Beyond multimorbidity: what can we learn from complexity science?

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Abstract

Multimorbidity – the occurrence of two or more long-term conditions in an individual – is a major global concern, placing a huge burden on healthcare systems, physicians, and patients. It challenges the current biomedical paradigm, in particular conventional evidence-based medicine's dominant focus on single-conditions. Patients' heterogeneous range of clinical presentations tend to escape characterization by traditional means of classification, and optimal management cannot be deduced from clinical practice guidelines.

In this article, we argue that person-focused care based in complexity science may be a transformational lens through which to view multimorbidity, to complement the specialism focus on each particular disease. The approach offers an integrated and coherent perspective on the person's living environment, relationships, somatic, emotional and cognitive experiences and physiological function. The underlying principles include non-linearity, tipping points, emergence, importance of initial conditions, contextual factors and co-evolution, and the presence of patterned outcomes.

From a clinical perspective, complexity science has important implications at the theoretical, practice and policy levels. Three essential questions emerge: (1) What matters to patients? (2) How can we integrate, personalise and prioritise care for whole people, given the constraints of their socio-ecological circumstances? (3) What needs to change at the practice and policy levels to deliver what matters to patients?

These questions have no simple answers, but complexity science principles suggest a way to integrate understanding of biological, biographical and contextual factors, to guide an integrated approach to the care of people with multimorbidity.

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Keywords

Multimorbidity, Complexity Science, Health, Person-Centered Care

Introduction

It can be complicated enough to care for patients with a single disease. But most patients presenting to primary care or to hospital are living with multiple chronic conditions – also known as multimorbidity.[1] Such multimorbidity is not well-addressed by current one-disease-at-a-time scientific evidence and clinical practice guidelines.[2]

Complexity science focuses on understanding, as a contextualized whole, the many parts of multifaceted phenomena.[3] Principles from complexity science can be useful in understanding the many interacting processes in multimorbidity, and in integrating care for whole people. Providing this integration is an essential task of the generalist,[4] but is something that all clinicians need to be able to do when managing patients with multimorbidity.

Relevant complexity science principles for understanding and managing multimorbidity include: non-linearity, tipping points, emergence, co-evolution, the importance of contextual factors and initial conditions, and the presence of patterned outcomes.

In this paper we articulate these principles and show how they can be used in both diagnostic and therapeutic processes for patients with multimorbidity. We illustrate the application of these principles to a specific case, in order to explicate how complexity science can make explicit the often tacit processes that astute clinicians use to provide patient-centred care.[5] The composite case vignette of Jennifer's story, based on the clinical experience of the authors, and presented in Box 1,

shows a cascade of inter-related medical and social problems, and their less familiar resolution through the application of complex science principles.

Multimorbidity – a Manifestation of Complex Causality

As human beings (though not always as busy doctors), we can intuitively see the multiple strands in Jennifer's story. We sense that individual biomedical diagnoses might be related in both their causation and potential resolution, and yet, individual diagnoses paint only fragments of the picture. We comprehend how loss and grief in various intertwined ways negatively affect her life. All of this is compounded by socioeconomic deprivation and the social determinants of health, which Dr. Patel clearly understands and which shape her responses to Jennifer's predicament as-a-whole.

This is what complexity is all about — as Alexander von Humboldt at the end of the 18th century stated: natural phenomena can only be 'fully understood' through the frame of a holistic web. In a web "*everything is interconnected*" — a change in one part of the web affects all parts of the web. He saw, as do astute clinicians, that "*In this great chain of causes and effects, no single fact can be considered in isolation*."[6]

Through a complexity science lens, multimorbidity is not the sum of discrete diseases. Rather, it is an *emergent state* arising from the interactions between a multitude of factors in a person's socio-ecological environment and inherited biology.[7-13] Jennifer's health trajectory shows the all-important interconnected, interdependent and dynamically interacting strands of her experience across many scales of aggregation (external environment to internal biological building blocks).[14] A broad, ecological frame enhances understanding of the complexities of her health experiences and her disease manifestations.[4, 9, 13, 15, 16]

Jennifer's health trajectory highlights the well-established associations between social disadvantage and the premature onset of multimorbidity,[17] but more importantly shows the complexities of the lack of strong social support networks,[18] the impact of increasing allostatic load on physiological dysregulation leading to diagnosable and disabling diseases,[19, 20] the association with social and emotional well-being, and the spiralling utilisation of health service and health system resources.[21] Hence one inevitably has to ask: is there a better way to understand multimorbidity than just two or more chronic conditions?[22 23] And how might a complex adaptive understanding help patients, health professionals, and their interactions?

