



OPINION ARTICLE

REVISED Applying a complex adaptive system's understanding of health to primary care [version 2; referees: 2 approved]

Previously titled: Health as a Complex Adaptive System: a new dimension of patient care in internal medicine and general practice

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Abstract

This paper explores the diagnostic and therapeutic potential of a new concept of health. Investigations into the nature of health have led to a new definition that explains health as a complex adaptive system (CAS) and is based on five components (a-e). Humans like all biological creatures must satisfactorily respond to (a) the demands of life. For this purpose they need (b) a biologically given potential (BGP) and (c) a personally acquired potential (PAP). These properties of individuals are embedded within (d) social and (e) environmental determinants of health. Between these five components of health there are 10 complex interactions that justify viewing health as a CAS. In each patient, the current state of health as a CAS evolved from the past, will move forward to a new future, and has to be analyzed and treated as an autonomous whole. A diagnostic procedure is suggested as follows: together with the patient, the five components and 10 complex interactions are assessed. This may help patients to better understand their situations and to recognize possible next steps that may be useful in order to evolve toward better health by themselves. In this process mutual trust in the patient-physician interaction is critical. The described approach offers new possibilities for helping patients improve their health prospects.

Open Peer Review

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version 1 published 12 Jul 2016	 report	 report

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REVISED Amendments from Version 1

The title was changed to better reflect the content of the article and meet the comments of reviewers Dr. Sturmborg and Dr. Delva. The language of the paper was submitted to a native English speaking person and changed accordingly. The "Methods" and "Result" parts were partly rewritten for clarification, the explanation of the Meikirch model and the part on "health as a complex adaptive system" supplemented for more precision. Gender-neutral usage of "patient" and "physician" were applied wherever possible.

Some abbreviations in **Box 1** were eliminated. **Figure 2** was redrawn to eliminate the term "attractor" because the authors felt that it is not essential for the explanation of a general model of a complex adaptive system in the context of this paper.

See referee reports

Introduction

Individuals consult their physicians when they feel something is out of order, e.g. when they experience pain, fatigue or some other disorder. Physicians then examine them and specifically look for pathological changes. After such an investigation they make a provisional diagnosis and explore their patients further or treat them according to what has been discovered. This approach and type of thinking goes back to the pathologist Rudolf Virchow who, in 1858, used 20 lectures to describe "cellular pathology", a characterization of different diseases¹. Although the foundations of medicine have evolved since then, the general principles of medical practice have remained the same. Only over the past 20 years has complexity science gradually entered into medicine^{2,3}. This has become particularly important for the interpretation of health and disease as different states of a complex adaptive system (CAS). The Meikirch model is a new definition of health that exhibits all the features of a CAS⁴. For such systems the concepts based on Virchow's pathology ideas are no longer adequate. An understanding of health and disease now requires appreciation of complexity science which introduces a new dimension for diagnosing and treating patients. It includes the potential of improving health in a way that was hitherto practiced only exceptionally. The purpose of this paper is to summarize the relevant features of the Meikirch model and to spell out in detail how the model and complexity science may be applied for a better understanding of a patient's disease and its treatment.

The Meikirch model: definition of health and disease

The Meikirch model is based on five components (**Box 1**) and 10 complex interactions (**Figure 1**). This framework allows us to define health and disease as a complex adaptive system (**Box 2**). **Figure 1** depicts the five components from *a* to *e*. The interactions are exhibited as double-edged arrows from 1 – 10. A short explanation of the five components and their interactions is presented below. The complete description of the model with its scientific background is given in the previous publications^{4,5}.

Each human being must fulfill the demands of his or her *life situation*⁶. Physiological, psychosocial and environmental demands vary with time and circumstances. *Physiological demands* are related to the homeokinetic balance of nutrients, energy and water

Box 1. Meikirch model: The five interacting components of health^{4,5}

- a. Life's demands
- b. Biologically given potential (BGP)
- c. Personally acquired potential (PAP)
- d. Social determinants
- e. Environmental determinants

necessary for maintaining bodily functions including procreation (examples are work, pregnancy, childbirth and brain function). *Psychosocial demands* are the individual's exposure and response to social conditions needed to succeed in social integration and mental, personal and spiritual development. Expectations and roles related to work, family and society as a whole combine with personal aspirations, values and lifestyle in changing settings and contexts. This also includes peace with the fact that every human being must die. *Environmental demands* include the availability of and immediate or latent threats from living conditions (e.g., water, nutrients, climate, radioactivity, pollutants, carcinogens, workplace conditions).

