

CPCE Health Conference 2021

**Applications of Systems Thinking in Health and Education:
its Roles and Perspectives for a Sustainable Future in the Time of Pandemics**

Oscar WK Chiu & Ben YF Fong
Division of Science, Engineering and Health Studies, PolyU CPCE

20 September 2021

Major Sections

Introduction:

- Systems thinking approach, methodologies and tools example

Applications of Systems Thinking

- Public health
- Medication adherence



Systems thinking and COVID-19

Systems thinking in education for a sustainable future

Introduction

Systems thinking - definitions

- ❖ A general conceptual framework and orientation for viewing and understanding of the inter-connectedness and inter-relationships between systems or components of systems, as well as their relationships to a functioning whole
- ❖ Being a long-established concept, it is still attracting vast consideration in research and encompassing advanced work in contemporary science
- ❖ Has widespread applications in different disciplines
- ❖ Useful approach to address complexity and to puzzle out the dynamics and interactions between individual systems or elements of systems

De Savigny, D., & Adam, T. (Eds.). (2009). *Systems thinking for health systems strengthening*. World Health Organization.

Trochim, W. M., Cabrera, D. A., Milstein, B., Gallagher, R. S., & Leischow, S. J. (2006). Practical challenges of systems thinking and modeling in public health. *American journal of public health*, 96(3), 538-546.

Introduction

A holistic approach for understanding the interactions of system elements and facilitating a deep analysis of system dynamics, allowing:

- ✓ Identification of root causes and critical selection of focused areas
- ✓ Redesign of systems

Reports highlighting promising applications of systems thinking for understanding of the complexity nature when addressing complex social processes, problems or situations such as:

- ✓ Covid-19
- ✓ Community-level interventions

Hassan, I., Obaid, F., Ahmed, R., Abdelrahman, L., Adam, S., Adam, O., ... & Kashif, T. (2020). A Systems Thinking approach for responding to the COVID-19 pandemic. *Eastern Mediterranean Health Journal*, 26(8), 872-876.

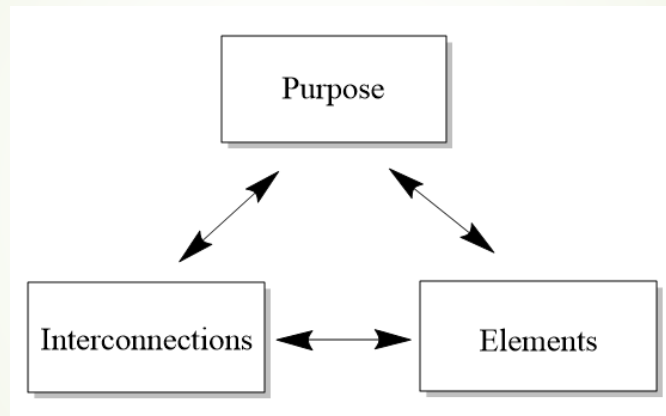
Kusumastuti, Y. S., Eliyana, A., Wahyudin, F. S., Abdurahman, T., & Sari, P. (2020). Leading Business Amidst the Pandemic: The Application of Systems Thinking. *Systematic Reviews in Pharmacy*, 11(11), 1754-1757.

Trickett, E. J., Beehler, S., Deutsch, C., Green, L. W., Hawe, P., McLeroy, K., ... & Trimble, J. E. (2011). Advancing the science of community-level interventions. *American journal of public health*, 101(8), 1410-1419.