Understanding & Managing Multimorbidity through a Complexity Lens

Box 2 depicts how complexity science principles — knowing the properties of complex systems — can be used to understand and manage multimorbidity. Box 2 also shows how each principle applies to Jennifer's story.

The **non-linearity** of complex systems creates **tipping points** in which small interventions can have large effects (or lack of intervention can lead to rapid deterioration). Being open to these tipping points is an opportunity for novel understanding and harm-reducing, efficient, and effective interventions to improve the lives of people living with multimorbidity.

The property of **emergence** arises from intricate causal relations across different scales and feedback mechanisms. It provides an opportunity for astute clinicians to search for, and to act on, teachable moments that arise because of the complex causality underlying multimorbidity.

Recognizing the **co-evolution** of the many systems affecting people living with multimorbidity provides an opportunity for patients and their clinicians to change together in their shared understanding of the patient's related illnesses and their integrated opportunities for healing.

Understanding that **context and initial conditions are important** in multimorbidity can help clinicians and patients to work together to improve the biology underlying multiple diseases, and the social and environmental factors that influence the experience of illness and health.

The **patterned outcomes** that are a feature of complex systems allows clinicians to identify phenotypes that include but transcend individual disease labels, and to use therapeutic trials and observation of changes over time to help patients improve.

The emergence of multimorbidity is the outcome of ongoing integrated and interconnected processes whose dynamics impact on all parts — the person's living environment, their relationships, their somatic, emotional, social and cognitive experiences, and their internal physiological function. These give rise to a vast and heterogeneous range of clinical presentations, many of which escape characterization by traditional means of clinical classification, and whose management is not captured in clinical practice guidelines.

Whole-person multimorbidity management, rather than being focused on the treatment of multiple disease manifestations, requires a systemic person-in-context perspective. Health professionals using complexity science principles are better able to work effectively with non-medical sectors to address the community-level social and environmental conditions[24] affecting their patients' health. This is the domain of *complexity-based care,* an approach that consciously takes into account the real-life complex-adaptive dynamics of a person's inter-related illnesses and potential healing trajectories.[25, 26] This goes beyond the traditional patient-centered approach focused on making the patient a partner in their care[27] to consider the complex adaptive systems affecting healing and health.

Complexity Principles Help Clinicians to Focus on the Whole Person in Context

Health problems and treatments tend to *interact in ways* that increase the danger of a narrow, conventional biomedical/EBM focus. Compounded by measuring and rewarding clinicians for their *quality* of care, one disease at a time, even primary care clinicians — whose focus is on the whole person, and in whose practices multimorbidity is the norm — can lose sight of the whole and ignore the fact that improving human health requires different approaches than just treating *the sum of diseases*.[15, 28]

Starting with the person in their family and community context, rather than starting with the disease, enables the doctor to focus on what is most important to the patient. Doing that over time, with empathy, develops trusting relationships that allows care to be integrated — such as choosing with the patient a single behavioural or pharmacological intervention that may not be the narrowly-evidence-based treatment for any single condition, but that has beneficial effects for multiple conditions, or that conveys preventive benefits and avoids harmful interactions among therapies — it addresses the *system of the person as-a-whole*.

As made explicit by Jennifer's story, almost all of her deteriorating and subsequently improving disease manifestations are related to important initial conditions and occur in an interdependent fashion. It was the shared understanding of her personal circumstances and perceptions that allowed the formulation of a management plan that comprehensively addressed her multiple — somatic, emotional, social and cognitive — care needs. Her illness trajectory also demonstrates the nonlinear responses of the effects of complexity-centred consultations[26] — targeted small interventions at the right point in time enabled her to implement changes that modulated – as yet not fully understood — physiological pathways which allowed her health to re-emerge.

