

Table 1. Systems archetypes with their associated (1) storylines (causal theories), (2) patterns of system behaviour over time and (3) system structures (CLDs) as well as leverage points, along with public health examples (all derived from our scoping review of the public health literature, except for Escalation and Tragedy of the Commons). In the system structures (CLDs), 's' marks a positive causal relationship: factors change in the same direction (if the cause increases, the effect increases), while 'o' marks a negative causal relationship: factors change in the opposite direction (if the cause increases, the effect decreases). 'B' marks a balancing feedback loop (leading to stability), while 'R' marks a reinforcing feedback loop (leading to exponential growth/decay).

Systems archetype	(1) Storyline (causal theory) (Kim and Anderson, 1998)	(2) Pattern of system behaviour over time (Kim and Anderson, 1998) (3) System structure (CLD) (Kim and Anderson, 1998)	Leverage point (Kim and Anderson, 1998)	Public health example
Fixes that Fail	A quick solution to a problem's symptom temporarily eases a problem but creates delayed unintended consequences, ultimately worsening the original problem and prompting repeated use of the same ineffective fix (Kim and Anderson, 1998).		Recognise that quick fixes only treat symptoms and pair them with a deeper, long-term solution to address the root cause (Kim and Anderson, 1998).	Allocating more resources to treating non-communicable diseases reduces their prevalence in the short term, reinforcing continued treatment investment. However, this diverts resources from prevention, which could more effectively reduce long-term prevalence (Sharma et al., 2020).
Shifting the Burden	Reliance on quick fixes reduces the pressure to pursue fundamental solutions, creating a recurring cycle where symptoms return and attention drifts further from the root cause (Kim and Anderson, 1998).		Distinguish between symptomatic and fundamental solutions, which requires examining the problem from multiple perspectives (Kim and Anderson, 1998).	Increased telehealth use improves short-term healthcare access and outcomes in rural Australia, but overreliance may reduce government investment in long-term workforce solutions. This could worsen healthcare inaccessibility, as telehealth cannot address all needs (Osman et al., 2024).
Limits to Success	Initial actions lead to positive results, but the success meets with constraints that eventually slow or reverse progress, where more of the same actions no longer lead to more growth (Kim and Anderson, 1998).		Identify pressures that will come into play with continued success and explore ways to relieve limits before they cause problems (Kim and Anderson, 1998).	Reinforcing feedback loops in integrated health care systems drive growth by expanding patient populations, reducing per-capita costs, lowering premiums and generating income for further capacity and efficiency improvements. Conversely, balancing feedback loops emerge as growth increases wait times, lowers care quality and prompts inefficiencies, such as excessive specialist referrals, which raise costs and can drive patients away (Hirsch and Immediato, 1999).
Drifting Goals	Gaps between desired and actual performance are addressed by gradually lowering targets, causing slow, sometimes unnoticed declines in overall performance (Kim and Anderson, 1998).		Understand what drives goal-setting and anchor goals outside the system, to prevent gradual decline and reinforce real corrective actions (Kim and Anderson, 1998).	Efforts to recruit and retain veteran healthcare providers aim to align the number of providers with staffing goals, but high patient loads per provider lead to burnout and high turnover, especially in rural areas. Redirecting veterans to community care can alter staffing goals, potentially prompting facility downsizing and reducing the pressure to hire

				additional veteran healthcare providers (Kenzie et al., 2022).
Growth and Underinvestment	Failure to invest in capacity as growth nears limits causes declining performance and demand, which reinforces underinvestment and further constrains future growth (Kim and Anderson, 1998).	The figure consists of two parts. The top part is a line graph with five vertical dashed lines labeled A through E. It plots several variables against time: Demand (solid black line), Capacity (dashed grey line), Perceived Need to Invest (dotted grey line), Capacity Investments (dash-dot grey line), and Capacity Reductions (long-dash grey line). Demand peaks around point C and declines thereafter. Capacity increases until point D, where it begins to decrease due to reductions exceeding investments. The bottom part is a causal loop diagram titled "Limits to Success". It shows nodes for Growth Effort, Demand, Capacity, Investment In Capacity, Perceived Need to Invest, Impact of Limiting Factor, and Performance Standard. Key feedback loops include R1 (Growth Effort → Demand) and B2 (Demand → Capacity → Investment In Capacity → Perceived Need to Invest → Demand). Loop B3 involves Capacity, Investment In Capacity, and Perceived Need to Invest.	Examine assumptions behind capacity decisions, looking at both past performance and future demand, and build capacity proactively (Kim and Anderson, 1998).	A company's cycle-to-work initiative initially boosts employee cycling through substantial investments, but as the perceived gap to the goal narrows, investment stalls, slowing adoption and causing some employees to revert to old habits. Over time, lowered expectations and reduced efforts lead to further underperformance (Milton et al., 2024).

Success to the Successful	When multiple parties compete for limited resources, initial success attracts more resources, reinforcing advantage and limiting opportunities for others, even when alternative options might be superior (Kim and Anderson, 1998).	The graph shows 'Resources to A' (solid line) increasing over 'Time' and 'Resources to B' (dashed line) decreasing. 'A's Success' (solid line) increases while 'B's Success' (dashed line) decreases. The flowchart shows a reinforcing loop: 'Success of A' leads to 'Allocation to A Instead of B', which leads to 'Resources to A', which leads to 'Success of A'. A similar loop exists for B, but it is weaker due to the allocation bias.	Analyse why the system favours one winner, strengthen the losing party, promote collaboration over competition and define success at a higher, collective level (Kim and Anderson, 1998).	Historical disparities in street tree distribution create reinforcing feedback loops: wealthier neighbourhoods with more trees (considered beneficial to mental health) gain benefits, advocate effectively for new trees and receive additional resources, while tree-poor neighbourhoods experience fewer benefits, less advocacy and continued low investment. This perpetuates inequities over time and interacts with broader historical patterns of segregation, discrimination and resource disparities (Alvarado et al., 2023).
Escalation	Actions by one party to address perceived threats provoke counteractions from the other, creating a reinforcing cycle that intensifies tension and instability between both sides (Kim and Anderson, 1998).	The graph shows 'A's Activity' (solid line) and 'B's Activity' (dashed line) both increasing in a step-like fashion over 'Time'. The flowchart shows a reinforcing cycle: 'Threat to A' leads to 'Activity by A', which leads to 'A's Result', which leads to 'Quality of A's Position Relative to B's', which leads to 'Threat to B', which leads to 'Activity by B', which leads to 'B's Result', which leads back to 'Threat to A'.	Identify the comparative measure and system delays fueling conflict and perceived threat and examine underlying assumptions driving threat responses (Kim and Anderson, 1998).	The ongoing 'arms race' between the tobacco industry and public health requires constant product (for the tobacco industry) and messaging (for public health) innovation. Unlike earlier campaigns with stable messaging, public health must now continuously adapt to keep pace with evolving tobacco products (McKelvey and Halpern-Felsher, 2019).

Tragedy of the Commons	Individuals exploit shared resources for personal gain without considering collective impact, eventually overloading the system and reducing benefits, or even causing collapse, for everyone (Kim and Anderson, 1998).		Make the eventual collective loss tangible to individuals and align individual incentives with collective long-term outcomes (Kim and Anderson, 1998).	In universal health coverage, funding is fragmented across multiple providers and departments, creating competition for resources. This fragmentation reduces accountability for the system as a whole and whether it makes the best use of finite resources (Wilson et al., 2020).
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Table 2. Review of the application of systems archetypes in public health research.