Introduction

Systems thinking – system test and tools example

System test

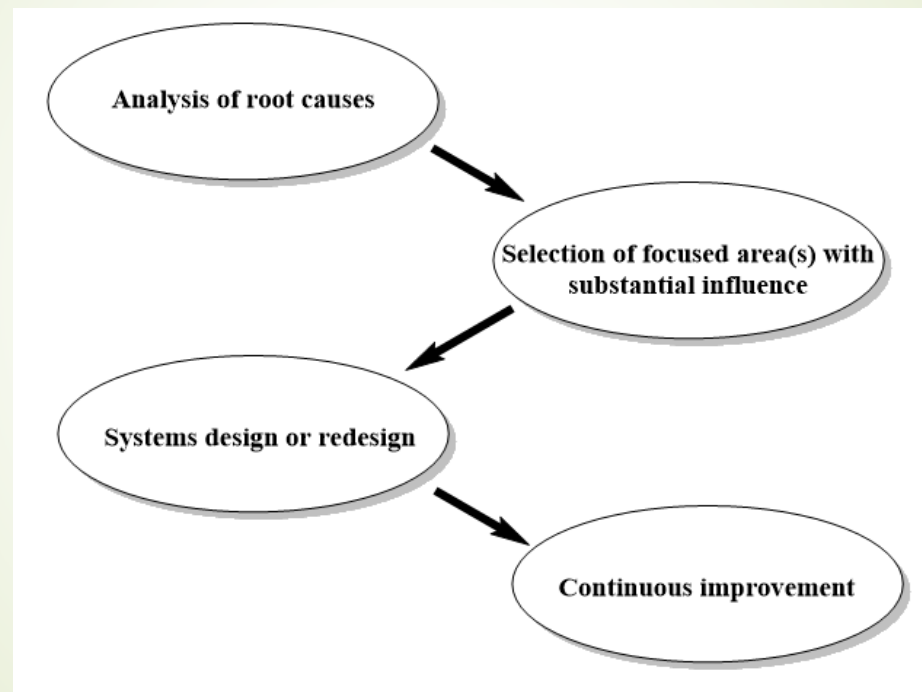


Example of systems thinking tools: **Feedback loop**

Arnold, R. D., & Wade, J. P. (2015). A definition of systems thinking: A systems approach. *Procedia computer science*, 44, 669-678.

Introduction

Important steps in Systems Thinking:



Kusumastuti, Y. S., Eliyana, A., Wahyudin, F. S., Abdurahman, T., & Sari, P. (2020). Leading Business Amidst the Pandemic: The Application of Systems Thinking. *Systematic Reviews in Pharmacy*, 11(11), 1754-1757.

Applications of Systems Thinking

- Multilevel and multisector approaches are required for **efficient and sustainable prevention of complex chronic disease**
- Systems thinking: encompassing a concept of **trans-disciplinarity** and aiming to design, exercise and evaluate interventions when dealing with **public health issues**
- Also sees its promising use in **health promotion**

Hawe, P., Shiell, A., & Riley, T. (2009). Theorising interventions as events in systems. *American journal of community psychology*, 43(3-4), 267-276.

Leischow, S. J., Best, A., Trochim, W. M., Clark, P. I., Gallagher, R. S., Marcus, S. E., & Matthews, E. (2008). Systems thinking to improve the public's health. *American journal of preventive medicine*, 35(2), S196-S203.

Wilson, A., Wutzke, S., & Overs, M. (2014). The Australian Prevention Partnership Centre: systems thinking to prevent lifestyle-related chronic illness. *Public Health Res Pract*, 25(1), e2511401.

Applications of Systems Thinking

Reported examples

Use of systems thinking in the analysis of cervical cancer prevention:

- ✓ A **systems map** was developed to reveal obstacles to successful cervical screening
- ✓ Also used to illustrate the inter-relationships between different components and elements of the cervical screening program
- ✓ Understanding the gaps in cervical screening systems allowed for structuring the most appropriate interventions for improvement

Suba, E. J., Murphy, S. K., Donnelly, A. D., Furia, L. M., Huynh, M. L. D., & Raab, S. S. (2006). Systems analysis of real-world obstacles to successful cervical cancer prevention in developing countries. *American journal of public health*, 96(3), 480-487.

Applications of Systems Thinking

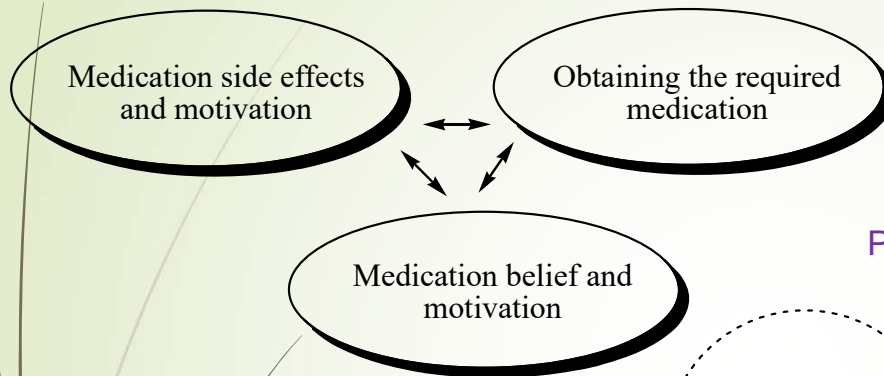
Reported examples

Use of systems thinking for understanding the complexity associated with medication adherence for patients with diabetes mellitus:

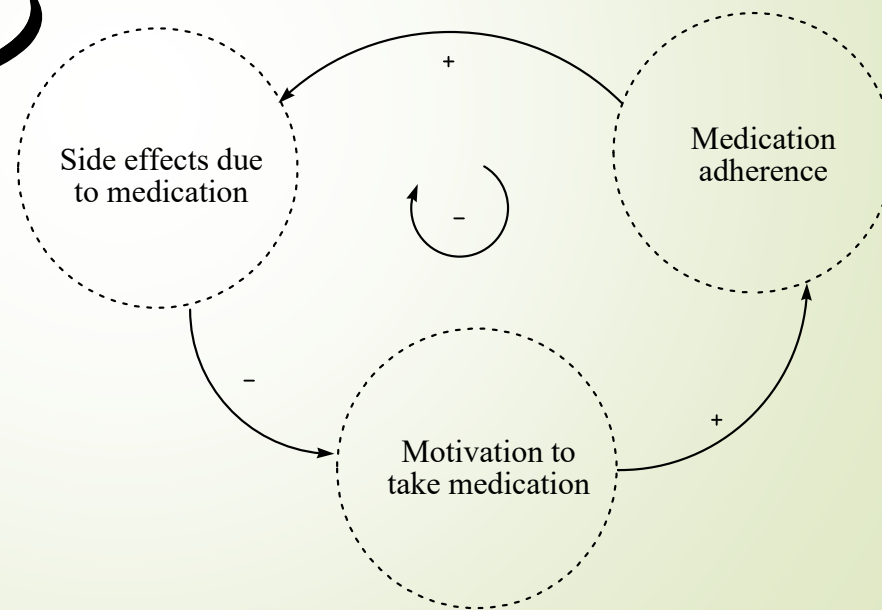
- ✓ Exploring the factors and factor relationships related to medication adherence using casual model
- ✓ 3 sets of **feedback relationship** were included to facilitate development of more effective intervention measures and reduce risks from lack of medication adherence

Ferreira, S., & Castleberry, G. (2019). A Systems Thinking Perspective of Medication Adherence for Patients with Diabetes Mellitus. *Procedia Computer Science*, 153, 218-224.

Applications of Systems Thinking



Part of modified casual diagram:



Ferreira, S., & Castleberry, G. (2019). A Systems Thinking Perspective of Medication Adherence for Patients with Diabetes Mellitus. *Procedia Computer Science*, 153, 218-224.

Systems thinking and Pandemic

Before COVID-19

Systems thinking approach already widely used for public health issues, including health practice, research and policy, before COVID-19:

- Facilitation of a deep understanding of system complexity behind public health issues

Swanson, R. C., Cattaneo, A., Bradley, E., Chunharas, S., Atun, R., Abbas, K. M., ... Best, A. (2012). Rethinking health systems strengthening: Key systems thinking tools and strategies for transformational change. *Health Policy and Planning*, 27(4), iv54–iv61.

Zięba, K. How can systems thinking help us in the COVID-19 crisis?. *Knowledge and Process Management*.

Systems thinking and COVID-19

In the wake of COVID-19

Growing potential of this approach in addressing complicated inter-relations triggered by COVID-19:

- The case of healthcare mask production in Korea
- Report on the use of systems thinking in COVID-19 pandemic for reducing the number of victims caused by the pandemic

Kusumastuti, Y. S., Eliyana, A., Wahyudin, F. S., Abdurahman, T., & Sari, P. (2020). Leading Business Amidst the Pandemic: The Application of Systems Thinking. *Systematic Reviews in Pharmacy*, 11(11), 1754-1757.

Lee, E., Chen, Y.-Y., McDonald, M., & O'Neill, E. (2020). Dynamic response systems of healthcare mask production to COVID-19: A case study of Korea. *Systems*, 8(2), 18.