The potential of an individual to meet the demands of life is partly biological e.g. a gift of nature - *biologically given potential (BGP)*, and partly acquired during life - *personally acquired potential (PAP)*. At birth the BGP is based on the genetic equipment, epigenetic regulation and quality of the pregnancy. The BGP diminishes throughout life and is zero at the time of death. During the lifetime the BGP may be threatened or damaged by socioeconomic disadvantages, diseases, injuries and/or defects. The PAP results from the entirety of physiological, mental, spiritual and social resources acquired during the lifetime. It may continue to grow when a person cares for it. Social and environmental conditions also influence the growth of the PAP by providing or withholding determinants of health.

Social determinants of health strongly interact with the demands of life and the potentials of the individual⁴. Equity and equality, social concerns, working conditions, autonomy and social participation affect health and longevity^{7,8} and are also major determinants. Likewise, *environmental determinants of health* are factors in living and working conditions that affect each person. They may sometimes be of global significance like natural resources, catastrophes, population growth and climate change^{9,10}.

Based on these five components and their interactions with each other the Meikirch model represents a new definition of health and disease as shown in **Box 2**. Possible individual and public health care outcomes as a result of a hypothetical implementation of the Meikirch model have been discussed elsewhere and suggestions for clinical and health systems research have been made⁵.

Health as a Complex Adaptive System (CAS)

A complex adaptive system is an entity with a more or less permeable boundary between it and its nearby environment (**Figure 2**)¹¹. It can take up material and energy from the environment (input),

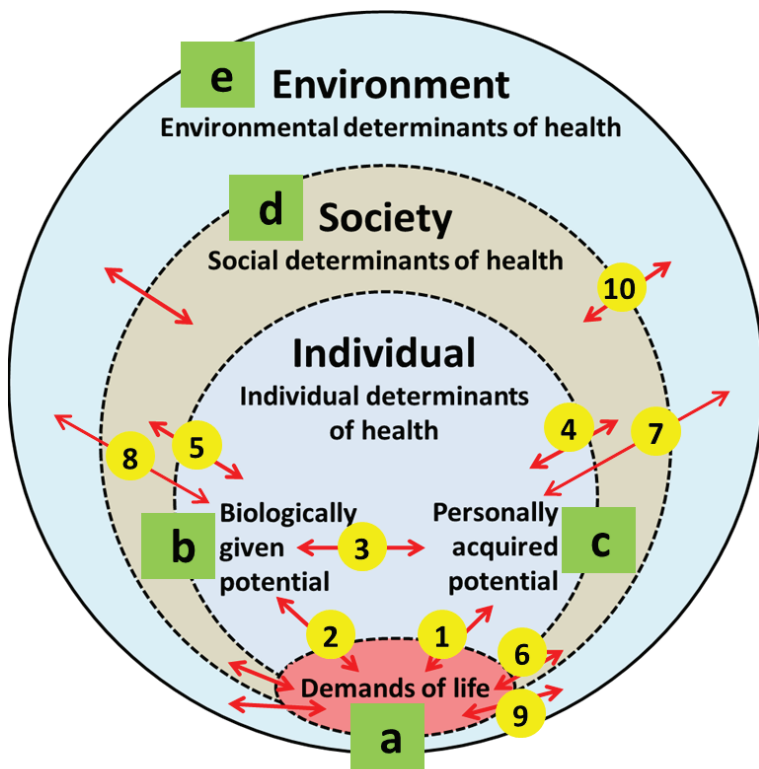


Figure 1. The Meikirch model consists of five components (a–e) and ten complex interactions (1–10).

Box 2. Wording of the Meikirch model i.e. the definition of health and disease^{4,5}

1. Health is a dynamic state of wellbeing emergent from conducive interactions between an individual's potentials, life's demands, and social and environmental determinants.
2. Health results throughout the life course when an individual's potentials and social and environmental determinants suffice to respond satisfactorily to the demands of life. Life's demands can be physiological, psychosocial, and environmental, and vary across individuals and contexts, but in every case unsatisfactory responses lead to disease.

release end products (output, e.g. entropy) and do work. Within the system there are many different parts called agents. In Figure 2 they are symbolized as circles. They continuously and autonomously interact with each other in a nonlinear manner, contributing to the product, the so-called emergence of the CAS. The term emergence indicates a new and often unpredictable quality which is more than the sum of the functions of each part. A CAS always functions as a whole. A CAS is equipped with a learning and bonus arrangement for the interactions among its agents. This gives it the possibility to adapt to changes in the environment, i.e. to learn. If for some reason this adaptation functions poorly, the CAS suffers. If it does not function at all the CAS becomes chaotic, goes into a crisis or vanishes. Repeated minor critical disturbances may lead to the