Description of the study						Purposes of systems archetypes in public health – How systems archetypes could help bridge the gap between system structure and leverage points	Reflecting on the use of systems archetypes in public health – Methodological benefits and considerations of systems archetypes as an analytical tool to help bridge the gap between system structure and leverage points	
Citation	Domain	Research aim	Was the study qualitative or quantitative?	Was the starting point of the study a causal loop diagram/map or a systems archetype?	Which systems archetypes were identified in the study?	What was the purpose of systems archetypes in the study?	Did the study clarify that systems archetypes are hypothesis-generating tools requiring further testing? If so, how?	Did the study engage with the three entry points – (1) storyline (causal theory), (2) pattern of system behaviour over time and (3) system structure (CLD) – for identifying a systems archetype? If so, how?
1. Alvarado (2023)	Public health	"To develop systems thinking-	Qualitative	Causal loop diagram/map	- Fixes that Fail	Change the system – 2. Reason through	"Importantly, these CLDs are not intended to make robust empirical predictions, but	(1) Storyline (causal theory) ✓ Storyline supported with literature

		informed hypotheses around the relationship between street trees and mental health, taking into account unintended consequences and feedback patterns over time"			- Success to the Successful	unintended consequences of <i>future</i> interventions	rather to generate systems thinking-informed hypotheses, which can then be tested empirically and refined or refuted."	✓ Storyline checked with experts (2) Pattern of system behaviour over time ✓ Use of pattern of system behaviour over time mentioned in methods/results – "We asked ourselves the following questions: How would key variables in the CLD change over time? How would these changes over time vary under different starting conditions? We developed qualitative behavior over time graphs (Kim 1994) of key variables to reflect our hypotheses and then interrogated the drivers of these patterns." X Pattern of system behaviour over time not presented as a graph over time X Pattern of system behaviour over time not explicitly cross-checked with empirical data (3) System structure (CLD) X CLD(s) of systems archetype(s) not presented
2. Benninger (2021)	Public health	"To provide an illustration of how system archetypes offer an analytic tool for examining complex community issues" [...] "such as incarceration and poverty, that structure food system inequity in urban communities" and "for generating [...] opportunities for transformation"	Qualitative	Causal loop diagram/map	Fixes that Fail	Understand the system – 1. Understand how the current system functions Change the system – 1. Generate ideas of how to intervene to change how the system functions	"Future simulation modelling research may assess whether these are indeed leverage points to transform behaviour of the system over time [...]."	(1) Storyline (causal theory) ✓ Storyline supported with interview data (2) Pattern of system behaviour over time X Use of pattern of system behaviour over time not mentioned in methods/results X Pattern of system behaviour over time not presented as a graph over time X Pattern of system behaviour over time not explicitly cross-checked with empirical data (3) System structure (CLD) ✓ CLD(s) of systems archetype(s) presented
3. Botwright (2025)	Healthcare policy	To apply "systems thinking to characterise the dynamics underlying the unforeseen impact of the 2022 policy ["changing access to dialysis services for patients with kidney failure"], in order to propose context specific policy interventions"	Qualitative	Causal loop diagram/map	- Drifting Goals - Fixes that Fail - Growth and Underinvestment - Out of Control - Relative Achievement - Relative Control - Shifting the Burden - Success to the Successful - Underachievement	Understand the system – 2. Understand unintended consequences of <i>past/current</i> interventions Change the system – 1. Generate ideas of how to intervene to change how the system functions	"[...] but verifying this hypothesis is important for evaluating the applicability of general solution archetypes. We plan to explore both of these questions further through system dynamic modelling of interventions [...] and through longer-term monitoring of the final policy change."	(1) Storyline (causal theory) ✓ Storyline supported with literature ✓ Storyline supported with interview, focus group and survey data ✓ Storyline checked with experts (2) Pattern of system behaviour over time X Use of pattern of system behaviour over time not mentioned in methods/results X Pattern of system behaviour over time not presented as a graph over time X Pattern of system behaviour over time not explicitly cross-checked with empirical data (3) System structure (CLD) ✓ CLD(s) of systems archetype(s) presented

4.	Clifford Astbury (2025)	Public health	"To identify cases of the 'Fixes that Fail' systems archetype and explore how unrecognised complexity and policy resistance can lead to policy failure in managing wildlife and ecosystems, considering what the impacts may be on the risk of zoonotic spillover events and key food system outcomes"	Qualitative	Causal loop diagram/map	Fixes that Fail	Understand the system – 2. Understand unintended consequences of <i>past/current</i> interventions	"By embedding these 'Fixes that Fail' within the spillover subsystem and wider system elements, we developed causal theory in the shape of CLDs around the impact of these policy failures on the risk of zoonotic spillover events and food system outcomes."	(1) Storyline (causal theory) ✓ Storyline supported with literature ✓ Storyline supported with interview data (2) Pattern of system behaviour over time X Use of pattern of system behaviour over time not mentioned in methods/results X Pattern of system behaviour over time not presented as a graph over time X Pattern of system behaviour over time not explicitly cross-checked with empirical data (3) System structure (CLD) ✓ CLD(s) of systems archetype(s) presented
5.	Das (2024)	Occupational health	"To examin[e] [...] and develop [...] a systemic archetype grounded in the dynamic interplay and causal connections between different factors related to worker behaviour in road construction projects, with the aim of understanding how worker behaviour influences accidents at worksites and identifying potential avenues for accident reduction through planned behaviour"	Qualitative	Causal loop diagram/map	New systems archetype proposed	Understand the system – 1. Understand how the current system functions Change the system – 1. Generate ideas of how to intervene to change how the system functions	"This research extends its scope to postulate dynamic theories and leverage points for action."	(1) Storyline (causal theory) ✓ Storyline supported with literature ✓ Storyline supported with survey data ✓ Storyline checked with experts (2) Pattern of system behaviour over time X Use of pattern of system behaviour over time not mentioned in methods/results X Pattern of system behaviour over time not presented as a graph over time X Pattern of system behaviour over time not explicitly cross-checked with empirical data (3) System structure (CLD) ✓ CLD(s) of systems archetype(s) presented
6.	Davis (2018)	Public health	"To utilise concepts from systems science to understand the development, evolution and sustainability of [...] [a community-based participatory research] partnership"	Qualitative	Causal loop diagram/map	No systems archetypes identified	Understand the system – 1. Understand how the current system functions Change the system – 1. Generate ideas of how to intervene to change how the system functions	No systems archetypes identified	No systems archetypes identified
7.	Duryan (2012)	Healthcare policy	"To explore the application of SD	Qualitative	Causal loop diagram/map	Shifting the Burden	Understand the system – 2.	"To understand system behavior over time, it is necessary to visualize the dynamics of	(1) Storyline (causal theory) ✓ Storyline supported with interview data

		[system dynamics] modelling when analysing decision-making processes within an ID [intellectual disabilities] provider organisation, with the intent of optimising allocation of existing resources so as to improve efficiency and effectiveness of resource utilisation"				Understand unintended consequences of past interventions Change the system – 1. Generate ideas of how to intervene to change how the system functions	system behavior using real data. Available data can be used to quantify the model and observe real world systems via computer simulation. The simulated system model can be validated by initializing it at past points in time and comparing the results it produces with historical data."	✓ Storyline checked with experts (2) Pattern of system behaviour over time X Use of pattern of system behaviour over time not mentioned in methods/results X Pattern of system behaviour over time not presented as a graph over time X Pattern of system behaviour over time not explicitly cross-checked with empirical data (3) System structure (CLD) ✓ CLD(s) of systems archetype(s) presented
8. Gillies (2008)	Healthcare policy	To use system archetypes "within an Australian hospital to promote organisational learning": to "recognise patterns of behaviour that are already present in [...] organisations" and to facilitate "strategic analysis" and "policy modification"	Quantitative	Causal loop diagram/map	- Drifting Goals - Eroding Goals - Growth and Underinvestment - Limits to Growth - Reinforcing Escalation	Understand the system – 2. Understand unintended consequences of <i>past/current</i> interventions Change the system – 2. Reason through unintended consequences of <i>future</i> interventions	"The development of the archetype dynamic hypothesis in Figure 2 focused on these systemic root causes and issues and leveraging the benefits of strategic policy changes."	(1) Storyline (causal theory) ✓ Storyline supported with focus group data ✓ Storyline checked with experts ✓ Systems archetype(s) translated into simulation model(s) (2) Pattern of system behaviour over time ✓ Use of pattern of system behaviour over time mentioned in methods/results – "A complex simulation model based on this analysis was constructed and validated against two years of historical case mix patient episodic data. A description of selected archetypes identified together with the simulation graphs from the model is provided below." ✓ Pattern of system behaviour over time presented as a graph over time – "The archetypal behaviours over time are tested and validated in the simulation model and shown in Figures 6 and 7." ✓ Pattern of system behaviour over time explicitly cross-checked with empirical data – "Archetype model reference behaviour - The descriptors of hospital performance are defined as the following quantitative and qualitative measures and are used as the simulation model metrics for output assessments: [...]." (3) System structure (CLD) ✓ CLD(s) of systems archetype(s) presented
9. Guo (2015)	Occupational health	"To better understand dynamic complexity of construction safety management by	Qualitative	Systems archetype	- Fixes that Fail - Shifting the Burden - Limits to Growth	Understand the system – 1. Understand how the current system functions	"Considering that the archetype development is a general theory building process [...]."	(1) Storyline (causal theory) ✓ Storyline supported with literature ✓ Storyline supported with interview data (2) Pattern of system behaviour over time