The Challenge and Promise for Health Professionals

Managing patients with multimorbidity as *whole-people*, while highly beneficial to those patients, simultaneously has significant effects on health professionals — it can challenge their reductionist basic training, individual clinical and interpersonal competence, practice organisation, interdisciplinary working styles, and last but not least, stress and burnout, especially when working with persistent chronic disadvantaged communities.[29]

The co-occurrence and interactions among multiple diseases in the same person create unique challenges, as EBM-guideline based interventions which focus on each individual disease may not be valid since people with multiple conditions are commonly excluded from the RCTs that inform such clinical guidelines.[30] Well-studied single organ diseases behave rather differently in the context of other diseases (e.g. heart disease).[31] Patients, and especially elderly patients, strictly managed to each disease guideline experience more adverse events, can have poorer quality of life and higher overall mortality rates.[32]

Patients with multimorbidity benefit from investment of time.[32] Continuity of care is an important element of the effective and efficient management of this patient group and is associated with better health outcomes and savings of limited health system resources.[32, 33] However operationalising continuity of care within increasingly complex care delivered by multidisciplinary teams remains a challenge.

Practice Infrastructure

Effective and efficient multimorbidity care, besides of person-centred clinical approaches, depends on having a practice-based support team connected to the local practice environment and patient population. This allows every health professional to readily tap into the resources and skill of

colleagues to seamlessly address a patient's *most pressing* issues *at this point in time.*[34] A local practice-based support team ensures adaptive care responses to enhance a person's road to recovery.[34] Information systems are needed that use artificial intelligence to present prioritized information,[35] rather than current electronic medical records that typically support one-disease-at-a-time care.

Social Justice

For Jennifer, a holistic approach by a dedicated doctor she knew and trusted, and who knew only too well how the blight of deprivation affected her patients' lives, was transformational. But Dr Patel, like all doctors who work in deprived areas, knows many 'Jennifers' whose life trajectories and outcomes are not so positive. The problems that patients of low socioeconomic status face reflect the wide inequalities in wealth and power that most countries have, and the social determinants that underpin those inequalities.[36] The impact of deprivation has been recently shown into sharp focus during the COVID-19 pandemic.[36-38] Changing the fundamental causes of health inequalities requires political commitment to social justice and social change. Although this is beyond the control of any single individual, doctors (like Dr Patel) can play an important role through advocacy and 'social medicine'[39] (see Box 3). Whether complexity science can also be helpful in politics and policy making is contested, but in principal it can provide the basis of a collaborative approach based around systems thinking.[40]

Conclusions

The emergence of multimorbidity is a systemic phenomenon that requires systemic approaches at the theoretical, practice and policy levels. Implementing complexity-focused care is facilitated by looking at three key domains: (1) What matters to patients? (2) How can we integrate, personalise

and prioritise care for whole people given the constraints of their socio-ecological circumstances? (3) What needs to change at the practice and policy levels to deliver what matters to patients?

Systemic care delivered in primary care with its focus on the person complements the specialism focus on each individual disease.[28] For people living with multiple chronic conditions, that systemic care can be greatly enhanced by understanding and applying the complexity science principles of non-linearity, tipping points, emergence, co-evolution, the importance of contextual factors and initial conditions, and the presence of patterned outcomes.

References

1. Fortin M, Brovo G, Hudon C, Vannasse A, Lapointe L. Prevalence of multimorbidity among adults seen in family practice. *Ann Fam Med*. 2005;3(3):223-8. doi: http://dx.doi.org/10.1370/afm.272

2. Heath I, Rubinstein A, Stange KC, Driel MLv. Quality in primary health care: a multidimensional approach to complexity. *BMJ*. 2009;338:b1242. doi: http://dx.doi.org/10.1136/bmj.b1242

3. Ackoff RL, Gharajedaghi J. Reflections on Systems and Their Models. *Systems Research*. 1996;13(1):13-23. doi: http://dx.doi.org/10.1002/(SICI)1099-1735(199603)13:1<13::AID-SRES66>3.0.CO;2-O

4. Stange KC. The Generalist Approach. *Ann Fam Med*. 2009;7(3):198-203. doi: http://dx.doi.org/10.1370/afm.1003

5. Sturmberg JP, Martin CM. Knowing - in Medicine. *J Eval Clin Pract*. 2008;14(5):767-70. doi: http://dx.doi.org/10.1111/j.1365-2753.2008.01011.x