Systems thinking and COVID-19

In the wake of COVID-19: more examples

Casual loop diagrams were developed:

- ✓ Regarding societal response to the COVID-19 threat, showing the use of the systems thinking approach to bridge public health issues with social relations, perceptions, etc.
- ✓ The use of casual loop diagram to link the different areas of economy, environment, health, and society with the important elements:
 - government activities performed due to the COVID-19 outburst;
 - individual perspective on pandemic

Bradley, D. T., Mansouri, M. A., Kee, F., & Garcia, L. M. T. (2020). A systems approach to preventing and responding to COVID-19. *E Clinical Medicine*, 21, 100325.

Klement, R. (2020a). Systems thinking about SARS-CoV-2. *Frontiers in Public Health*.

Sahin, O., Salim, H., Suprun, E., Richards, R., MacAskill, S., Heilgeist, S., ... Beal, C. D. (2020). Developing a preliminary causal loop diagram for understanding the wicked complexity of the COVID-19 pandemic. *Systems*, 8(2), 20.

Systems thinking and COVID-19

In the wake of COVID-19: more examples

- Views opposing the use of a reductionist approach to solve problems related to COVID-19, a trans-disciplinary approach is preferred rather than an isolated view from scientific disciplines
- Lack of holistic approach may result in taking excessive anti-COVID-19 measures, incurring high financial and costs, as well as resource mis-allocation
- The reductionist approach also arouses concerns of ethical questions regarding basic civil rights or social contact

Ioannidis, J. P. A. (2020). Coronavirus disease 2019: The harms of exaggerated information and non-evidence-based measures. *European Journal of Clinical Investigation*, 50(4), e13222.

Klement, R. (2020b). The SARS-CoV-2 crisis: A crisis of reductionism? *Public Health*, 185, 70–71.

Zięba, K. How can systems thinking help us in the COVID-19 crisis?. *Knowledge and Process Management*.

Systems thinking and COVID-19

In the wake of COVID-19: more examples

A systems thinking framework was proposed to:

- ✓ support decision-making for sample collection (large scale) or distribution operations of vaccine
- ✓ develop pandemic response plans by conducting evaluations of policies and interventions
- ✓ integrate models to have dynamic assessment of evolving situations with public health data leading to optimization of operational decisions for responses

Araz, O. M., Ramirez-Nafarrate, A., Jehn, M., & Wilson, F. A. (2020). The importance of widespread testing for COVID-19 pandemic: systems thinking for drive-through testing sites. *Health Systems*, 9(2), 119-123.

Systems thinking and COVID-19

How systems thinking may help policymaker?

Complexity of societal and public health issues requiring an inter-disciplinary, holistic perspective for the design and implementation of policies

Systematic thinking approach helps policymakers:

- ✓ analyze the situation and view the problem beyond the chain of infection
- ✓ have a better understanding of the adverse effects of COVID-19 and decisions with multiple consequences in society considering the various interconnected factors behind the dynamic systems

Bamakan, S. H. (2021). Role of social responsibility in prevention of the COVID-19 outbreak from systems thinking perspective. *Public health*, 190, e18.

Post-pandemic: Systems thinking and sustainable environment

- ◆ **Prominent need for a sustainable environment for healthy ageing**
- ◆ **Rising concerns of chemical pollutions, importance of educational reform in chemistry incorporating an interdisciplinary approach informed by systems thinking for a sustainable future**

Chiu, W. K., & Fong, B. Y. Green diet and public health. In *The Routledge Handbook of Public Health and the Community* (pp. 325-333). Routledge.

Fong, B. Y., Chiu, W. K., Chan, W. F., & Lam, T. Y. (2021). A Review Study of a Green Diet and Healthy Ageing. *International Journal of Environmental Research and Public Health*, 18(15), 8024.

Matlin, S. A., Mehta, G., Hopf, H., & Krief, A. (2015). The role of chemistry in inventing a sustainable future. *Nature chemistry*, 7(12), 941-943.

Systems thinking and sustainable environment

Advocation of reform in chemical education

Chemistry is a central science:

- ✓ having important links with different scientific disciplines
- ✓ expected to play a pivotal role in addressing challenges outlined in the **United Nations Sustainable Development Goals**.