		exploring archetypes of construction safety" and "provide systemic insights into dealing with the complexity"				Change the system – 1. Generate ideas of how to intervene to change how the system functions		✓ Use of pattern of system behaviour over time mentioned in methods/results – "The purpose was to identify behaviour patterns under each safety theme and to explore the underlying structure that can explain the patterns." ✓ Pattern of system behaviour over time presented as a graph over time – "Behaviour over time - Fig. 5 shows a typical behaviour pattern of the archetype of 'safety regulations'." ✓ Pattern of system behaviour over time explicitly cross-checked with empirical data – "A process of constant comparison was used, which helped the researchers to see if the [interview] data support the behaviour patterns." (3) System structure (CLD) ✓ CLD(s) of systems archetype(s) presented
10. Hirsch (1999)	Healthcare policy	"To present [...] the advantages of microworld learning environments to [...] ["illuminate strategic choices and their consequences"] and describe [...] two system dynamics-based microworld learning environments and their use by healthcare providers as they navigate through complexity and uncertainty", using systems archetypes "as a device to capture what is learned [...] and to help microworld users apply what is learned to similar situations in their own organisations"	Quantitative	Systems archetype	- Accidental Adversaries - Balancing Two Boats - Limits to Success - Shifting the Burden	Change the system – 2. Reason through unintended consequences of <i>future</i> interventions	"When users have an immediate situation where they can test the insights derived in the simulated environment [...]"	(1) Storyline (causal theory) ✓ Storyline supported with group model building data ✓ Storyline checked with experts ✓ Systems archetype(s) translated into simulation model(s) (2) Pattern of system behaviour over time ✓ Use of pattern of system behaviour over time mentioned in methods/results – See publication Hirsch and Kemeny (1994a) referred to in paper: "A summary of the model embedded in this learning environment is presented in Figure 1. The model is described in more detail by Hirsch and Kemeny (1994a)." ✓ Pattern of system behaviour over time presented as a graph over time – "Simulations in which users play different roles, making their own decisions but affecting each other, can bring this archetype to life. For example, results of a simulation (ADVERSARIES), shown in Figure 4, show what might happen when [...]" ✓ Pattern of system behaviour over time explicitly cross-checked with empirical data – See publication Hirsch and Kemeny (1994a) referred to in paper: "A summary of the model embedded in this learning environment is presented in Figure 1. The model is described in more detail by Hirsch and Kemeny (1994a)." (3) System structure (CLD) ✓ CLD(s) of systems archetype(s) presented

11. Jenko (2016)	Healthcare policy	To use "a systems thinking approach to develop and implement a downloadable bereavement booklet for families"	Qualitative	Systems archetype	- Fixes that Fail - Limits to Growth	Understand the system – 2. Understand unintended consequences of <i>past/current</i> interventions Change the system – 1. Generate ideas of how to intervene to change how the system functions	The insights derived from the systems archetypes are experimented with in the development and implementation of a downloadable bereavement booklet for families in a community medical centre with 800+ beds.	(1) Storyline (causal theory) ✓ Storyline supported with experiential knowledge ✓ Storyline checked with experts (2) Pattern of system behaviour over time X Use of pattern of system behaviour over time not mentioned in methods/results X Pattern of system behaviour over time not presented as a graph over time X Pattern of system behaviour over time not explicitly cross-checked with empirical data (3) System structure (CLD) ✓ CLD(s) of systems archetype(s) presented
12. Kenzie (2022)	Healthcare policy	"To identify interrelationships between variables underlying challenges to veteran access to primary care and potential opportunities for change - known as leverage points in systems science" and "to synthesise stakeholder perspectives about complex dynamics underlying rural veteran access to primary care in Oregon, Washington, and Idaho"	Qualitative	Causal loop diagram/map	Drifting Goals	Understand the system – 1. Understand how the current system functions	The insights derived from the systems archetypes are experimented with: "The findings of this study are currently being used to inform development of a multilevel intervention to improve rural veteran access to care in a pilot study [...]."	(1) Storyline (causal theory) ✓ Storyline supported with interview data ✓ Storyline checked with experts (2) Pattern of system behaviour over time X Use of pattern of system behaviour over time not mentioned in methods/results X Pattern of system behaviour over time not presented as a graph over time X Pattern of system behaviour over time not explicitly cross-checked with empirical data (3) System structure (CLD) ✓ CLD(s) of systems archetype(s) presented
13. Koh (2023)	Healthcare policy	"To engage stakeholders in uncovering the factors that facilitate or inhibit implementing community-based fall prevention programs in Singapore, with a focus on the interrelationships between those factors"	Qualitative	Causal loop diagram/map	- Fixes that Fail - Limits to Growth	Change the system – 2. Reason through unintended consequences of <i>future</i> interventions	"Furthermore, to generate more insights to support the development of a national fall prevention strategy, future work would involve developing a credible quantitative model for simulation."	(1) Storyline (causal theory) ✓ Storyline supported with group model building data (2) Pattern of system behaviour over time X Use of pattern of system behaviour over time not mentioned in methods/results X Pattern of system behaviour over time not presented as a graph over time X Pattern of system behaviour over time not explicitly cross-checked with empirical data (3) System structure (CLD) ✓ CLD(s) of systems archetype(s) presented
14. Kontogiannis (2021)	Healthcare policy	To "explore [...] how the principles of resilience can be translated into leverage points to	Qualitative	Systems archetype	- Escalation - Fixes that Fail - Limits to Growth	Change the system – 1. Generate ideas of how to intervene to change how the system functions	"In this article, resilience has been modelled as leverage points that could overcome some constraining effects of archetypes in terms of anticipation, responding, monitoring and adaptation or learning."	(1) Storyline (causal theory) ✓ Storyline supported with literature (2) Pattern of system behaviour over time