6. Doherr D. Alexander von Humboldt's idea of interconnectedness and its relationship to interdisciplinarity and communication. *Journal of Systemics, Cybernetics and Informatics*. 2015;13(6):47-51. doi:

7. Goh K-I, Cusick ME, Valle D, Childs B, Vidal M, Barabási A-L. The human disease network. *Proceedings of the National Academy of Sciences*. 2007;104(21):8685-90. doi: http://dx.doi.org/10.1073/pnas.0701361104

8. Hidalgo CA, Blumm N, Barabási A-L, Christakis NA. A Dynamic Network Approach for the Study of Human Phenotypes. *PLoS Computational Biology*. 2009;5(4):e1000353. doi: http://dx.doi.org/10.1371/journal.pcbi.1000353

9. Goh K-I, Choi I-G. Exploring the human diseasome: the human disease network. *Briefings in Functional Genomics*. 2012;11(6):533-42. doi: http://dx.doi.org/10.1093/bfgp/els032

10. Sturmberg JP. Multimorbidity and chronic disease: an emergent perspective. *J Eval Clin Pract*. 2014;20(4):508-12. doi: http://dx.doi.org/10.1111/jep.12126

11. Lefèvre T, d'Ivernois JF, De Andrade V, Crozet C, Lombrail P, Gagnayre R. What do we mean by multimorbidity? An analysis of the literature on multimorbidity measures, associated factors, and impact on health services organization. *Revue d'Épidémiologie et de Santé Publique*. 2014;62(5):305-14. doi: http://dx.doi.org/10.1016/j.respe.2014.09.002

12. Feldman K, Stiglic G, Dasgupta D, Kricheff M, Obradovic Z, Chawla NV. Insights into Population Health Management Through Disease Diagnoses Networks. *Scientific Reports*. 2016;6:30465. doi: http://dx.doi.org/10.1038/srep30465

13. Sturmberg JP, Picard M, Aron DC, et al. Health and Disease—Emergent States Resulting from Adaptive Social and Biological Network Interactions. *Frontiers in Medicine*. 2019;6:59. doi: http://dx.doi.org/10.3389/fmed.2019.00059

14. Sturmberg JP, Bennett JM, Martin CM, Picard M. 'Multimorbidity' as the manifestation of network disturbances. *J Eval Clin Pract*. 2017;23(1):199-208. doi: http://dx.doi.org/10.1111/jep.12587

15. Sturmberg J, Lanham HJ. Understanding health care delivery as a complex system. *J Eval Clin Pract*. 2014;20(6):1005-9. doi: http://dx.doi.org/10.1111/jep.12142

16. McWhinney IR. The Importance of being Different. William Pickles Lecture 1996. *Br J Gen Pract*. 1996;46(7):433-6. doi:

17. McLean G, Gunn J, Wyke S, et al. The influence of socioeconomic deprivation on multimorbidity at different ages: a cross-sectional study. *Br J Gen Pract*. 2014;64(624):e440-e7. doi: http://dx.doi.org/10.3399/bjgp14X680545

18. Holt-Lunstad J, Smith TB, Layton JB. Social Relationships and Mortality Risk: A Meta-analytic Review. *PLOS Medicine*. 2010;7(7):e1000316. doi: http://dx.doi.org/10.1371/journal.pmed.1000316

19. Friedman E, Shorey C. Inflammation in Multimorbidity and Disability: An Integrative Review. *Health Psychol*. 2019;38(9):791-801. doi: http://dx.doi.org/10.1037/hea0000749

20. McEwen BS. Brain on stress: How the social environment gets under the skin. *Proceedings of the National Academy of Sciences*. 2012;109(Supplement 2):17180-5. doi: http://dx.doi.org/10.1073/pnas.1121254109

21. Barnett K, Mercer SW, Norbury M, Watt G, Wyke S, Guthrie B. Epidemiology of multimorbidity and implications for health care, research, and medical education: a cross-sectional study. *The Lancet*. 2012;380(9836):37-43. doi: http://dx.doi.org/10.1016/s0140-6736(12)60240-2

22. van den Akker M, Buntinx F, Knottnerus JA. Comorbidity or multimorbidity. *European Journal of General Practice*. 1996;2(2):65-70. doi: http://dx.doi.org/10.3109/13814789609162146

23. Institute of Medicine. *Living Well with Chronic Illness: A Call for Public Health Action*. Washington, DC: The National Academies Press; 2012. 350 p.

