharmacists' experiences of managing multimorbidity: A 'Pandora's box'. *The British Journal of General Practice*, *60*(576), e285. doi:10.3399/bjgp10X514756 PMID:20594430

Smith, S., Soubhi, H., Fortin, M., Hudon, C., & O'Dowd, T. (2012). Interventions for improving outcomes in patients with multimorbidity in primary care and community settings. *The Cochrane Library*. PMID:22513941

Stange, K. (2005). Radical Ideas. *Annals of Family Medicine*, *3*(4), 369–371. doi:10.1370/afm.387 PMID:16871650

Warkentin, M., Bapna, R., & Sugumaran, V. (2001). E-knowledge networks for inter-organizational collaborative e-business. *Logistics Information Management*, *14*(1/2), 149–163. doi:10.1108/09576050110363040

Weiss, C. O., Varadhan, R., Puhan, M. A., Vickers, A., Bandeen-Roche, K., Boyd, C. M., & Kent, D. M. (2014). Multimorbidity and evidence generation. *Journal of General Internal Medicine*, *29*(4), 653–660. doi:10.1007/s11606-013-2660-5 PMID:24442333

WHO. (2006). *Tackling Europe's Major Diseases: The Challenges and Solutions*. Copenhagen: World Health Organisation Europe.

Wills, M. J., Sarnikar, S., El-Gayar, O. F., & Deokar, A. V. (2010). Information Systems and Healthcare XXXIV: Clinical Knowledge Management Systems—Literature Review and Research Issues for Information Systems. *Communications of the Association for Information Systems*, *26*(1), 565–598.

KEY TERMS AND DEFINITIONS

Chronic Disease: Long lasting disease that can be managed to some extent, but that cannot be cured.

Clinical Pathways: Also known as care pathways or care maps, these are used to manage the quality in health care concerning the standardization of care processes. They promote organized and efficient patient health care based on evidence based practice.

Clinical Practice Guidelines: Recommendations that are intended to optimize patient care for a particular disease or illness. These are informed by a systematic review of evidence and an assessment of the benefits and harms of alternative care options.

Computerized Decision Support Systems (Clinical Context): Any electronic system designed to aid directly in clinical decision making, in which characteristics of individual patients are used to generate patient specific assessments or recommendations that are then presented to clinicians for consideration.

Electronic Health Record: Digital version of a patient's paper chart.

General Practitioner: A medical practitioner who treats patients of all ages in the general community, as well as providing preventative and health education to these patients.

Multimorbidity: The coexistence of two or more chronic illnesses in an individual.