		break the system archetypes or create new positive archetypes that help control the epidemic problem"			- Tragedy of the Commons - Shifting the Burden			X Use of pattern of system behaviour over time not mentioned in methods/results X Pattern of system behaviour over time not presented as a graph over time X Pattern of system behaviour over time not explicitly cross-checked with empirical data (3) System structure (CLD) ✓ CLD(s) of systems archetype(s) presented
15. McAvoy (2025)	Healthcare policy	"To visualise the review patient dynamics with the goal of seeding a policy shift away from local "firefighting" fixes towards more sustainable systemic solutions that can reduce waitlists and deliver timely, equitable access to the right care"	Qualitative	Causal loop diagram/map	Generic Two-Loop	Understand the system – 2. Understand unintended consequences of <i>past/current</i> interventions Change the system – 1. Generate ideas of how to intervene to change how the system functions	"In Fig. 7, polarities do not hold true in all cases because the net flow ultimately determines how accumulations behave, so the use of stocks can provide a more thorough picture of potential system behaviour." "The evidence from the workshops supports an investigation of current review appointments processes and the value of exploring alternative cost-effective strategies (e.g. criteria-led discharge, alternate pathways) for review patients in the management of growing waitlists."	(1) Storyline (causal theory) ✓ Storyline supported with group model building data ✓ Storyline supported with empirical data (2) Pattern of system behaviour over time X Use of pattern of system behaviour over time not mentioned in methods/results X Pattern of system behaviour over time not presented as a graph over time X Pattern of system behaviour over time not explicitly cross-checked with empirical data (3) System structure (CLD) ✓ CLD(s) of systems archetype(s) presented
16. Milton (2024)	Public health	To "introduce the concept of adaptive policies and illustrate how this innovative approach to policy making may be beneficial for reducing physical inactivity"	Qualitative	Systems archetype	- Fixes that Fail - Growth and Underinvestment - Limits to Success	Understand the system – 2. Understand unintended consequences of <i>past/current</i> interventions Change the system – 1. Generate ideas of how to intervene to change how the system functions	"We introduce the concept of adaptive policies and illustrate, through 3 hypothetical examples, how this innovative approach to policymaking may be beneficial for reducing physical inactivity"	(1) Storyline (causal theory) ✓ Storyline supported with literature (2) Pattern of system behaviour over time X Use of pattern of system behaviour over time not mentioned in methods/results X Pattern of system behaviour over time not presented as a graph over time X Pattern of system behaviour over time not explicitly cross-checked with empirical data (3) System structure (CLD) ✓ CLD(s) of systems archetype(s) presented
17. Mohammadi (2018)	Occupational health	To "(a) explore the behaviour patterns (archetypes) of construction safety occurring at project level, and (b) suggest solutions on how to manage the undesired effect of these archetypes"	Qualitative	Causal loop diagram/map	- Fixes that Fail - Shifting the Burden	Understand the system – 1. Understand how the current system functions Change the system – 1. Generate ideas of how to intervene to change how the system functions	"In this paper, the grounded theory method developed by Glaser and Strauss (1967) and the content analysis was used for collecting and analyzing data, as well as developing the archetypes. [...] one of the main objectives of grounded theory resides in linking these concepts to generate meaningful theories (Luna-Reyes & Andersen, 2003)."	(1) Storyline (causal theory) ✓ Storyline supported with interview data ✓ Storyline supported with literature (2) Pattern of system behaviour over time ✓ Use of pattern of system behaviour over time mentioned in methods/results – "The purpose of the second step was to generalize from the specific variables to the patterns of behaviors by considering the causal relationships between them. [...] In this step, the trend of each variable was also collected [...]" "The aim of this step was to identify behavior patterns of each safety problem/theme and to explore the factors involved in each problem/theme." ✓ Pattern of system behaviour over time presented as a graph over time – "Each archetype is completely discussed at

								different steps of dynamic complexity, behavior over time, and the leverage point to show how to deal with the archetype.” ✓ Pattern of system behaviour over time explicitly cross-checked with empirical data – “It should be noted that the sources of the data of figures in the behavior over time sections are based on the collected trend of variables from interviews.” (3) System structure (CLD) ✓ CLD(s) of systems archetype(s) presented
18. Mohammad i (2020)	Occupational health	To “(1) explore the behaviour patterns (archetypes) of safety involving construction workers; and (2) suggest solutions on how to manage the undesired effect of these archetypes”	Qualitative	Causal loop diagram/map	- Fixes that Fail - Limits to Growth - Shifting the Burden	Understand the system – 1. Understand how the current system functions Change the system – 1. Generate ideas of how to intervene to change how the system functions	“[...] the researcher seeks to systematically develop a theory that explains the problem [...].”	(1) Storyline (causal theory) ✓ Storyline supported with interview data ✓ Storyline supported with literature ✓ Storyline checked with experts (2) Pattern of system behaviour over time ✓ Use of pattern of system behaviour over time mentioned in methods/results – “The second step focuses on using causal relationships between the variables. [...] At this step, the trend of each variable was also collected (step 2 in Fig. 1: selective coding).” “The purpose of selective coding was to detect the behavior patterns under each safety problem and to explore the contributing factors in each of them.” ✓ Pattern of system behaviour over time presented as a graph over time – “The identified archetypes have been illustrated at different steps including the dynamic theory, behavior over time, and the leverage point to show how to manage the archetype.” X Pattern of system behaviour over time not explicitly cross-checked with empirical data (3) System structure (CLD) ✓ CLD(s) of systems archetype(s) presented
19. Nguyen (2025)	Healthcare policy	“To identify and address potential policy resistance in our targeted interventions [“in health and social care”], helping decision-makers understand and mitigate the potential for efforts to relieve pressures in one part of the system to exacerbate issues elsewhere”	Qualitative	Causal loop diagram/map	- Out of Control - Relative Achievement - Relative Control - Underachievement	Understand the system – 2. Understand unintended consequences of <i>past/current</i> interventions	“An inherent limitation of the qualitative SD approach is that while it provides a holistic view of the system, it does not offer definitive quantitative solutions. To quantitatively understand the implications, it is necessary to focus on specific elements within the system and conduct further testing.”	(1) Storyline (causal theory) ✓ Storyline supported with interview data ✓ Storyline supported with empirical data ✓ Storyline supported with literature ✓ Storyline checked with experts (2) Pattern of system behaviour over time X Use of pattern of system behaviour over time not mentioned in methods/results X Pattern of system behaviour over time not presented as a graph over time X Pattern of system behaviour over time not explicitly cross-checked with empirical data (3) System structure (CLD) ✓ CLD(s) of systems archetype(s) presented

20.	Osman (2024)	Healthcare policy	To “us[e] [...] systems archetypes [...] as a magnifying lens to investigate potential telehealth unintended consequences or outcomes”	Qualitative	Systems archetype	- Fixes that Fail - Shifting the Burden	Change the system – 2. Reason through unintended consequences of <i>future</i> interventions	“Although systems archetypes cannot necessarily predict these outcomes, they are valuable for helping anticipate unintended, unforeseen outcomes and facilitating discussions about them to mitigate their negative impact and maximise their benefits.” “We provide a hypothetical scenario of these two archetypes within the rural Australian telehealth context to demonstrate the value of this approach to understanding the implementation of telehealth in rural areas.”	(1) Storyline (causal theory) ✓ Storyline supported with literature (2) Pattern of system behaviour over time X Use of pattern of system behaviour over time not mentioned in methods/results X Pattern of system behaviour over time not presented as a graph over time X Pattern of system behaviour over time not explicitly cross-checked with empirical data (3) System structure (CLD) ✓ CLD(s) of systems archetype(s) presented
21.	Proust (2012)	Public health	To “suggest that the collaborative development of conceptual models can help a group to identify potential leverage points for effective adaptation” “strategies that promote urban health and well-being in the face of climate change”	Qualitative	Causal loop diagram/map	Success to the Successful	Understand the system – 1. Understand how the current system functions Change the system – 1. Generate ideas of how to intervene to change how the system functions	“A small set of such models can be used to express hypotheses that capture key aspects of the dynamics of the group’s system-of-interest.” “But, prediction is not possible without some kind of dynamical model of how things might change as time passes.”	(1) Storyline (causal theory) ✓ Storyline supported with group model building data ✓ Storyline supported with literature (2) Pattern of system behaviour over time X Use of pattern of system behaviour over time not mentioned in methods/results X Pattern of system behaviour over time not presented as a graph over time ✓ Pattern of system behaviour over time explicitly cross-checked with empirical data – “In terms of the Success to the Successful structure of Figure 9, it reduced the extent to which Portland designers assumed that travellers to the downtown area would use cars – indeed, they moved to an urban design that strongly discouraged such travel.” (3) System structure (CLD) ✓ CLD(s) of systems archetype(s) presented
22.	Sharif (2016)	Public health	To “develop and adapt an existing food security framework” “to include dimensions of people, process and policy”	Qualitative	Systems archetype	- Attractiveness Principle - Limits to Growth - Tragedy of the Commons	Change the system – 1. Generate ideas of how to intervene to change how the system functions	“The authors outline systems archetypes based upon a combination of the Limits of Growth, Tragedy of the Commons and Attractiveness Principle archetypes [...] to identify and explore a range of food security scenarios and potential outcomes.”	(1) Storyline (causal theory) ✓ Storyline supported with literature (2) Pattern of system behaviour over time X Use of pattern of system behaviour over time not mentioned in methods/results X Pattern of system behaviour over time not presented as a graph over time X Pattern of system behaviour over time not explicitly cross-checked with empirical data (3) System structure (CLD) ✓ CLD(s) of systems archetype(s) presented
23.	Sharma (2020)	Public health	“To describe the role of tobacco and alcohol use in the interaction of social determinants of NCDs [non-communicable diseases] in Nepal”	Qualitative	Causal loop diagram/map	- Drifting Goals - Fixes That Fail - Shifting the Burden	Understand the system – 1. Understand how the current system functions	“The sub-systems and archetypes informed by the current case study districts are a starting point for critical dialogue and action in Nepal in understanding and addressing the complex issue of reducing behavioural risks and in mitigating the burden of NCDs [non-communicable diseases].”	(1) Storyline (causal theory) ✓ Storyline supported with interview and focus group data ✓ Storyline supported with empirical data ✓ Storyline supported with literature ✓ Storyline checked with experts (2) Pattern of system behaviour over time