297 24. Watt G, Brown G, Budd J, et al. General Practitioners at the Deep End: The experience and views
298 of general practitioners working in the most severely deprived areas of Scotland. *Occasional paper*
299 *(Royal College of General Practitioners)*. 2012(89):i-40. doi:
300 http://dx.doi.org/10.3399/bjgp12X652427

301 25. Scott JG, Cohen D, DiCicco-Bloom B, Miller WL, Stange KC, Crabtree BF. Understanding Healing
302 Relationships in Primary Care. *Ann Fam Med*. 2008;6(4):315-22. doi:
303 http://dx.doi.org/10.1370/afm.860

304 26. Scott JG, Warber SL, Dieppe P, Jones D, Stange KC. Healing journey: a qualitative analysis of the
305 healing experiences of Americans suffering from trauma and illness. *BMJ Open*.
306 2017;7(8):e016771. doi: http://dx.doi.org/10.1136/bmjopen-2017-016771

307 27. NEJM Catalyst. What Is Patient-Centered Care? 2020. Available from:
308 https://catalyst.nejm.org/doi/full/10.1056/CAT.17.0559.

309 28. Stange KC, Ferrer RL. The Paradox of Primary Care. *Ann Fam Med*. 2009;7(4):293-9. doi:
310 http://dx.doi.org/10.1370/afm.1023

311 29. Sinnott C, Mc Hugh S, Browne J, Bradley C. GPs' perspectives on the management of patients with
312 multimorbidity: systematic review and synthesis of qualitative research. *BMJ Open*.
313 2013;3(9):e003610. doi: http://dx.doi.org/10.1136/bmjopen-2013-003610

314 30. Fortin M, Dionne J, Pinho G, Gignac J, Almirall J, Lapointe L. Randomized Controlled Trials: Do They
315 Have External Validity for Patients With Multiple Comorbidities? *The Annals of Family Medicine*.
316 2006;4(2):104-8. doi: http://dx.doi.org/10.1370/afm.516

317 31. Forman DE, Maurer MS, Boyd C, et al. Multimorbidity in Older Adults With Cardiovascular Disease.
318 *J Am Coll Cardiol*. 2018;71(19):2149-61. doi: http://dx.doi.org/10.1016/j.jacc.2018.03.022

319 32. Wallace E, Salisbury C, Guthrie B, Lewis C, Fahey T, Smith SM. Managing patients with
320 multimorbidity in primary care. *BMJ : British Medical Journal*. 2015;350:h176. doi:
321 http://dx.doi.org/10.1136/bmj.h176

322 33. Sturmberg JP, Cilliers P. Time and the consultation - an argument for a 'certain slowness'. *J Eval*
323 *Clin Pract*. 2009;15(5):881-5. doi: http://dx.doi.org/10.1111/j.1365-2753.2009.01270.x

324 34. Bayliss EA, Bonds DE, Boyd CM, et al. Understanding the Context of Health for Persons With
325 Multiple Chronic Conditions: Moving From What Is the Matter to What Matters. *The Annals of*
326 *Family Medicine*. 2014;12(3):260-9. doi: http://dx.doi.org/10.1370/afm.1643

35. Manz CR, Parikh RB, Small DS, et al. Effect of Integrating Machine Learning Mortality Estimates With Behavioral Nudges to Clinicians on Serious Illness Conversations Among Patients With Cancer: A Stepped-Wedge Cluster Randomized Clinical Trial. *JAMA Oncology*. 2020:e204759-e. doi: http://dx.doi.org/10.1001/jamaoncol.2020.4759

36. Laurencin CT, McClinton A. The COVID-19 Pandemic: a Call to Action to Identify and Address Racial and Ethnic Disparities. *J Racial Ethn Health Disparities*. 2020;7(3):398-402. doi: http://dx.doi.org/10.1007/s40615-020-00756-0

37. Khunti K, Singh AK, Pareek M, Hanif W. Is ethnicity linked to incidence or outcomes of covid-19? *BMJ*. 2020;369:m1548. doi: http://dx.doi.org/10.1136/bmj.m1548

38. Chung RY, Dong D, Li MM. Socioeconomic gradient in health and the covid-19 outbreak. *BMJ*. 2020;369:m1329. doi: http://dx.doi.org/10.1136/bmj.m1329

39. University of Glasgow. The Scottish Deep End Project [September 3, 2020]. Available from: https://www.gla.ac.uk/researchinstitutes/healthwellbeing/research/generalpractice/deepend/.