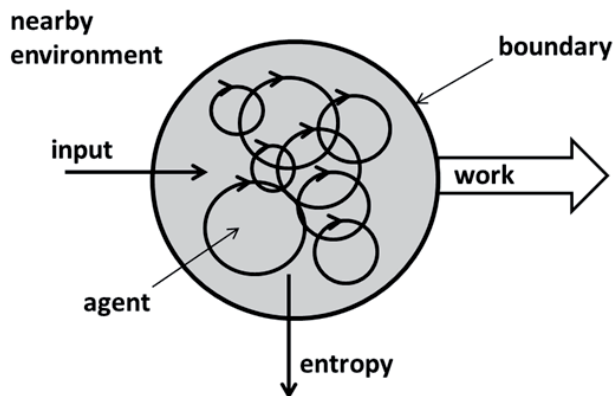


Figure 2. General model of a complex adaptive system (CAS).

so-called butterfly effect². This effect refers to the image of a butterfly that flaps its wings in South America and induces a hurricane in Texas. Examples of medical conditions where a similar mechanism may lead from minor incidents to major consequences are ventricular fibrillation, epileptic seizures, tantrum, and psychotic states. Every CAS has evolved from a prior condition and autonomously progresses toward an unforeseeable future state. A CAS may be part of a larger CAS or be composed of many CASs. Such structures are called nested CASs.

In the Meikirch model the five components (a–e) including their subcomponents are regarded as agents (Figure 1). Interacting with each other they spontaneously arrange themselves in such a way that the evolving emergence, i.e. the state of health, is the result of the functioning of the system as a whole. In each case a specific working-arrangement is in operation, but it is not necessarily the best solution for the system. Energy flow in humans has been called vitality, drive, or sense of purpose. This indicates that energy flow may be material and immaterial, e.g. based on a desire to be loved, on a pursuit of values, or on living for a spiritual purpose. Investigation of the material and immaterial double nature of human energy flow may help toward a better understanding of a person's health.

An entire life is an evolutionary process. Biologically human life originates with the fertilization of an oocyte. This then passes through the stages of embryo and foetus to the maturity needed for birth. At some time during intrauterine life the personality of the individual is created. At least, physicians and midwives say that in a new-born it is clearly recognizable. From then on the complete Meikirch model is fully operational throughout all the life course phases of each person. Thus evolution from birth to death demonstrates clearly how many adaptive processes occur as part of the different complex interactions described by the model. While the two potentials evolve, the demands of life, the social, and the environmental determinants also vary. Within these limiting and supporting contexts individuals follow an autonomously chosen course of life. Under such conditions it is not surprising that some adaptations may not be fully successful for some period of time or permanently. Challenging examples are malnutrition, infectious diseases, love deprivation, sexual maturation, pregnancy, genetic defects, professional stress, the raising of children, physical involution, aging, etc. Such changes may lead the health of an individual as a system into a state of crisis. If it is minor, the two potentials may still manage the demands of life and the difficulties may resolve spontaneously after some time. Such situations may represent illnesses, but are not considered as disease or pathological. They may, though, evolve into a chronic state that draws energy from the person and thereby may explain, for instance, insomnia, chronic fatigue, or somatoform symptoms. If the defect becomes more severe it may lead to a disease that requires more medical attention. In the Meikirch model the term "disease" implies that for some reason one or several adaptation processes are not successful enough to empower the two potentials to satisfy the demands of life.

Methods

To allow for future research, hypothetical consequences of the Meikirch model and of the properties of CASs have been explored with the purpose of better understanding the state of health of patients, particularly in primary care. According to the Meikirch model, health of a healthy individual or of a patient is considered to be a nested CAS, composed of grouped CASs and being embedded in higher CASs. For the analysis of various conditions, the significance of each of the five components and of each interaction within the Meikirch model were visualized. In addition, possibilities of supporting favourable evolutions of the respective CAS and its meaning for the whole person (nested CAS) were analysed. In this

process, the deduction (from observation to theory) and induction (from theory to observation) cycles were repeated until coherent results were achieved.

Results

Categories of illness and disease

Disturbances in health and healing follow a pattern that can be described by four categories:

1. Minor maladaptations lead either immediately or with varying delays to discomfort (illness) or to signs of a disease. Examples for the former are minor acute infections or tension headaches, and for the latter, overweight, type 2 diabetes, or arterial hypertension.
2. A more severe disturbance of the system leads it into a crisis, i.e. it becomes "chaotic". Such states may be corrected spontaneously, for example, or by behavioural changes, or by interacting with a physician or healer, by medications, or by medical or surgical interventions. Thereafter there may not be an immediate complete recovery to health. The full adaptive evolution may take time and further interventions, i.e., convalescence or rehabilitation, may be needed. These phenomena may lead to complete healing or to healing with remaining defects.
3. If a CAS is disturbed continuously for a prolonged time, the CAS may not be able to satisfactorily respond to the demands of life. This represents a chronic disease or invalidity. If the condition is progressive and serious, it may lead to death. Examples are rheumatic or degenerative diseases and different types of neoplasms.
4. Considering a disturbed state of health as a maladapted CAS implies that patients cannot simply be healed by the actions of a competent physician. Healing is much rather the result of a process of self-reorganization, enabling the two potentials to again satisfactorily fulfil the demands of life. The task of physicians and other health professionals therefore consists in being competent advisors and fellow human beings that assist the patient in realizing the necessary evolution himself.