								X Use of pattern of system behaviour over time not mentioned in methods/results X Pattern of system behaviour over time not presented as a graph over time X Pattern of system behaviour over time not explicitly cross-checked with empirical data (3) System structure (CLD) ✓ CLD(s) of systems archetype(s) presented
24. Sharma (2023)	Public health	"To describe the role of dietary practices and physical activity in the interaction of the social determinants of NCDs [non-communicable diseases] in Nepal"	Qualitative	Causal loop diagram/map	- Drifting Goals - Fixes that Fail - Shifting the Burden	Understand the system – 1. Understand how the current system functions	"We have indicated within the paper that localised qualitative and quantitative studies are needed to understand the dynamics interactions of the social determinants of NCDs [non-communicable diseases] and their key risk factors. Further, the CLDs can be improved as new evidence emerges, which is one of the key strengths of systems thinking approaches to understand and tackle a complex problem."	(1) Storyline (causal theory) ✓ Storyline supported with interview and focus group data ✓ Storyline supported with empirical data ✓ Storyline supported with literature ✓ Storyline checked with experts (2) Pattern of system behaviour over time X Use of pattern of system behaviour over time not mentioned in methods/results X Pattern of system behaviour over time not presented as a graph over time X Pattern of system behaviour over time not explicitly cross-checked with empirical data (3) System structure (CLD) ✓ CLD(s) of systems archetype(s) presented
25. Sharma (2024)	Public health	"To develop a systems thinking informed understanding of challenges for services and whānau [Māori family/households] related to the COVID-19 pandemic and consider opportunities for improving whānau support during future COVID-19 waves or other pandemics"	Qualitative	Causal loop diagram/map	Fixes that Fail	Understand the system – 2. Understand unintended consequences of <i>past/current</i> interventions CHANGE THE SYSTEM – 1. Generate ideas of how to intervene to change how the system functions	"The study aimed to understand systemic barriers and opportunities in supporting whānau through COVID-19 from a Māori health and social service provider perspective. The study developed a causal loop diagram to illustrate those key systemic barriers and opportunities to support whānau."	(1) Storyline (causal theory) ✓ Storyline supported with focus group and group model building data ✓ Storyline supported with literature ✓ Storyline checked with experts (2) Pattern of system behaviour over time X Use of pattern of system behaviour over time not mentioned in methods/results X Pattern of system behaviour over time not presented as a graph over time X Pattern of system behaviour over time not explicitly cross-checked with empirical data (3) System structure (CLD) ✓ CLD(s) of systems archetype(s) presented
26. Sobratee (2022)	Public health	"To envision and co-design a future state of the food [...] that ought to be both sustainable and healthy for the smallholder system and previously disadvantaged group in South Africa"	Qualitative	Causal loop diagram/map	- Shifting the Burden - Successful	Understand the system – 1. Understand how the current system functions Change the system – 1. Generate ideas of how to intervene to change how the system functions	"[...] we explain the causal pathways in order to improve clarity on the relevance of the proposed corresponding mechanisms that ought to produce the expected outcomes."	(1) Storyline (causal theory) ✓ Storyline supported with focus group and group model building data ✓ Storyline supported with literature ✓ Storyline checked with experts (2) Pattern of system behaviour over time X Use of pattern of system behaviour over time not mentioned in methods/results X Pattern of system behaviour over time not presented as a graph over time

								X Pattern of system behaviour over time not explicitly cross-checked with empirical data (3) System structure (CLD) ✓ CLD(s) of systems archetype(s) presented
27. Wolstenholme (2022)	Healthcare policy	To "explore [...] new and novel ways of using generic systems archetypes to create a hypothesis linking general Integrated Care Systems to congestion reduction throughout hospitals", where systems archetypes "are applied here collectively in tandem", "where the unintended consequence of one archetype becomes the driver for the next"	Quantitative	Systems archetype	- Out of Control - Underachievement	Understand the system – 2. Understand unintended consequences of <i>past/current</i> interventions Change the system – 2. Reason through unintended consequences of <i>future</i> interventions	"The work here has extrapolated early quantitative modelling results into a broad and succinct hypothesis, capable of drawing attention for further testing, which is already starting."	(1) Storyline (causal theory) ✓ Storyline supported with experiential knowledge ✓ Storyline checked with experts ✓ Systems archetype(s) translated into simulation model(s) (2) Pattern of system behaviour over time X Use of pattern of system behaviour over time not mentioned in methods/results ✓ Pattern of system behaviour over time presented as a graph over time – "Figure 1. The generic underachievement problem archetype and an example of its behaviour over time." Figure 3. The generic out-of-control problem archetype and an example of its behaviour over time." X Pattern of system behaviour over time not explicitly cross-checked with empirical data (3) System structure (CLD) ✓ CLD(s) of systems archetype(s) presented
28. Wong (2012)	Healthcare policy	To "describe [...] the process of taking a chronic operational problem common to many publicly funded hospitals and from it designing a conceptual model that provides a roadmap to address the problem situation"	Qualitative	Causal loop diagram/map	Generic Two-Loop	Understand the system – 2. Understand unintended consequences of <i>past/current</i> interventions Change the system – 1. Generate ideas of how to intervene to change how the system functions	"It [system dynamics methodology] provided a framework to elicit system description from stakeholders, identified and conveyed dynamic and complex structure and policies in the system, and generated hypotheses for how the system created the chronic troubling behaviour (Lane et al, 2003; Lattimer et al, 2004)."	(1) Storyline (causal theory) ✓ Storyline supported with focus group data ✓ Storyline supported with experiential knowledge ✓ Storyline supported with empirical data ✓ Storyline checked with experts (2) Pattern of system behaviour over time X Use of pattern of system behaviour over time not mentioned in methods/results X Pattern of system behaviour over time not presented as a graph over time X Pattern of system behaviour over time not explicitly cross-checked with empirical data (3) System structure (CLD) ✓ CLD(s) of systems archetype(s) presented
29. Zhang (2016)	Public health	"To illustrate the causal relationships between SDGs [Sustainable Development Goals], examine system structures using generic system archetypes, and identify leverage points to effectively	Qualitative	Causal loop diagram/map	- Growth and Underinvestment - Limits to Growth - Reinforcing Growth	Change the system – 2. reason through unintended consequences of <i>future</i> interventions	"This model is the first attempt to understand the direct and indirect linkages between the SDGs [Sustainable Development Goals] and the potential positive or negative influences they have on each other."	(1) Storyline (causal theory) ✓ Storyline supported with experiential knowledge ✓ Storyline supported with literature (2) Pattern of system behaviour over time ✓ Use of pattern of system behaviour over time mentioned in methods/results – "The expected behavior for this archetype is an exponential growth of system performance over time [18]." "The expected behavior for a system operating under the

		influence intentional and minimize unintentional changes in the system"						Limits to Growth archetype is a bounded, S-shaped growth curve [18]." X Pattern of system behaviour over time not presented as a graph over time X Pattern of system behaviour over time not explicitly cross-checked with empirical data (3) System structure (CLD) ✓ CLD(s) of systems archetype(s) presented
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Table 3. Summary descriptives of the studies.

Domain	Number of studies (sum = total (29))
• Healthcare policy	13
• Public health	12
• Occupational health	4
Was the study qualitative or quantitative?	Number of studies
• Qualitative	26
• Quantitative	3
Was the starting point of the study a causal loop diagram/map or a systems archetype?	Number of studies
• Causal loop diagram/map	21
• Systems archetype	8
Which systems archetypes were identified in the study?	Number of studies
• Fixes that Fail	15
• Shifting the Burden	11
• Limits to Success	10
• Drifting Goals	6
• Growth and Underinvestment	4
• Success to the Successful	4
• Tragedy of the Commons	2
• Escalation	2
• Other systems archetype identified	16

Table 4. Summary purposes of systems archetypes across the studies.