Advance of chemical technology can lead to serious threats to human health and the environment:

- ✓ Various literatures from scholars and educators have explicitly stated the importance of rethinking education with elements of green and sustainable chemistry for a sustainable future

Anastas, P. T., & Zimmerman, J. B. (2018). The United Nations sustainability goals: How can sustainable chemistry contribute? *Current Opinion in Green and Sustainable Chemistry*, 13, 150-153.

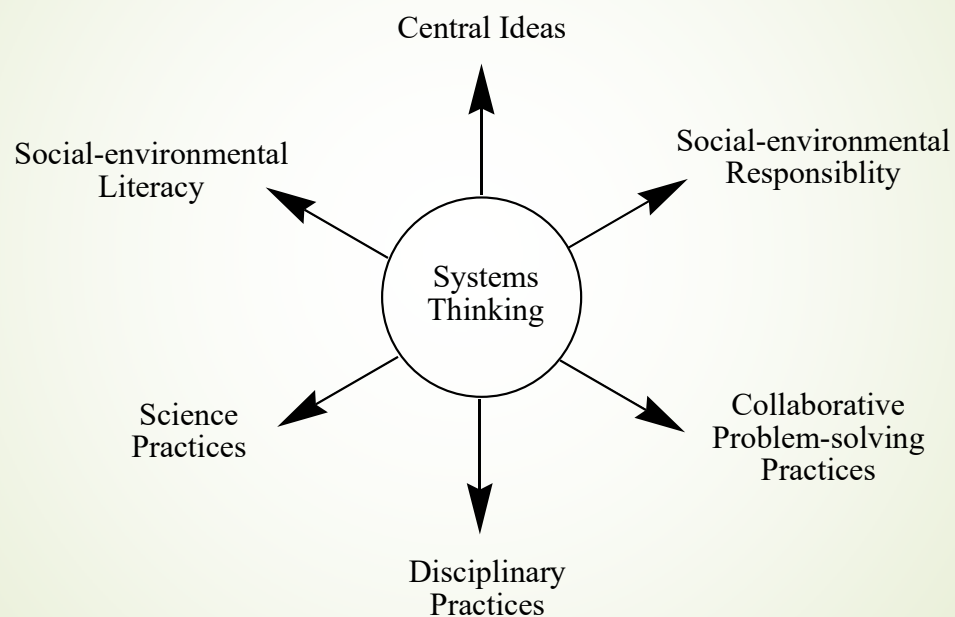
Aubrecht, K. B., Bourgeois, M., Brush, E. J., MacKellar, J., & Wissinger, J. E. (2019). Integrating Green Chemistry in the Curriculum: Building Student Skills in Systems Thinking, Safety, and Sustainability. *Journal of Chemical Education*, 96(12), 2872-2880

Holme, T. A., & Hutchison, J. E. (2018). A central learning outcome for the central science. *Journal of Chemical Education*, 95(4), 499-501.

Systems thinking and sustainable environment

Developing competencies based on systems thinking and integration of chemical themes relevant to major planetary challenges, including chemical speciation, chemical control, etc.

Example: evaluation of strategies for synthesizing green biodegradable polymers considering economic, environmental and social factors



Mahaffy, P. G., Matlin, S. A., Whalen, J. M., & Holme, T. A. (2019). Integrating the molecular basis of sustainability into general chemistry through systems thinking. *Journal of Chemical Education*, 96(12), 2730-2741.

Talanquer, V., Bucat, R., Tasker, R., & Mahaffy, P. G. (2020). Lessons from a Pandemic: Educating for complexity, change, uncertainty, vulnerability, and resilience. *Journal of Chemical Education*, 97(9), 2696-2700.

Challenges of incorporation of systems thinking in education for sustainable future

- Challenges associated with increasing content complexity in chemical context
- Recent report on potential methodology: systems-oriented concept map extension (SOCME) diagrams as visualizing tools to support systems thinking
- Continuing efforts are required in the incorporation of systems thinking in education for a sustainable environment

Mahaffy, P. G., Matlin, S. A., Holme, T. A., & MacKellar, J. (2019). Systems thinking for education about the molecular basis of sustainability. *Nature Sustainability*, 2(5), 362-370.