Assessment of a patient's health

It always is appropriate to examine patients with an ordinary medical history and physical examination to which all indicated laboratory tests and imaging procedures are added. Simultaneously it may be purposeful to perform an analysis of the patients' health as a CAS. In this case the five components and the ten complex interactions of the Meikirch model are assessed by an extended history as exemplified in Box 3. This process assures that all possibly important aspects are evaluated. A thorough analysis will give patients a new way to look at their health and how they had conducted their lives. They will discover aspects they did not think about before, and this may be of therapeutic value. At the same time the physician may start to interpret the patients' history and findings in a new way. This may discover further possibilities for helping a patient to autonomously evolve to a new state which hopefully comes closer to health.

Box 3. Assessment of a patient's health by taking a history focussing on all aspects of the Meikirch model

In addition to the five components and the ten complex interactions the energy flow and other patterns of the model also need to be investigated. The questions enumerated are just examples that have to be adapted and complemented further as needed for each patient's specific problems.

Questions related to the components of the model (a–e):

- a) What specifically are the demands of life to which the patient has to respond?
- b) How does the patient perceive the evolution of his or her physical health?
- c) How does the patient feel about him- or herself? Can he or she manage themselves? Does he or she invest in the future?
- d) How is the patient integrated into family, household, friends, society and government?
- e) In which type of natural environment does the patient live?

Questions about the interactions (1–10)

1. How does the physical body of the patient (past and current) interact with the demands of life?
2. How does the patient deal with his or her physical, psychological and spiritual demands of life?
3. How does the patient interact with him- or herself, especially with the body? Does he or she invest in it?
4. How does the patient interact with family, household, friends, and government etc.?
5. How does the physical body of the patient interact with the society (past, present, future)?
6. How does the society influence the demands of life?
7. What is the attitude of the patient toward his natural environment?
8. Which are the past, present and future interactions of the natural environment with the patient's physical body?
9. How does the natural environment modify the patient's demands of life?
10. How does the society interact with his or her natural environment?

Questions about vitality, motivation and purpose in life

- What is the source of the patient's vitality? Is it spontaneous or rather focused on objectives or purposes? Which occasions induce which type of vigour? What is his or her purpose in life?
- How is the patient's physical, intellectual, and emotional vitality? How much is hedonistic and how much eudaimonic?
- What does the patient do with his or her vitality? Is it used mostly in family, profession, or hobbies?
- What is the energy flow between the patient and the physician like?

Questions about temporal patterns

- When did the patient feel completely healthy the last time? When and how did he or she lose health or wellbeing?
- What were the manifestations of the crisis?
- How was the time course of the disease up to now? Which factors induced aggravation and which brought about improvements? Which changes within or outside the patient induced which type of changes?
- What is the explanation of the patient for the current state of health and for the failure to improve it? What does the patient need in order to surmount the present crisis?
- What are the future plans of the patient? How much sense of purpose do they evoke?

Treatment

Obviously, for all medically diagnosed conditions treatments are to be prescribed as indicated. Yet, in medicine, indications generally leave considerable room for judgements. Thus the findings collected by assessing all the components and interactions of the Meikirch model must be considered and integrated as far as possible. A CAS cannot be manipulated to health. It must be assisted as it reorganizes itself autonomously to a new state, in order to better fulfil the demands of life and hence better health and well-being. The role of the physician, therefore, is to accompany the patient during the process he goes through. Some advice, assistance, or therapeutic

intervention may be helpful, but only the patients are in a position to create their new future state for themselves. By analysing their condition as a CAS together with their physician including all components and all interactions of the model they presumably receive many new ideas that they can use to emerge into a healthier state in the future. For example, they may want to make up their mind whether or not they will accept all the conditions that have determined their life in the past. In this respect, a discussion with their physician of alternatives with their consequences may be useful. For many patients it might be constructive to deal with the energy flow in their system, e.g. to speak about the purpose of their lives.

The process of reorientation based on the Meikirch model takes time. During this period it may help the patient if they find in their physician a trustworthy human being with whom they can discuss all sorts of alternatives. Ultimately though, patients have to create their own future. It will encourage them if they feel understood, trusted and accompanied by an experienced person with a sincere interest in their wellbeing.

When is attention to the Meikirch model and the principles of a CAS indicated?

In primary care, such as general internal medicine and general practice, there are many patients who come for consultations because they feel ill. Yet, on examination no clear pathology is found. Thus far such complaints have been explained as functional and often were regarded by physicians as unimportant. Patients then received drugs that may be symptomatically beneficial or placebos or, more often than not, harmful or nocebos. Instead of acting with benign neglect, the Meikirch model offers a true and positive alternative approach. In many cases it will help the patients to understand their problems, to readjust their potentials and to advance their readaptation to the demands of life. Thereby patients may again come closer to a state of health and wellbeing.

