

TECHNOLOGY

HOW NETWORK MEDICINE CAN DRIVE HEALTHCARE SYSTEMS REDESIGN

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Networks in medicine are interpreted differently in different health systems. In American health care, the term might conjure identifiable—and perhaps loathed—insurance networks, which dictate resource utilization for patients and doctors. In the Netherlands, network medicine is viewed as the next evolution of healthcare system redesign, with one of the eight major academic hospital systems declaring this year that their strategic aim is to become an “academic medical network.” But what exactly does this mean?

In short, network medicine is a healthcare system configured like a web of services: different strands in the web can be pulled, offering the appropriate services at the right time by the right types of physicians and healthcare professionals. At the center of this network stands a single patient.¹ Here, we offer a primer on network medicine and describe its actualization in outpatient general medical practice redesign in the Netherlands.

What Is Network Medicine?

In science, *network medicine*, which comes from network-based thinking, originated from objectives to better understand and address the complex relationships between human health, disease, and other factors, such as genetics and social determinants of health.² This includes, for example, biological (e.g., metabolic, regulatory, RNA networks), disease, and pharmacological networks, which are understandably complex.² Network medicine concepts offer an important approach for medical research and in life sciences: by applying mathematics, computational methods, and vast sets of data, new scientific discoveries become possible. However, associated risks and biases of such approaches also can result.

Most relatable for the everyday general internist are disease networks. Clinical complexity is our specialty, after all, and we encounter disease networks daily in the form of multimorbidity; when we prescribe, we consider relevant biological and pharmacological networks, seeking to personalize disease risk or complication risk assessments. We also deliver care in increasingly convoluted and bureaucratic healthcare systems. Finally, general internists are experts in understanding how social determinants of health increase our patients’ vulnerability to illness and poor health. We are also attuned to patients’ well-being and its connections to social issues, like climate change, social justice, immigration, and other sociopolitical and cultural issues. In the Netherlands, this disease complexity may mean building networks of subspecialty care, in which different clinics and hospitals partner to manage or treat different parts of a patient’s care (e.g. regional oncology care).

Healthcare delivery is also influenced by social, technological, information, and other networks. For example, telemedicine and other e-health services create new technological networks that enable patients to remotely connect with their care teams, or for patients to connect with each other. Electronic health records and other devices collect massive amounts of information about patients with virtually limitless possibilities for information exchange. Physicians’ social or professional networks, for those who engage in using social media, enable remote connections with colleagues across the globe.

In essence, the ideas of network medicine facilitate a different way of thinking about systems of health and well-being. They offer explanations for healthcare system complexities by mapping—or creating—connections be-

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tween different parts of various networks, and they open possibilities for new connections, communities, and opportunities.

Network Medicine as a New Model of Care

How does network medicine translate to policy and practice? The Netherlands has a well-developed first-line healthcare system: each individual has access to a general practitioner, and access to hospitals, including general hospitals and academic tertiary care centers, is possible with a general practitioner's referral. Recently, the Dutch Federation of Medical Specialists (FMS) published a vision paper, "The Medical Specialist of 2025," on how network medicine can evolve further, including how the medical specialist's role, including that of a general internist, changes within that network.³

In the FMS vision of network medicine, the aim is to "deliver the right care, by the right healthcare professional, at the right time and at the right price."³ It emphasizes cross-disciplinary, transmural care collaboration, with a strong foundation of accessibility to accurate patient information and appropriate signals to trigger timely care escalation or referrals. Thus, the medical specialist is matched to the clinical need for their expertise (patient's disease stage or complexity) and patient-preferred or most appropriate platform for care (in-person or virtual).

ParkinsonNet in the Netherlands is another example of network medicine implementation. ParkinsonNet was designed to foster education, communication, and collaboration between multiple disciplines engaged in the community-based care of patients with Parkinson's disease.⁴ Since then, the model is evolving further towards a new design, with the key feature involving specialized training of nurse practitioners to offer first-line services to patients in their

homes and communities—the outer spokes of the network—with progression towards a central hub along the inner spokes. Moving towards the inner spokes means engaging more specialized healthcare professionals and care settings, as needed as the patient's chronic condition progresses. This design overlaps with another model, translated literally from Dutch, as substitution.

Substitution refers to the transition of sets of care services from one clinical setting to a different care setting, or tasks are transferred from one health professional to another within the same care setting. The latter is recognizable as the concept of "working at the top of one's license." In addition, specialty training of nurses or nurse practitioners addresses an issue of scarcity of specialty care, which is a key part of the plan for the new Dutch Parkinson's disease network medicine model. Analogous models for the general internist could be a nurse specialized in diabetes care or a pharmacist who offers smoking cessation services. Penalties for short-term hospital readmissions in the United States might incentivize substitution; for example, a patient with diabetic complications might receive similar or quality care for lesser cost through a combination of outpatient specialty care and home services, rather than by an acute care hospitalization. Or, a patient who traditionally might be seen for an urgent issue in-person at their primary care physician's office could alternatively be seen through telemedicine urgent care services, which are widespread in the United States. Substitution clearly has benefits and drawbacks depending on its context in certain clinical situations.

Compared to *integrated care* (e.g., chains of care or care pathways), typically more efficiency-driven and condition-centric, network medicine acknowledges system complexity and aims to overcome the managed

linearity and uniformity of integrated care that in reality often does not exist. Up to two-thirds of Americans over 65 and more than one-third of Dutch people over 55 have two or more chronic conditions, so providing integrated care for each condition for patients with multimorbidity can quickly become unwieldy and complicated.

The nearest American cousin of a network medicine model could be the *patient-centered medical home neighborhood*, in which the primary care physician is the central contact point and coordinator of care for a patient. The "neighbors" include specialists, hospitals, nursing homes, ancillary care providers, and more, with everyone collaborating to provide care centered on the patient.⁵

From Theory to Application

To achieve the FMS's vision of network medicine, health information technologies play a key supportive role, whether they are data collection devices like wearables or patient-reported outcome measurement platforms, communication or social platforms, advanced analytics, smart medical devices, or artificial intelligence. Information systems are opportunities for innovation, and their integration into a network of care is heavily emphasized as an enabler for seamless and uninterrupted care across settings and healthcare professionals (i.e. information networks). Essentially, this is a magnification of the *Five Rights* of clinical decision support systems; offer the right information to the right person in the right format through the right channel at the right time in workflow.

In the end, perhaps the label of the care model matters less than the reality of the systems in which we and our patients live and work. Healthcare delivery is still a humanistic service and healthcare systems can always do better in improving outcomes and reducing unneces-

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sary costs. Network medicine, as conceived and driven in the Dutch context, offers yet one more model of care to consider, and if it delivers on its promises to improve patient outcomes, efficiency and satisfaction of care provision by physicians and healthcare professionals, and without increasing costs, then it is worth a closer look.

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