JOURNAL of DESIGN THINKING

Design Thinking Strategies for Complex Situations: COVID-19 in Western Australia and New South Wales

***Terence Love*[1*], *Paul Cozens*[2], *Trudi Cooper*[3]**

[1] Department of Industrial design, Kish International Campus, University of Tehran, Iran. Email: t.love@love.com.au
[2] Design Out Crime and CPTED Centre, Love Services Pty Ltd, Western Australia, Australia. Email: pmcozens@outlook.com
[3] Edith Cowan University, Joondalup, Australia. Email: t.cooper@ecu.edu.au

[*]**Corresponding author:** Terence Love

DOI: 10.22059/JDT.2024.380841.1129

Received: *14 August 2024,* ***Revised:*** *9 September 2024,* ***Accepted:*** *9 September 2024,* ***Available Online*** *from 9 September 2024.*

Abstract

This paper outlines an argument for changing the foundation of design thinking practices to include causal feedback loops instead of primarily predicting futures using linear causal relations. The paper suggests for most real-world design situations the traditional linear causal perspective is insufficient and leads to lower value design outcomes. The authors propose instead designers address real-world complex design situations via design methods that include feedback loops, which require different design methods and tools. The discussion in the paper follows the understanding of systems researchers. The authors provide an example of the significant differences in outcomes using a comparative case study of government strategies in Western Australia and New South Wales to address COVID-19 and its adverse consequences including crime. The design of Western Australia's strategies took into account feedback loops between factors. In contrast, New South Wales government strategies followed a traditional design approach based on linear causal relations without feedback loops similar to that used for long-term resource planning in hospitals. The Western Australian outcomes were significantly better than those of New South Wales in terms of infections, deaths, hospital resource management, and across economic and social benefits and this can be tied to the differences in design approach. The authors contend that in most real-world complex design contexts it is necessary for designers to move away from traditional design thinking based on linear causal relations and instead assume that all design thinking requires consideration of, and prediction of outcomes by, feedback loops between design factors.

Keywords

Systems, Feedback Loops, Causal, Crime, COVID-19.

Introduction

Designers contribute to the livability of urban landscapes, and this includes ensuring that urban design supports human health and well-being and minimizes crime (Chang & Egbutah, 2015; Cozens, 2016; Duhl & Sanchez, 1999; Home Office, 2004; Megahed & Ghoneim, 2020; Northridge & Sclar, 2003; Shipway & Homel, 1999; WHO, 2020). The recent emergence of COVID-19 resulted in design changes to human environments and vice versa. This is an echo of other historical events such as the way bubonic plague and fire underpinned the renewal of Renaissance cities in the 14th-17th centuries. The fire that burned most of London in 1666 is credited with more or less ending the Great Plague of London that started in 1665. In turn that led to increased planning control and design guidelines that restricted the use of wood in buildings to reduce fire risk. Del Carmen and Robinson (2000) argued slum clearances during the Industrial Revolution in the UK used crime prevention strategies to reduce tuberculosis and cholera as well as decrease crime in the dangerous areas known as *rookeries* (Beames, 1850). These rookeries were areas of over-populated multi-occupancy dwellings resulting from rapid urban population growth driven by poverty, collapse in agricultural work, and, later, decreases in infant and adult mortality. The design of sanitary reforms in the Victorian era in the UK sought to fight epidemics of cholera and typhoid and led to new design/planning regulations. The recent COVID-19 global pandemic has similarly shaped design practices and had *a direct bearing on the very foundations of urban planning and architecture theory and practice* (Megahed & Ghoneim, 2020). The above links between design thinking of urban design, population health, and crime prevention are echoed in the most recent definition of crime prevention in environmental design (CPTED) of ISO 22341:2021 (ISO, 2021) and Cozens (2016) a process for analyzing and assessing crime and security risks to guide development, site management and the use of the built environment in order to prevent and reduce crime and the fear of crime, and to promote and improve public health, quality of life and sustainability.