What was the purpose of systems archetypes in the study?	Number of studies
• <i>Single purpose</i>	12
Understand the system	
1. Understand how the current system functions	3
2. Understand unintended consequences of <i>past/current</i> interventions	2
Change the system	
1. Generate ideas of how to intervene to change how the system functions	2
2. Reason through unintended consequences of <i>future</i> interventions	5
• <i>Dual purpose</i>	17
Understand & change the system	
- 1. Understand how the current system functions & 2. Generate ideas of how to intervene to change how the system functions	8
- 2. Understand unintended consequences of <i>past/current</i> interventions & 1. Generate ideas of how to intervene to change how the system functions	7
- 2. Understand unintended consequences of <i>past/current</i> interventions & 2. Reason through unintended consequences of <i>future</i> interventions	2

Table 5. Summary engagement with the three entry points – (1) storyline (causal theory), (2) pattern of system behaviour over time and (3) system structure (CLD) – for identifying a systems archetype.

Did the study engage with the three entry points – (1) storyline (causal theory), (2) pattern of system behaviour over time and (3) system structure (CLD) – for identifying a systems archetype? If so, how?	Number of studies
(1) Storyline (causal theory)	Total number of studies that engaged with (1) storyline (causal theory) = 28
• Storyline supported with interview/focus group/survey/group model building data	21
• Storyline supported with literature	18

• Storyline checked with experts	16
• Storyline supported with empirical data	5
• Storyline supported with experiential knowledge	4
• Systems archetype(s) translated into simulation model(s)	3
(2) Pattern of system behaviour over time	Total number of studies that engaged with (2) pattern of system behaviour over time = 9
1. Use of pattern of system behaviour over time mentioned in methods/results 2. Pattern of system behaviour over time presented as a graph over time 3. Pattern of system behaviour over time explicitly cross-checked with empirical data	4
1. Use of pattern of system behaviour over time mentioned in methods/results 2. Pattern of system behaviour over time presented as a graph over time	1
1. Use of pattern of system behaviour over time mentioned in methods/results	2
2. Pattern of system behaviour over time presented as a graph over time	1
3. Pattern of system behaviour over time explicitly cross-checked with empirical data	1
(3) System structure (CLD)	Total number of studies that engaged with (3) system structure (CLD) = 27
• CLD(s) of systems archetype(s) presented	27

Using systems archetypes in public health: A scoping review connecting system dynamics literature and public health applications

Supplementary Material

Table S1 presents an overview of the different definitions for systems archetypes given across the literature we reviewed.

Table S1. Systems archetypes definitions.

Citation	Systems archetypes definition
Meadows (1982) (Meadows, 1982)	"Computer-free systems insights that any adult can carry in his or her head to deal with the persistent, system-dependent malfunctions of a complicated society"
Kim (1992) (Kim, 1992)	"One class of tools that capture the "common stories" in systems thinking – dynamic phenomena that occur repeatedly in diverse settings"
Kim (1992); Kim (1994) (Kim, 1992, Kim, 1994)	"Certain common dynamics that seem to recur in many different settings. These archetypes, consisting of various combinations of balancing and reinforcing loops, are the systems thinker's "paint-by-numbers" set – users can take real-world examples and fit them into the appropriate archetype. They serve as a starting point from which one can build a clearer articulation of a business story or issue."
Goodman & Kemeny in Senge (1994) (Goodman & Kemeny in (Senge, 1994))	- "Accessible tools with which managers can quickly construct credible and consistent hypotheses about the governing forces of their systems" - "A natural vehicle for clarifying and testing mental models about those systems" - "Powerful tools for coping with the astonishing number of details that frequently overwhelm beginning systems thinkers" - "Nothing more than a mental model made visible"
Lane & Smart (1996) (Lane and Smart, 1996)	"Recurrent patterns of structure which illustrate common but counter-intuitive relationships between policy and behaviour in complex dynamic systems"
Kim & Anderson (1998) (Kim and Anderson, 1998)	- "Recurring, generic systemic structures that are found in many kinds of organisations, under many circumstances, and at different levels or scales, from internal personal dynamics to global international relations" - "The 'classic stories' in systems thinking – common patterns and structures that occur repeatedly in different settings"
Lane (1998) (Lane, 1998)	"Qualitative maps – simplified causal loop diagrams – combined with a story which encourages the development of feedback thinking", which "illustrate a 'management principle' about the counter-intuitive behaviour of a system, indicating that an unexpected consequence may flow from a policy"
Wolstenholme (2003) (Wolstenholme, 2003)	"A formal and free-standing way of classifying structures responsible for generic patterns of behaviour over time, particularly counter-intuitive behaviour"
Meadows (2008) (Meadows, 2008)	- "Common system structures that produce characteristic patterns of [problematic] behaviour" - "System structures that produce [...] common patterns of problematic behaviour [...] [that] need to be changed [because] the destruction they cause is often blamed on particular actors or events, although [they] are actually a consequence of system structure"

Table S2 presents quotes related to how systems archetypes could help bridge the gap between system structure and leverage points identified across the literature we reviewed.

Table S2. How systems archetypes could help bridge the gap between system structure and leverage points, and contribute to identifying unintended consequences of past/current or future interventions.

How systems archetypes could help bridge the gap between system structure and leverage points	
Systems archetypes may help link system structure to leverage points	"The purpose of the systems archetypes is to recondition our perceptions, so as to be more able to see structures at play, and to see the leverage in those structures. Once a systems archetype is identified, it will always suggest areas of high- and low-leverage change." (Senge, 1990) "They are powerful tools for diagnosing problems and identifying high-leverage interventions that will create fundamental change." (Kim, 1992)

	"The archetypes consist of different combinations of reinforcing and balancing loops, and when applied to business problems, can yield insight into the structure at work and reveal possible high-leverage interventions." (Kim, 1994) "In essence, these structures attempt to characterise common dysfunctions in high order dynamic systems and through an understanding of the dynamic structure suggest antidotes. The nature of the dysfunction and that of the antidote are not obvious, i.e. they are both counter-intuitive. This is because "[t]he complex system presents an apparent cause that is close in time and space to the observed symptoms. But the relationship is usually not one of cause and effect. Instead both are coincident symptoms arising from the dynamics of the system structure." (Forrester 1969, 110)." (Lane and Smart, 1996) "the aim is to provide some qualitative insight into a situation which offers a guide to action" (Lane and Smart, 1996) "Because the systems archetypes open a window onto important, recurring "stories" that happen in all walks of organizational life. The archetypes let us step back and see that many organizations – from small startups to huge, established companies – experience similar systemic challenges. Systems archetypes help us deepen our understanding of these challenges and design effective action plans for addressing them." (Kim and Anderson, 1998) "In addition, each archetype offers prescriptions for effective action. When we recognize an archetype at work, we can use the theory behind it to explore the problem and work toward an intervention." (Kim and Anderson, 1998)
Systems archetypes may help understand unintended consequences of <i>past/current</i> interventions	"First, the archetypes can be used as diagnostic tools for developing an understanding of a current situation." (Kim, 1994) "AS DIAGNOSTIC TOOLS The archetypes provide a systemic structure and storyline that we can use to "diagnose" or make sense of a particular situation. By developing a deeper understanding of how we came to be in the current "mess," we are able to identify the fundamental forces that brought us there and then point to ways to resolve the current situation and avoid repeating such errors in the future." (Kim, 1994) "At the heart of the art of systems story telling [through systems archetypes] is one question: How did we (through our internal thinking, our processes, our practices, and our procedures) contribute to or create the circumstances (good and bad) we face now?" (Senge, 1994) "System archetypes (Senge 1990; Wolstenholme 1990) were introduced as a formal and free-standing way of classifying structures responsible for generic patterns of behaviour over time, particularly counter-intuitive behaviour. Such "structures" consist of intended actions and unintended reactions and recognise delays in reaction times." (Wolstenholme, 2003)
Systems archetypes may help reason through unintended consequences of <i>future</i> interventions	"Second, as planning tools, they [the systems archetypes] can help us anticipate future consequences and plan for them." (Kim, 1994) "AS PLANNING TOOLS Rather than just diagnosing a problem after the fact, some of the archetypes can also be used more proactively as planning tools. By looking ahead at the systemic consequences of proposed actions, we can identify structures that may impede our progress and then plan for them in advance. Using the archetypes in this way can help potential problems to surface long before they happen and provide a window of opportunity to intervene when we have the most leverage for taking effective action." (Kim, 1994) "We can even use archetypes to sharpen our ability to anticipate difficulties, communicate about them with our colleagues, and find ways to address them together." (Kim and Anderson, 1998) "The archetypes are especially valuable for generating new and expansive questions in response to problems you encounter and stories you hear. For example, "What unintended long-term effects might that solution have?" "What pressure will we relieve with this response to the problem?" "Is there something we don't do now to solve the problem because it's too expensive or time consuming?" "What aspect of our organization might slow down or stop this planned growth strategy?"" (Kim and Anderson, 1998) "The stance taken in this paper is that system archetypes have an important and multiple role to play in systemic thinking. They can provide a free-standing means by which to apply systems thinking by conveying to people that their plans for change will have side effects, and encouraging them to explore these." (Wolstenholme, 2003)