40. Cairney P. Complexity Theory in Political Science and Public Policy. *Political Studies Review*. 2012;10(3):346-58. doi: http://dx.doi.org/10.1111/j.1478-9302.2012.00270.x

Box 1 – Case Vignette

Jennifer, a woman in her 50s, became low spirited and isolated after the death of her spouse. She consulted her GP practice frequently, seeing numerous different doctors and nurses that she didn't know well. The consultations were short and rushed and she generally couldn't make sense of their explanations which often included medical jargon. Over the course of the two years since her husband's death, her diagnoses included depression, anxiety, agoraphobia, obesity, hypertension, and type 2 diabetes. She was on repeat prescriptions for six different drugs. Over the following year, she continued to gain weight, and developed low back pain and indigestion, which resulted in additional prescriptions.

Around this time, the practice was conducting an audit of patients on more than 5 repeat prescriptions, and the senior partner, Dr Patel, recognised her name – she and the district nurse had helped provide terminal care for Jennifer's husband. Dr Patel – who was part of an advocacy group of GPs working in very deprived areas who lobbied for better social conditions and services on behalf of their patients – decided to start afresh and booked an extended consultation with Jennifer (which was only possible because the practice was part of a Government-funded pilot study).

Taking a 'what matters to you' rather than 'what is the matter with you' approach, Dr Patel listened empathically to her patients' story and together they began to unpack the sequence of events following her bereavement, something no-one had done before. It became apparent to both of them how unresolved grief, financial problems, and isolation had affected Jennifer's life; sadness and loneliness fuelled depression and comfort eating of cheap junk food; weight gain led to hypertension and diabetes; all contributed to her chronic pain. This was a painful realisation for both – for Jennifer who felt ashamed that things had got so bad, and for Dr Patel who felt ashamed at the lack of continuity and the polypharmacy and likely over-medicalisation that had occurred. What Jennifer appreciated most was that the GP who had cared for her husband had taken the time to listen to her, and seemed also to understand the 'bigger picture' of the struggles of living in a poor area. Jennifer didn't feel judged.

With Jennifer's agreement, Dr Patel referred her to the practice welfare rights officer, who helped her fill in the correct forms to claim benefits she was entitled to. She also referred her to the community links practitioner (as part of social prescribing and community development) who discussed the things Jennifer used to enjoy doing and the local community resources she might contact. Over time, Jennifer plucked up the courage to contact a suggested mental health charity, and over the course of the next 6 months she had made new friends and taken up her old passion for cooking – something she had stopped doing after her husband died. She also took up walking with her new friends, lost weight and gained fitness. Her blood pressure and diabetes improved, and the back pain reduced. Her depression resolved and several of her medications were reduced or stopped by Dr Patel, who continued to see her every 3-6 months. In Jennifer's own words, she got her life back.

347 **Box 2 – Making explicit complexity science principles relevant to caring for multimorbidity**