Discussion

At the present time the Meikirch model is a hypothesis grounded on a theoretical and conceptual framework. Yet, up till now much of health care has not been concerned with an understanding of the *nature* of health; it used instead an intuitive notion of wellbeing which did not lead to new insights. In contrast, a rational understanding of health - as given by the Meikirch model - offers innovative opportunities. Today this model is better founded on scientific evidence than other definitions of health. Its ultimate validity, however, will be documented only by using and evaluating it in practice. This must be done with due consideration to the special features of the model. Much further research is urgently needed.

For the past 150 years medicine has been working with methods derived from Newtonian natural science and obviously has achieved major advances. They are based, however, predominantly on materialism and neglect the social and spiritual features of human nature. In addition, until recently medicine has not considered systems theory. It appears that these two aspects offer new opportunities for health care to become even more effective. Systems thinking implies that science based on Newton must be complemented by complexity science. Particularly for the purpose of health care a phenomenological, narrative, and evolutionary holism must be added to analytical reductionism¹¹. Poorly functioning parts are not simply corrected by appropriate drugs or surgical operations. Instead considerations of the evolution of the patient's health to its present state, earlier successes in self-management and failures in the handling of his present crises can be evaluated. Here, Antonovsky's sense of coherence and meaningfulness also may be very helpful¹². The necessary changes a patient has to realize must not come top-down from the physician, but rather bottom-up, originating in the patients themselves, e.g., via new insights. For this purpose mutually trusting patient-physician interactions are critical

for a successful future: the physician must believe in the patient's abilities to evolve to a new state and must accompany and support him with loving wisdom in this endeavour.

When speaking with older and experienced general practitioners, and when reading about how they managed their difficult patients, it becomes evident, that they knew their patients from the past quite well. In many difficult situations they often had to accompany rather than to treat them. Such patients remained very loyal because they understood what their doctor had contributed to their health. At the same time physicians realized that they had nothing more to offer than their personal support as a professional human being. The Meikirch model offers now a rational approach to such difficult cases and it is hoped that the five components and the ten complex interactions will lead to new opportunities for patients to move toward better health. At the first glance the described system's approach to patient care is similar to what Michael Balint intended with his groups¹³. He was a psychiatrist and pursued the purpose of "Training General Practitioners in Psychotherapy" to better understand and respond to the needs of their difficult patients. In contrast, the systems theory approach focusses on a new look at a patient's possible unresolved evolutionary steps, analyses the biological given and personally acquired potentials and offers him an opportunity to progress further in his personal biography. More research is needed to validate the promises and limitations of this methodology.

The Meikirch model distinguishes two types of very different potentials with which the demands of life must be met, the biologically given potential (BGP) and the personally acquired potential (PAP). The latter is the resource that continuously pilots the adjustment to new life situations. It is the locus of executive functions¹⁴. For this purpose it interacts with all components of the system. The PAP is the seat of memory, visions, fantasy, reasoning, attentional control and inhibitory control, and problem solving. Its sustained evolution toward more and more wisdom is critical for the maintenance of health. The PAP can learn to compensate in part for losses of the BGP. This leads to an interesting aspect of the relationship between the two potentials. It may be compared to rider and horse. If the rider wants that his horse serves him well he has to take good care of his horse. It appears that the neglect of the PAP in modern medicine is well perceived by patients and they have turned to complementary or alternative medicine. In fact, much of the success of homeopathy and other methods might be explained by the physician/patient interaction with its effects on the complex adaptive system that expresses the patient's health. This mechanism may be relevant also for much of the success of other complementary or alternative treatments. It is our opinion, however, that it will be better to work with the CAS in a planned and scientifically justifiable manner based on the Meikirch model than to apply unproven methods. The model would also serve as an excellent framework for a proper practice of evidence based medicine as defined by David L. Sackett: "Evidence-based medicine (EBM) requires the integration of the best research evidence with our clinical expertise and our patient's unique values and circumstances¹⁵." This applies also to the newly evolving holistic clinical approach "Integrative Medicine and Health" that "reaffirms the importance

of the relationship between practitioner and patient, focuses on the whole person, is informed by evidence, and makes use of all appropriate therapeutic and lifestyle approaches, healthcare professionals and disciplines to achieve optimal health”¹⁶.

When looking at health as a lifelong and complex evolutionary process, it is not surprising that crises do occur frequently. Throughout human life there are several major and many minor evolutionary steps to be taken. End of breastfeeding, beginning of school, puberty, professional formation and advancement, partnership, family, menopause, and involution of old age are some of the more demanding processes. Today they must be overcome in a society that offers insufficient respect for the personality of each individual. Lack of a motivating purpose in life and insufficient social support have become almost normal. Economic exploitation, power plays, isolation, social neglect and even wars weigh heavy on the demands of life. A culture that is really concerned with the

health and wellbeing of its individuals needs to strongly support lifelong human development by investing in life-affirming compassion and truth⁵. The Meikirch model provides a framework for how this could be achieved.