The above examples of the relationships between design and health (and crime) are intrinsically of simple linear causality. They have the form *wooden buildings burn, therefore use design strategy that excludes wood*. Other similar examples of such linear causality include:

- *Increased housing density* in an area causes *increased availability of potential workers*.
- *Shortage of housing stock* causes *increased house prices and rents* and *greater homelessness*.

Expressed symbolically, A causes B and C; where A is *shortage of housing stock*, B is *increased house prices and rents* and C is *greater homelessness*. This is simple linear causality. It can be more complicated yet remain *simple causality* in the sense that A may cause changes to B and C which may in turn cause changes to another factors D, E, F, and G. It is mentally straightforward to predict outcomes of design decisions in such simple linear causal situations in which a factor, A, causes changes in factors B and C. It is more difficult, but still possible, to mentally predict outcomes of more complicated situations, usually with the help of some visual aids such as those of Robert Horn (e.g., http://bobhorn.us/assets/uc-bigscreen-platformsforthought-what-is-3_reduced.pdf). This centrality of prediction of outcomes resulting from different design decision making is a key issue.

Most design and planning situations are complex, which is recognized in the design literature of *wicked problems* and planning complexity (for example Briggs, 2012; Rittel, 1972; 1972; 1984; Rittel & Webber, 1974; 1984). Complex design situations have feedback loops between the factors that influence outcomes. Feedback loops are processes that influence causal relationships in ways that are not simple and linear.

Complex design situations with feedback loops present a completely different kind of problem to those with linear causality. One minimally complex design example might be a situation where an inner-city area known for vibrancy, music, art, musicians and artists, etc. perceived as culturally attractive and then subject to gentrification.

The gentrification results in higher living costs and less access to unused buildings. The artistic, homeless and insecurely housed people that gave the area its culturally attractive character are actively driven away as they are not considered to give positive *character* to gentrified areas. These changes reduce the area's previous attractiveness.

Another example of a complex design thinking situation with a single feedback loop might be that in a working-class suburb, increased house prices and rents result in gentrification that makes local shopping more viable, and that in turn results in the conversion of some residential properties to businesses and shops – reducing the housing stock and further increasing house prices and rents resulting in increasingly rapid displacement elsewhere of the original working class residents.

Both are examples of a situation with a first order feedback loop. In the first case, the feedback loop causes the collapse of the factors that made the area attractive. In the second case, the outcome of the feedback loop drives up rents and displaces residents. In both cases, the trend towards homelessness increases.

For complex situations with feedback loops, especially multiple feedback loops, the design thinking and prediction of outcomes necessary for successful designing is much more difficult than for simple linear causality. This can be seen in the increased difficulty in predicting outcomes from design decision in the above single feedback loop situations. For example, for designers to be able to accurately answer the question, *How much will homelessness change and why?*

One possibility, gentrification leads to lower population density (fewer people living in a single space, and less multi-generational households, shared houses, and multi-key dwellings). What occurs depends upon a variety of social factors, such as whether there is cheaper housing and employment somewhere else, and the kinship networks people have. There are different possible outcomes. The first, is no effect on homelessness. People may move away and find housing and work in cheaper locations. There is a shortage of workers in the gentrified neighborhoods as people who used to work there move elsewhere and choose not to commute, thus making it difficult for the newly arrived to find cleaners or gardeners. Clearly, this may not result in a rise in homelessness.

A second possible outcome is the location of homelessness may be displaced. Displacement of poorer families and individuals into fewer locations or at greater distances from employment may occur. This can result in increased travel distances to work for displaced people and in overcrowding in other locations increasing family stress.

A third possible outcome is a temporary increase in homelessness which resolves over time. It may result in the loss of informal support and make life more difficult for those remaining, who may gradually drift away to live elsewhere; and eventually this becomes the same as the first outcome, with no effect on homelessness.

A fourth possible outcome is people may stay in the area sleeping in cars, couch surfing, or sleeping on the streets to be close to employment and social networks until driven out as the area gentrifies.

The additional difficulties in understanding and predicting outcomes stem from the structural differences in causality due to feedback loops in the situations. Expressed in a symbolically similar manner to the previous examples the changes in A, cause changes in B and C, and these also result in changes in A which cause further changes in B and C which in turn cause changes in A and so on.