	"Understanding archetypal problem-generating structures is not enough. Putting up with them is impossible. They need to be changed. The destruction they cause is often blamed on particular actors or events, although it is actually a consequence of system structure. Blaming, disciplining, firing, twisting policy levers harder, hoping for a more favorable sequence of driving events, tinkering at the margins – these standard responses will not fix structural problems. That is why I call these archetypes "traps." But system traps can be escaped – by recognizing them in advance and not getting caught in them, or by altering the structure – by reformulating goals, by weakening, strengthening, or altering feedback loops, by adding new feedback loops. That is why I call these archetypes not just traps, but opportunities." (Meadows, 2008)
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Table S3 presents quotes concerning the methodological benefits that systems archetypes may provide along with related considerations, as explained across the literature we reviewed.

Table S3. Methodological benefits and considerations of systems archetypes as an analytical tool to help bridge the gap between system structure and leverage points.

Methodological benefits	Methodological considerations	
1. Systems archetypes can help systematise generating hypotheses about system behaviour and leverage points...	...however, these hypotheses still require testing	...however, these hypotheses focus on specific types of system behaviour
"Such "laundry lists" of important variables hint at the enormous detail complexity of realistic management problems. It's easy to get lost in the "trees" of these details and lose sight of the "forest" – mastering the dynamic complexity essential to successful strategy. Here's where the discipline of systems thinking finds its greatest advantage. By using the systems archetypes we can learn how to "structure" the details into a coherent picture of the forces at play." (Senge, 1990) "An archetype is nothing more than a mental model made visible. With the archetype before them, one person says, "This is how I think it works." Then, typically, a colleague replies, "No, that's not how it works at all." The team starts to recognize how both viewpoints are true; they each see different aspects of the same interrelationships. As they continue, the structure begins to reflect the collective thinking of the team. As more and more people comment, confidence grows that this archetype speaks to reality as people know it. Even if you agree on what structure is involved, you will have varying perceptions of the implications. "We agree it's a 'Limits to Growth' dynamic, but you think the constraint is our succession policy, and I think it's our customer relations." You may agree that the fix has backfired, but not on what to do about the undesirable consequences. But you now have a language for describing what each person sees,	"Case studies, systems thinking, and soft OR usually lack the discipline of explicit model creation and simulation and so rely on subjective use of unreliable intuition for evaluating the complex structures that emerge from the initial description of the real system." (Forrester, 1994) "Case studies suffer from their dependence on intuitive judgment for policy analysis. A case-study description will usually imply a high-order, nonlinear feedback system. No one can reliably anticipate the behavior of such a system. The case-study approach may correctly identify structure and policies in the system under consideration, but then draw incorrect dynamic conclusions. Many years ago, several hundred people attended a major anniversary celebration at the Harvard Business School. The program included a demonstration of the case-study method for which participants divided into classrooms of some 50 people each. The written description of the case had been distributed in advance. The group that I observed correctly identified the issues, structure, and relevant policies in the situation. The discussion progressed to recommendations for improvement. As it happened, the case was one for which we had done a system dynamics model and had tested alternative policies. The policy recommendations of the case-study group were wrong and entirely inconsistent with the	"Causal loop diagramming uses the same "language" as the archetypes – causal links from one element to another. But the structure is more flexible; causal loop diagrams don't presume a preexisting template into which you've got to force-fit the situation." (Sterman in (Senge, 1994)) "A metaphor, or any framework for conceptualisation, highlights certain aspects of the world and obscures others, producing a one-sided kind of insight. Counter-intuitive system archetypes, as an integral part of the larger framework systems thinking, are similarly one-sided." (Lane and Smart, 1996) "It is clear that they cannot summarise all of SD [system dynamics] in a handy tee-shirt slogan form and may not be a complete list." (Lane, 1998)