Author contributions

Both authors contributed to drafting the work, were involved in the revision of the draft manuscript and have agreed to the final content.

Competing interests

No competing interests were disclosed.

Grant information

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Dianne Delva

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I would like to thank the authors for their explanations and revisions of the paper: Applying a complex adaptive system's understanding of health to primary care.

It is very clear, provides much food for thought in thinking about health and disease in people as complex adaptive systems. The paper provides a framework for considering the variability in how patients adapt to various conditions. It also centers the responses on the patient and their "Healing is much rather the result of a process of self-reorganization, enabling the two potentials to again satisfactorily fulfil the demands of life." And helps the physician to know that compassion, humanism, creativity and willingness to stand by are legitimate roles.

I have read this submission. I believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard.

Competing Interests: No competing interests were disclosed.

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This is an article describing the confluence of two theories, the model of health as defined by the authors in the Meikirch model which appears to be a model developed and published by the authors, and complex adaptive systems. The authors propose this as a method to better help patients adapt and aim towards improved health.

Strengths:

The authors have developed a theory and are proposing this explicit theory can better support patient

care. Primary care is known for its complexity and uncertainty. Thus the system is a good framework for thinking about a holistic approach to patient care and to the variability of adaptation based on the components. The categories of illness and disease would be helpful for learners to understand that not all illness has a desired resolution. The comments on complex adaptive systems as a way of understanding health in individuals and society is useful in reminding us that linear models often ignore the unintended consequences of change.

Suggestions:

As a family physician, I found the paper both interesting and difficult to follow. In general the language is clear with minor errors. I am not an expert on complex adaptive systems but agree with the comment regarding the use of some terms as detracting from the premise of the article.

My main suggestion would be to expand the methods section. It is not clear to me who was involved in the process, how this was carried out. I wonder if this would be better as a theoretical proposal rather than a scientific study. The examples chosen seem to be the opinions of the authors and have not been tested. Some are quite vague and would require fuller explanation.

I also agree that comparing this theory to others might be useful. McWhinney is referenced and as a leader in Family Medicine in Canada, the four principles of family medicine and a model we use to teach residents for patient-centered care helps us to provide care in family medicine that is not likely to be enhanced by the model. The four principles are:

- The family physician is a skilled clinician.
- Family medicine is a community-based discipline.
- The family physician is a resource to a defined practice population.
- The patient-physician relationship is central to the role of the family physician.

It may be that the authors are specialists and thus are less familiar with general/family practice. The idea that “Physicians then examine them and specifically look for pathological changes.” is not the premise for family medicine in Canada. The four principles address the environment and social determinants of health in situating the patient in the community and family in which they live. The idea of accompanying the patient resides in the value of continuity of care and the patient-physician relationship. Knowing the patient’s values and past helps to tailor the approach to support the patient in the direction they wish to go. The skilled clinician is a critical thinker who can deal with uncertainty and as a resource to the practice population advocates for the system to better serve the population.

In Canada we teach a model of interviewing that includes the traditional history focused on disease interwoven with the IFFE model. These include the patient’s ideas of what is wrong with them, their fears, how their function is affected and their expectations from the physician/system. These questions are essential to the patient-centered approach and situate the consultation clearly with the patient as the CAS.

In particular, I find the suggestions for taking a history based on the model cumbersome and clearly the language would be challenging for patients. It is also not clear to me how these questions are related to the CAS.

The treatment approach mirrors the patient-centered approach taken in family medicine. We know that patients often do not fill prescriptions and asking patients what might work for them or what they are comfortable with, helps one to support a treatment approach that is right for the particular patient. Being aware that a patient does not have the resources to access a particular treatment is essential to a

collaborative effort for care.

Some of the examples either require more explanation or less linear thinking. The idea that *in utero* does not include the environment overlooks the social determinants of health of the mother and their effect on the *in utero* environment.

I have been involved in a number of Balint groups and recall reading Michael Balint's book. The statement "He was psychiatrist and pursued the purpose to train general practitioners in psychotherapy." does not reflect my experience. My understanding was he focused on Difficult Clinician-patient relationships to help general practitioners interact and "accompany" our patients more effectively. The groups were meant to support physicians in their own context. I did not see this as training in psychotherapy.

Minor suggestions

"Examples of medical conditions are ventricular fibrillation, epileptic seizures, tantrum, or psychotic states." This statement needs further explanation. It is not logical from the discussion if we think of health in a holistic manner.

There may be cultural differences in writing and I appreciate English may not be the first language of the authors; however I find it a poor reflection to refer to all patients and physicians as male.