Of course, the above are idealized examples in which just one feedback loop of causality results in all the factors influencing each other, thus making prediction of outcomes difficult to understand. Real-world design thinking, however, must contend with such interactions for a large number of multiple factors. However, even simple examples of real design situations with feedback loops present much more difficulty than the above when the actual feedback loops are taken into consideration.

Problematically, some designers have succumbed to recasting complex design situations as simple linear causal ones. The result, of course, is the faulty prediction of outcomes, worse outcomes, increased costs, and failed designs. Reflecting on this professional error, some in the urban design and planning arena have argued that design and planning theories (and research) have adopted an analytical scope that is too limited e.g. (Yiftachel & Huxley, 2000; Yiftachel, 2001). This paper points to the remedy of including feedback loops.

In what follows, the diagramming follows the conventions of Systems Dynamics' use of causal loop diagrams and stocks and flows models (Binder et al., 2004). Figure 1 below is an example of the relatively simple feedback loops of causality relating to the design and planning of public green space to help with clean air in a city. Although this involves relatively few factors, it is obvious how much more difficult is the design thinking necessary to predict the consequences of individual design decisions.

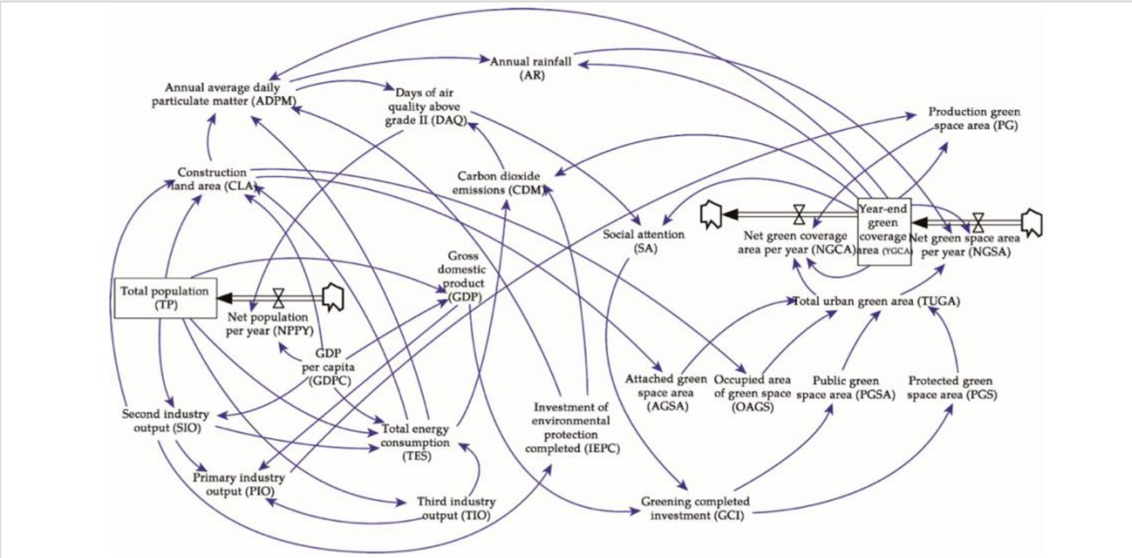

Figure 1: *Source Li et al., 2016.*

Figure 2 is another example of another real complex design thinking situation with feedback loops. In this case, the diagram shows the causal feedback loops of multiple design factors influencing public health in relation to transport.