clarifying the differences, and building more choices (not answers) into your thinking." (Senge, 1994) "In many ways, using an archetype is like putting on a special pair of eyeglasses. If you look at a situation through the lens of "Shifting the Burden," you ask different questions and focus on different elements than if you had used "Tragedy of the Commons" as a lens. It is not so much a question of which archetype is "right," but rather what insights each archetype offers. Using the archetypes as lenses requires a basic understanding of the main lessons, key elements, and outcomes or high-leverage actions that each one embodies. This level of understanding lets you go into a situation, identify potential themes, explore their implications, and gain a better understanding of the problem. The key question is not, "Is this 'Shifting the Burden' or 'Fixes That Fail'?" but "Is it helpful to view this particular situation as a 'Shifting the Burden'? What can we learn, and what insights can we gain, by doing so? On the other hand, what could we learn if we viewed the situation as a 'Fixes That Fail'?" (Kim and Anderson, 1998) "In addition to resembling "lenses" for addressing issues, archetypes can serve as structural pattern templates. An archetype serves in this way when it helps you "see" a problem at the structural level – at the level of interrelated variables – rather than at the level of linear, cause-and-effect detail. With this structural-level perspective, you focus more on relationships and pay attention to larger "chunks" of the system (see "Archetypes as Structural Pattern Templates")." (Kim and Anderson, 1998)	system description as formulated at the beginning of the case discussion. Most misbehavior of corporate, social, and governmental systems arises from just this dependence on erroneous intuitive solutions to complex behavior." (Forrester, 1994) "I have inferred Jay [Forrester]'s view from comments that he has made in various forums. Recently his sentiments were reflected in an interview which appeared in the McKinsey Quarterly. In that interview, he stated that Systems Thinking will get you "less than 5 percent of the way towards a genuine understanding of systems. The other 95 percent lies in the rigorous System Dynamics-driven structuring of models and in the simulations based on these models" (McKinsey, 1992)." (Richmond, 1994) "In the world of archetypes, all the elements of a system remain vaguely defined, and we can only speculate about what patterns of behavior the systems will produce. On a computer model of a system, we can see what happens when we take these assumptions to logical conclusions. This makes modeling an extremely valuable form of inquiry – it provides new (and less risky) ways to test hypotheses before acting on them, and gives us the basis to design "learning laboratories" that serve as transforming environments for a team or organization." (Goodman in (Senge, 1994)) "When you create a map of a system, whether via archetypes, causal loop diagrams, or stocks and flows, you have done nothing more than propose hypotheses. These hypotheses require testing." (Sterman in (Senge, 1994)) "Predicting the behavior of even the simplest archetype would mean solving a high-order nonlinear differential equation in your head. Human beings do not have the cognitive capacity to do so. Many studies have shown that people's intuitive predictions about the dynamics of complex systems are systematically flawed." (Sterman in (Senge, 1994)) "We can therefore see that counter-intuitive system archetypes seek to leap-frog the whole process of model building, moving the user straight	
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	from conceptualisation to insights about a system." (Lane and Smart, 1996) "With counter-intuitive system archetypes, behaviour is merely inferred by mental simulation, a process which is known to be treacherous, and its implied use arguably constitutes a rejection of one of the core assumptions of system dynamics." (Lane and Smart, 1996) "Second, counter-intuitive system archetypes make a strong, though highly questionable, inference between a particular behaviour pattern and the underlying dynamic structure. This arises both in the dysfunctional behaviour that aids in the choice of counter-intuitive system archetype and in the more acceptable behaviour that is supposed to result from the application of the counter-intuitive management principle. However, with counter-intuitive system archetypes there is no rigorous linkage between system structure and system behaviour: the user is called upon to make an inference rather than a deduction." (Lane and Smart, 1996) "However, it is crucially important to note that he [Sterman] goes on to observe that counter-intuitive system archetypes constitute merely a hypothesis concerning the structure/behaviour link and that he argues strongly for the use of computer simulation for the rigorous testing of such hypotheses." (Lane and Smart, 1996) "In this paper Lane argues that archetypes – and other forms of "qualitative system dynamics – sacrifice "formulational validity", "experimental validity" and "data validity" in order to increase "process effectiveness". He comments that, whilst the resulting "operational validity" may still be high, this is purchased at a severe cost to "analytical quality", (Lane 1995a)." (Lane and Smart, 1996) "As these are only qualitative maps of systems, the confidence derived from AQ [analytical quality of policy insights] can only be very low. We simply cannot test the robustness of insights to parameter or structural changes. In fact, if the map deals with more than a small number of loops it is doubtful that any insights can be	
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	gained because we are inferring rather than deducing the behaviour of a complex feedback system. As these are not simulation models and have only weakly developed structures, there is no quantitative data, no formulation and no testing of structure by experimentation." (Lane, 1998) "Should we be confident of counter-intuitive system archetypes? It depends. There are very weak forms of SD [system dynamics] models. The only available insights are not grounded in simulation. The real links in a system are not developed in a rigorous way." (Lane, 1998) "Learning in and about complex systems requires constant iteration between experiments in the virtual world of models, where costs and risks are low, and interventions in the real world, where experiments are often costly and risky (Sterman, 1994). Failing to test models against evidence and through experiments in the real world cuts these critical feedbacks." (Sterman, 2018)	
2. Systems archetypes can support cross-checking hypotheses about system behaviour with (qualitative or quantitative) empirical data over time...	...however, leaving this cross-checking out risks jumping to conclusions	
"The next step is to bring the story or stories underlying your problem to the surface. This process is also known as model building; it can be a powerful learning process, especially for teams. During this phase, you develop a theory or hypothesis that makes sense, is logically consistent, and could – if accurate – explain why the system is generating the problems you see. Then, in the spirit of the scientific method, you test the story you have created. As in all model building, when the theory can't explain observations, then it needs refinement or revision. We are all natural model builders but rarely get a forum and the tools to exchange and examine our theories. The loops and archetypes give us those tools." (Senge, 1994) "The systems archetypes, as one class of systems thinking tools, can open a whole new dimension of your learning. Because each archetype comes with its own storyline (or causal theory), pattern of behavior over time, and systemic structure depicted in a causal loop diagram (like templates), you can connect to it and apply its learnings from any of those entry points (see "A Review of Causal Loop Diagrams"). As you work on a problem – going over the story, identifying key variables, sketching causal loop diagrams – you may suddenly find that something about the story resonates with one or more of the archetypes, giving you a new key for unlocking part or all of your problem. At other moments, you may finish graphing the behavior over time of key variables, and notice a pattern that seems to match a behavior pattern associated with one of the archetypes. A rich vein of questions, theories, and possibilities opens up for your investigation. Or, you may be looking over a causal loop diagram drawn by a colleague and notice a particular	"One finds this after-the-fact use of causal loops in the very popular The Fifth Discipline (Senge, 1990). The book presents causal loops of various management situations. The reader may erroneously get the impression that one can look at real life, draw a causal loop diagram, and then carry through a penetrating description of dynamic behavior." (Forrester, 1994) "On the other hand, unquestioning and superficial enthusiasm for systems thinking may lead some people into trouble. Some people attain enough revealing insights from systems thinking that they feel the need for nothing else. Such people are in danger of finding that systems thinking does not help in solving their problems, or worse, that they take ill-advised actions that make matters worse." (Forrester, 1994) "Again, to me, one of the major "problems" with System Dynamics was the "we have a way to get the wisdom, we'll get it, then we'll share it with you" orientation. I feel that Systems Thinking should be about helping to build people's capacity for generating wisdom for themselves. Though I believe that Senge offered the archetypes in this latter spirit, too many people are taking them as "revealed truth," looking for instances of that truth in their organisations (i.e., engaging in what amounts to a "matching exercise"), and calling this activity Systems Thinking. It isn't." (Richmond, 1994) "No one denies that spreadsheets are useful. But they also lowered the technical barriers facing people who wanted to do financial modeling. As a result, in the first few years after	

combination of loops that reminds you of the core structure of a certain archetype, and that prompts you to ask a question that had not yet occurred to either of you. At first, you'll probably find your own way of applying your understanding of the system archetypes – through using story themes, structure-behavior pairs, or generic causal loop diagrams. Eventually, you can use all three aspects of the archetypes to broaden your perspective on systemic problems, generate additional or unexpected questions, notice when you are experiencing one or more of these recurring dynamics, and anticipate possible future outcomes of current actions and events." (Kim and Anderson, 1998) "In order to make sense of our experience of the world, we must be able to relate that experience to a coherent, explanatory story. In other words, we need to create a theory about what we don't know based on something we do know. Each systems archetype embodies a particular theory about dynamic behavior that can serve as a starting point for selecting and formulating raw data into a coherent, explicit set of causal relationships (see the brief summaries of these theories in "Archetypes as Dynamic Theories"). Then, the archetypes can guide us further in testing those relationships through direct observation, data analysis, or group deliberation." (Kim and Anderson, 1998) "In this third volume, we take a closer look at what I refer to as the signature patterns of behavior associated with each archetype. By internalizing these signature patterns, we can enhance our capacity to detect situations where archetypal systemic forces are driving the (undesirable) results. Identifying and charting patterns of behavior over time can help us detect adaptive responses that are often invisible in the relatively short time horizons of day-to-day life. [...] These signature patterns can help us identify the archetypal forces at work in a given situation and guide us to more effective, longer term actions." (Kim, 2000) "By focusing on the behavior over time aspect of the archetypes the volume provides you with another entry point for identifying situations in which your organization may be stuck in one or more of these archetypes. Charting behavior over time is often an easier and more natural place for some people to start their systemic inquiry into an issue." (Kim, 2000)	the introduction of spreadsheets, the average quality of financial models plummeted. Today, many financial models are not only useless, but downright harmful to decision makers who build them. There is a danger that something similar may take place with the systems archetypes." (Stermann in (Senge, 1994)) "Without modeling, we might think we are learning to think holistically when we are actually learning to jump to conclusions." (Stermann in (Senge, 1994)) "Unfortunately, some people regard the archetypes as literal templates, where understanding your situation is just a matter of picking one, filling in the blanks, and applying the story's "moral," Where that happens, systems thinking, which should be a disciplined and creative process, becomes mere multiple choice." (Stermann in (Senge, 1994)) "How many people today believe that empirical data are of relatively minor importance in system dynamics? I am concerned that some may have impression that conceptualisation is the main thing and takes priority over the careful gathering of evidence, or that all the important evidence will come naturally and easily to the surface. I wonder, in other words, if the lines between exploratory modeling and scientific modeling may have been blurred in some minds, including those of some consultants and practitioners. We should resist the notion that system dynamics is mainly conceptual rather than empirical, that creativity is more important than thoroughness. System dynamics is much more than just another technique for brainstorming or critical thinking and will ultimately fade in significance and credibility to the extent that it backs away from its scientific roots. Scientific modeling can be pursued in any domain and regardless of whether the project is large or small in size. It is a method and a mindset, and its rationale lies in the distinction between apparent insights and validated insights." (Homer, 1995) "Counter-intuitive system archetypes may reduce the perceived need for model construction and the carefully validated application of the feedback perspective." (Lane and Smart, 1996) "In consequence, counter-intuitive system archetypes have merely an analogical relationship with real-world phenomena. By offering a shortcut to understanding dysfunctional system behaviour, counter-intuitive system archetypes simply ask us to see the world through these structures because we may find it helpful." (Lane and Smart, 1996) "Replacing a poor mental model with a diagram, archetype, or simulation that is not grounded in evidence and is poorly tested may create more harm by providing false confidence and more deeply embedding flawed mental models." (Stermann, 2018)
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