I have read this submission. I believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however I have significant reservations, as outlined above.

Competing Interests: No competing interests were disclosed.

Author Response 19 Sep 2016

Eckhart G. Hahn, Univeristy Hospital Erlangen, Germany

Response to the comments by Dr. Dianne Delva

We as authors appreciate the care Dr. Delva has devoted to our paper. It has helped us significantly to improve the manuscript and make it readable for family physicians. Also, we are happy that she recognizes the overall strengths of our contribution. We understand that she appreciated the value of thinking in terms of health and disease as complex adaptive systems (CAS) to embrace uncertainty and a holistic approach to patient care. In order to respond to her concerns with some aspects of our manuscript we would offer the following point by point response. We will also indicate where we have made changes and corrections of the manuscript.

1. From Dr. Delva's critical comments as a family physician we have come to the conclusion that the original title does not completely reflect the content of the paper and may be misinterpreted. We do not intend to challenge any of the established models as applied to family medicine. We rather intended to explore the possible results of applying the principles of complex adaptive system's thinking in primary patient care, possibly extending the present practice. Therefore, to avoid any misunderstanding, we have changed the title of the paper into "Applying a complex adaptive system's understanding of health to primary care". This was also suggested in the review of Dr. Sturmberg (accessible under <http://f1000research.com/articles/5-1672/v1>).

2. Interestingly, Dr. Delva refers to Dr. I. R. McWhinney, who had developed four principles for family medicine. He certainly is an important person for the principles of family medicine. These principles refer to the physician as a skilled clinician, to family medicine as a community based discipline, to family physicians as resource to a defined population, and view the patient-physician interaction as central. Interestingly these four postulates are also part of the Meikirch model. Also the proposals of the so called Wonca-tree are included in the model. The Meikirch Model is wider than the specific concepts for family medicine and therefore might in the future serve as an extended basis on which the others stand: this is what we suggest to explore.
3. We agree with Dr. Delva that the physician must value the continuity of care and be competent to deal with uncertainty. We, as proposed in the Meikirch model, have a different view how the patient should be supported, derived from the thinking of health and disease as a complex adaptive system. As a CAS, the patient's situation evolves independently and autonomously, often against his or her will. The support in our opinion has the purpose to help the patient to move to his new state that results in a more satisfactory emergence. Often the route to this new state is not the "direction the patient wants to go", but the direction to which the patient has to submit himself. That is why he needs the physicians support.
4. On page 4, an effort has been made to further clarify what a CAS means and what it may contribute to the primary care of patients. In figure 2 the term "attractor" was removed because it is not essential to understand the principle of a CAS.
5. On pages 5 and 6, the method section has been expanded as suggested by Dr. Delva. Both authors have contributed to the development and description of hypothetical consequences of the Meikirch model to stimulate future research. One of the authors (EGH) is trained in and practiced general internal medicine (and gastroenterology) and is familiar with Robert Nikolaus Braun's conceptual frame of family medicine which is prevalent in German speaking countries.
6. In a participatory and integrative approach to the patient, the inclusion of the patient's ideas, fears, functions and expectations (IFFE model) is indeed essential for any primary encounter between patient and physician. It is also part of the Meikirch model, as can be seen in box 3 on page 6. Dr. Delva finds it cumbersome to take a history based on the Meikirch model and states that it is not clear to her how the questions in box 3 are related to the CAS. Obviously this table contains examples, is not exclusive and must be adjusted to the patient's specific problems. The purpose of box 3 is to give the physician a tool to make sure that the history he took covers the whole Meikirch model, i.e. is complete in this sense. The questions suggested in box 3, derived from the Meikirch model with its complex interactions, will also be the basis for describing the patient as a CAS. The Meikirch model is in itself based on complex adaptive systems thinking. Dr. Delva, is right in suggesting to use plain language in real life communication with patients.
7. In order to clarify the issue of the situation in utero we believe that the direct environment of a fetus is the uterus of the mother. The environmental and social determinants of the mother have nonetheless an indirect effect on the child's development in utero as has been pointed out in a previous description of the Meikirch model.
8. Dr. Delva refers to her understanding of Balint groups. We have taken the information given in our paper directly from an original publication by Michael Balint (1896–1970) in the Br Med 1954 (see reference 13). Balint groups may have developed in a direction not intended by Balint himself, and we agree that the term psychotherapy is not well defined and can be

understood in many ways in Balint's original paper. The case reports included in this paper describe complex psychodynamic situations. We have changed our text on page 9 to stay as close to Balint's original paper as possible.

9. The butterfly effect used as a metaphor on page 4 is now described in more detail to assure a better understanding of our mentioning of ventricular fibrillation, epileptic seizures, tantrum or psychotic states. These conditions, because of their dramatic appearance, are exclusively meant as an illustration of the butterfly effect.
10. Wherever the gender-neutral terms "patient" or "physician" were used in our text we have now avoided to use them in a gender-specific context by either omitting "he" or "she" or using the plural, including in the abstract.