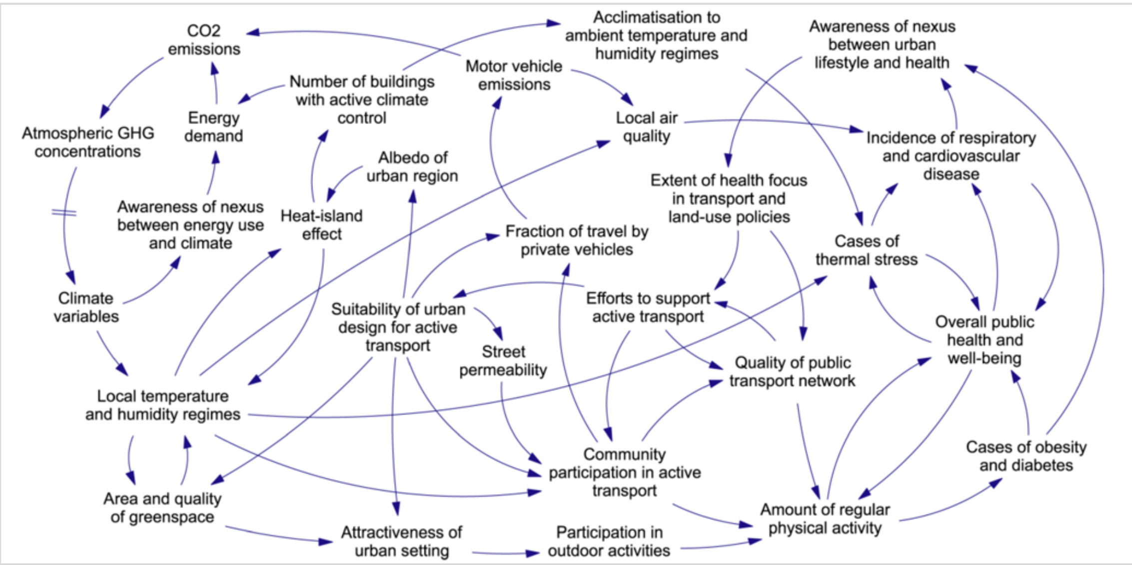

Figure 2: *Source Proust et al., 2019.*

It is important for designers to be able to predict the future consequences of design decisions. Reliable prediction of the future is the foundational and essential skill of any form of design or planning activity. If one cannot predict the future consequences of design or planning decisions reliably, then, although Design or Planning (with a capital D or P) self-evidently exists, it just isn't doing designing, design thinking or planning (with a small D, DT or P) as well as it could.

Looking at these relatively simple design situations reveal how much is the challenge for designers is predict how design decisions will affect outcomes *overall public health and well-being* in the above. This points to the need for new and different methods of design thinking for designers to include feedback loops in their design processes.

A key question for many design proposals is, *Will this design produce unintended negative outcomes?* Another important design thinking question is *How can the assumptions that inform the design and planning processes be improved?* (Sterman, 2002). Failure of prediction, and failure of design activities is costly. The routine application of feedback loop analysis in design thinking to more accurately predict outcomes increases the likelihood of project success and reduces the likelihood that unintended adverse consequences will be overlooked.

The need to include feedback loops in design involving complex situations has significant implications for collaborative and participative design activities. If individual designers or planners have difficulty to accurately predict outcomes from individual design decisions, then this problem is multiplied in collaborative design practices where each individual has a different mental model of the situation. In this latter case, the lack of coherent consensus on prediction means there is reduced or no real benefit in design quality from collaboration beyond designers feeling they have some social support from colleagues. In such design thinking and planning situations that involve feedback loops, stakeholder or community consultation, design teams, multidisciplinary teams, and the like are not likely to improve decision-making.

Complex situations whose behavior is shaped by feedback loops typically have dynamic and complex outcomes that change over time. Thus, design strategies that aim to achieve *an* outcome (i.e. a single fixed unchanging outcome) are inappropriate and will intrinsically fail. Outcomes of feedback loop situations will dynamically change in scope, scale, and direction over time. In other words, linear design thinking and planning approaches cannot be relied upon to achieve an intended outcome, as has been demonstrated by numerous historical design and planning failures.

Design Thinking and Planning approaches to address feedback loop situations are different in form to those used for the conventional simple linear causal situations. A different suite of design methods and planning tools are in most cases necessary for design thinking to undertake complex design with feedback loops. This paper will illustrate the above through a comparative case study focusing on the differing ways the Australian States of Western Australia and New South Wales addressed the COVID-19 epidemic and the related socio-economic issues, especially crime.