Complexity Science Principle	Use to understand multimorbidity (Diagnosis)	Use to manage & reduce the impact of multimorbidity (Therapy)
Non-linearity / Tipping points • Results often are not proportional to stimulus • Events – often unforeseen – cross a threshold and 'suddenly' change the structure and/or behaviour into a new direction	• Modelling & stories can be helpful. • Statistics are less helpful than in single disease states. • Learn from non-proportionate results to interventions.	• Look for small interventions that may have a big effect by working across multiple parts of the system. • Reduce polypharmacy • Don't get in the way when patients become unstuck. • Provide hope and tie hope into small changes that patients can observe.
Case application	*Jennifer entered a vortex of unhealthy behaviours, illness and despair after the death of her husband. Lack of being known, and being rushed in consultations, led to over-medicalisation.*	*An extended consultation with Jennifer (not possible in many settings) and taking a 'what matters to you' rather than 'what is the matter with you' approach, lead to a major turn-around.*
Emergence • Occurs when entities form complex behaviours as a collective • Arises from intricate causal relations across different scales & feedback • Cannot be easily predicted or deduced from behaviour of the parts	• Look for underlying complex causality. • Be open to unexpected effects. • Approach understanding and interventions with humility. • Listen to paradoxical observations that patients or family members may bring.	• Watch for and act on teachable moments. • Stay in relationship to allow time for emergence • Explore unexpected change, both positive and negative.
Case application	*Jennifer became low spirited and isolated after the death of her spouse and multiple declines in connection. Unresolved grief, financial problems, and isolation had affected Jennifer's life; sadness and loneliness fuelled depression and comfort eating of cheap junk food; weight gain led to hypertension and diabetes; all contributed to her chronic pain.*	*Jennifer took up walking with her new friends, lost weight and gained fitness. Her blood pressure and diabetes improved, and the back pain disappeared.*
Co-evolution • Each agent is changed • Parallel development of a sub-system with new characteristics and dynamics	• Observe changes in the patient and environment. • Be open to changing your opinion of the patient.	• Assess individual risk factors and treatment as they interact in the whole person. • Be open to trying new approaches as the patient changes. • Look at helping to change the patients social or physical environment.
Case application	*There was a painful realisation for both – for Jennifer who felt ashamed that things had gotten so bad, and for Dr Patil who felt ashamed at the lack of continuity and the polypharmacy and likely over-medicalisation.*	*Her depression waned and many of her medications were reduced or stopped by Dr Patil, who continued to see her every few months.*
Context & initial conditions are important • External conditions impact the behaviour of the system-as-a-whole	• Pay attention to family history. • Consider social & environmental determinants. • Knowing the patient who has the disease is as important as knowing each individual disease.	• Consider family interventions. • Link to social services. • Avoid medicalising social problems such as loneliness and grief. • Work on community and public health changes in addition to working with individual patients.
Case application	*We wonder about her family history of self-effacing approaches to stress, adverse childhood events, and depression. We wonder how early work accommodations to her losses might have helped to avert the downhill spiral.*	*It was very helpful to unpack the sequence of events following her bereavement. What Jennifer appreciated most was that the GP who had cared for her husband had taken the time to listen and seemed also to understand the 'bigger picture' of the struggles of living in a poor area. She didn't feel judged.*
Patterned Outcomes • Emergent processes, dependent on initial conditions, evolve in a limited number of possible ways resulting in recognisable patterns of outcomes	• Look for patterns across clusters of disease labels. • Look for patterns across multiple levels of the person's biological, social and environmental systems. • Look for family/community patterns. • Learn from commonalities & differences across multiple patients over time.	• Consider off-label treatments that could work across the common pathways underlying multiple diseases. • Try therapeutic trials and observe the pattern of results across multiple conditions.
Case application	*Around this time, the practice was conducting an audit of patients on more than 5 repeat prescriptions, and the senior partner, Dr Patel, recognised her name – she and the district nurse had helped provide terminal care for Jennifer's husband.*	*Dr. Patel tried both medical and non-medical interventions and encouraged Jennifer's experimentation with things that previously had brought her joy.*

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Box 3 – Social Medicine

Rudolph Virchow1 the father of social medicine said;

"Medicine is a social science, and politics is nothing else but medicine on a large scale. Medicine, as a social science, as the science of human beings, has the obligation to point out problems and to attempt their theoretical solution: the politician, the practical anthropologist, must find the means for their actual solution... Science for its own sake usually means nothing more than science for the sake of the people who happen to be pursuing it. Knowledge which is unable to support action is not genuine – and how unsure is activity without understanding... If medicine is to fulfill her great task, then she must enter the political and social life... The physicians are the natural attorneys of the poor, and the social problems should largely be solved by them."

Wittern-Sterzel, R (2003). "Politics is nothing else than large scale medicine"--Rudolf Virchow and his role in the development of social medicine". Verhandlungen der Deutschen Gesellschaft Fur Pathologie. 87: 150–157. PMID 16888907