Fink, W. & Kamenski, G. *Wien Med Wochenschr* (2009) 159: 173.
doi:10.1007/s10354-009-0666-8

Bircher J, Hahn EG: Understanding the nature of health: New perspectives for medicine and public health.

Improved wellbeing at lower costs [version 1; referees: 2 approved]. *F1000Res*. 2016;5:167. 27134730

10.12688/f1000research.7849.1 4837984. See page 4 „personally aquired potential“.

Competing Interests: No competing interests were disclosed.

Referee Report 25 July 2016

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This paper is an extension of the authors' previous paper in this journal and stimulates long overdue debate. My previous comments ¹ principally also apply to this paper.

Two additional points:

1. The paper's title "Health as a Complex Adaptive System: a new dimension of patient care in internal medicine and general practice" only loosely reflects the content of the paper, I would think that a title similar to "Applying a complex adaptive system's understanding of health to clinical care" would be stronger and more appropriate. Offering clinicians alternative ways of practicing is certainly most welcome.
2. The paper - implicitly - wrestles to come to terms with the notions of health in relation to the "non-health" terms of illness and disease ². Even definable pathology is not objective as many studies have shown significant disagreement between experienced clinicians looking at the same "example of disease". Highlighting the definitional problems and distinctions is especially important for primary care physicians as many people present with unspecific symptoms rather than a "specific diagnosis" ³. Diagnoses are socially constructed ⁴ and have become a "tyranny for

clinicians”⁵. From a complexity perspective thinking about patients’ complaints as “conditions” or “states of being” clearly fosters more creative approaches to patient care and the emergence of more satisfactory outcomes.

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I have read this submission. I believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard.

Competing Interests: No competing interests were disclosed.

Discuss this Article

Version 1

Author Response 19 Jul 2016

Eckhart G. Hahn, Univeristy Hospital Erlangen, Germany

We chose F1000Research for publication of our paper, because with the comment section this journal invites a scientific discourse on the subject. David C Norris MD, however, uses the first paragraph of his comment for a personal attack on the authors. This has nothing to do with a scientific discourse and therefore cannot be answered by scientific arguments.

Johannes Bircher and Eckhart G. Hahn.

Competing Interests: Johannes Bircher and Eckhart G. Hahn are the authors of the article.

Reader Comment 18 Jul 2016

David C. Norris, David Norris Consulting, LLC, USA

This paper is written in such a way no serious reviewer could afford to drop his or her guard against the possibility of a phenomenon like the [Sokal affair](#). That said by way of self-protection, I will proceed on the

assumption that the humanistic impulses evident in this piece reflect a sincere desire to broaden perspectives on human health and to encourage medical care that aims at such a broader vision. I can attest that this is sorely needed in my own country, and [this BMJ essay](#) by Emma Lewis corroborates my suspicion that this applies anywhere Medicine yields to centralized bureaucratic controls.

The authors could make this effort more credible by employing language and concepts drawn from the physical and complexity sciences only inasmuch and insofar as these demonstrably contribute to the clarity and intellectual content of the claims made here. The biggest red flag in this respect is Figure 2, where entropy is shown *flowing across a system boundary from a system to its environment*. Unless the authors are prepared to discuss the notion of *temperature* of a CAS, and to employ an *energy* concept in a critical and uniform fashion, then they might do well to abandon the language of thermodynamics altogether. In their gratuitous usage here, words like 'entropy', 'energy', 'work', 'attractor' seem little more than attempts to arrogate the authority of the well-organized fields of thermodynamics and dynamical systems theory to a decidedly unsystematic accretion of fanciful notions about health.

Methodologically, the authors might proceed to develop their notions into a coherent system of thought by proceeding along one or more of the following lines:

- Attempt a critical evaluation of the Meikirch model as a scientific theory, from which testable predictions can be derived. Surely, there are normative elements in any such theory, but these could be made explicit, and demarcated clearly from whatever scientific content the Meikirch model possesses.
- Present one or more case studies demonstrating the utility of the Meikirch model in the care of an individual patient. Evidence could be offered, as is customary, in the words of the patient. These words could demonstrate perhaps the organic 'emergence' of new understanding within the patient, utilizing whatever conceptual tools remain in the Meikirch model after it is purged of pseudoscientific terminology.
- Undertake a comparative analysis of several distinct approaches to developing broader notions of health and the aims of medical care. Consider serious work in this area by other researchers. Examine how that work demonstrates inadequacies in the Meikirch model, and vice versa as appropriate. If nothing else, such comparative analysis would help to illuminate what the actual content of the Meikirch model is.

I do not think it would reflect well on F1000Research *as a science journal* to accept this article in its present form.

Competing Interests: I declare no competing interests.