Health interventions for complex situations such as pandemics naturally involve multiple feedback loops between key factors. When the World Health Organization (WHO) declared COVID-19 a pandemic on March 11, 2020, a very small number of governments imposed rapid and severe lockdown measures; others responded less quickly. The health trajectories of the two approaches were dynamically different. A crucial difference between the design thinking underpinning the two differing approaches was understanding, in the successful approaches, that the COVID-19 phenomenon is dynamic and complex and includes feedback loops. Similarly, for crime due to COVID-19 feedback loops that modify criminal behavior (Drabek, 1986).

This paper uses the above background discussion and the following two case studies to propose that design thinking and planning theories and practices need to move beyond the traditional conventional linear causal approaches associated with *principles*, policies and theories, and participative design, and instead focus on design methods that centralize feedback loops in design thinking and decision-making.

Conceptual Framework

Conceptually, this paper uses comparative analysis of two complex design/planning strategy examples and draws on theories and concepts from systems analysis and complexity theory, plus new systems and complexity theory and concepts developed over the last two decades by Love in collaboration with Cooper (Love, 2001; 2002; 2007, 2008; 2009; 2010; Love & Cooper, 2007; 2007; 2008; 2011; 2011) and on criminological theories of CPTED and health of Cozens (Cozens, 2015; 2015; 2016; Cozens & Greive, 2009; Cozens & Love, 2009; Cozens et al., 2003; Cozens et al., 2004).

The approach echoes Rittel and Weber's boundary drawing in relation to what they called *wicked problems* (Rittel & Webber, 1974; 1984; 1972). Of special focus in this paper is the differences between design thinking and planning approaches in complex design situations with feedback loops in contrast to design situations with simple linear causality.

The authors' analytical approach contrasts with that of others analyzing design and planning strategies who primarily focus on linear causal methods, for example, the R-based view of the design of COVID-19 strategies common to health services e.g., (Kerr et al., 2021; Moss et al., 2020) and the crime prevention theory known as Routine Activity Theory (RAT) e.g., (Cohen & Felson, 1979; Felson & Clarke, 1998; Felson et al., 2020; Stickle & Felson, 2020) neither of which include feedback loops. We seek to highlight the importance of the difference between design situations with simple linear causality, and complex design situations (i.e. those with feedback loops) whose outcomes are almost always dynamic and continuously changing. This research uses systems dynamics causal loop diagramming to demonstrate the above via the two case studies of the COVID-19 pandemic in Western Australia and New South Wales, Australia.

Case Study: Western Australia and New South Wales

This comparative case study example is of the designed responses of government agencies in Western Australia and New South Wales to the COVID-19 epidemic including crime.

Western Australia (WA) is the largest state in Australia by area (around the same area as Western Europe). Its capital, Perth hosts around 80% of the population and, economically, primarily acts to service the extractive, agricultural, and tourism industries. As a result, much of the local economy of Perth itself focuses on service industries funded by revenue derived from industries in WA outside Perth. At the national scale, design and planning decisions in WA are important because the wealth generated in WA largely funds the remainder of Australia, as well as Australia-wide social benefits. This important national economic role of WA strongly influences WA government, industry, commercial, health and other socio-economic design and planning strategies.

New South Wales (NSW), in the east of Australia, has an advanced market economy with the main contributors being financial and insurance services, manufacturing, and tourism. Sydney, the capital of NSW, is the Australian base for many major manufacturing and commercial businesses and hosts the headquarters of commercial and public broadcasters. The governance of Sydney is distributed across 31 local government areas that make up the Sydney metropolis.

In response to COVID-19, Western Australia, and New South Wales developed and utilized very different designs of planning responses. In general, the Western Australian strategies were considerably more successful. This is based on the fact that, compared to New South Wales, Western Australia had:

- Almost zero lockdowns.
- Significantly less COVID-19 infection in the community (almost zero infections and deaths).
- Relatively normal life without restrictions for almost all of the population (except for being unable to leave Western Australia).
- Significantly increased economic outputs, domestic product, and growth in Western Australia, compared to the significantly reduced financial activity and outcomes in New South Wales (ABS, 2021).
- Expanded support for vulnerable citizens and groups.

- Local and hospital services operating well within capacity.
- Critical care services with spare capacity for normal illnesses.
- Normal health service provision.
- Smaller changes in crime.
- Almost zero civil disturbance

Below, we analyze these differences between WA and NWS outcomes in terms of the differences in design of the planning strategies in response to COVID-19, specifically, those structural design differences relating to feedback loops and causality of the effects of changes in design factors on each other used in WA, compared with more the linear causality design approach used in NSW.

1. *Western Australia*

Immediately. at the declaration of COVID-19 as a pandemic on March 11th, 2020, the WA government very rapidly (15th March) put the state in severe lockdown and constrained interstate and intrastate movement tightly, including strict closure of WA's international and interstate borders and isolation of arrivals into quarantine onto Rottnest Island (Dawson, 2020).This was prior to the closure of Australia's national borders by the Federal government. The result of designing such fast and extreme action that took into account the potential effects of feedback loops was that COVID-19 was contained and life for WA's citizens during the COVID-19 epidemic was substantially normal. The WA health infrastructure was unchallenged, and WA had positive economic outcomes, especially compared to other Australian States.

In short, the WA government realized and responded to the fact that positive feedback loops relating to COVID-19, and its propagation and its socio-economic effects would rapidly increase the size and scope of the problem unless action was designed to be taken immediately to fully control it. In system analysis terms, this was a recognition that the outcomes of a situation whose behavior is shaped by multiple feedback loops quickly get out of control due to the combination of positive feedback loops and lags in the effects of controlling strategies. By implementing strong and effective control strategies immediately, the Western Australian government was able to completely stop the spread of the virus. By combining this with rapid diagnosis and effective and immediate isolation of infected individuals, the spread of infection into the population was stopped. Key elements of the Western Australian Covid-19 protection strategy were:

- Immediate closure of WA borders (remembering that WA is the size of Europe).
- Division of WA into separate bounded regions, with no movement between them, and no access to Indigenous communities.
- A very brief period of household lockdown with strictly limited allowances for movement outside the home to obtain food or to undertake restricted exercise - all with masks (this was to give time to quickly identify where any cases were located whilst at the same time blocking further transmission).
- Public health advice to wash hands frequently.
- Strategies based directly on health advice from the Director-General of the Department of Health.
- Police redirection of duties and priorities to enforce lockdown and mask wearing and manage potential for civil insurrection. Many police crime prevention activities such as drunk driver testing was stopped.
- Significant investment in COVID-19 testing and contact tracing.
- Temporary housing provided to homeless people.
- A contact-tracing SAFEWA QR code app was immediately developed in WA and quickly implemented along with alternative contact movement recording comprising attendance sheets for name, time, date, and phone number in all cafes, shops, and other establishments open to the public.
- $5.5 billion WA recovery plan including funding for a new social housing program, to support the construction industry and support for reduced fees on TAFE courses (https://www.wa.gov.au/government/wa-recovery) .
- After the immediate short lockdown was completed, the WA state borders remained closed to international and interstate travel, and intrastate travel restrictions within WA applied. At this point, after it was clear that infection was stopped, the masking requirements were reduced.

Functionally, the primary aims of the WA government's COVID-19 strategies were:

- Protect people of WA, particularly the socio-economically disadvantaged, from the adverse effects of COVID-19.
- Ensure the absence of COVID-19 in the WA population.
- Maintain the economic activity of the extractive and agricultural industries.
- Avoid civil disturbance.
- Minimize crime.

Later, in 2021, two brief additional lockdowns were imposed each following the discovery of an infected person in the community due to (very rare) failure of infection control in quarantine.

This government awareness in WA to address the potentially extreme exponential feedback-related consequences of COVID-19 (suffered by other States and many countries) was identified by others. For example, Bradley et al. (2024) noted that *Given exponential growth in outbreaks, a later response will need more effort than an early one to be successful*. Bradley et al. presented a clear picture of the feedback loops involved (Figure 3).

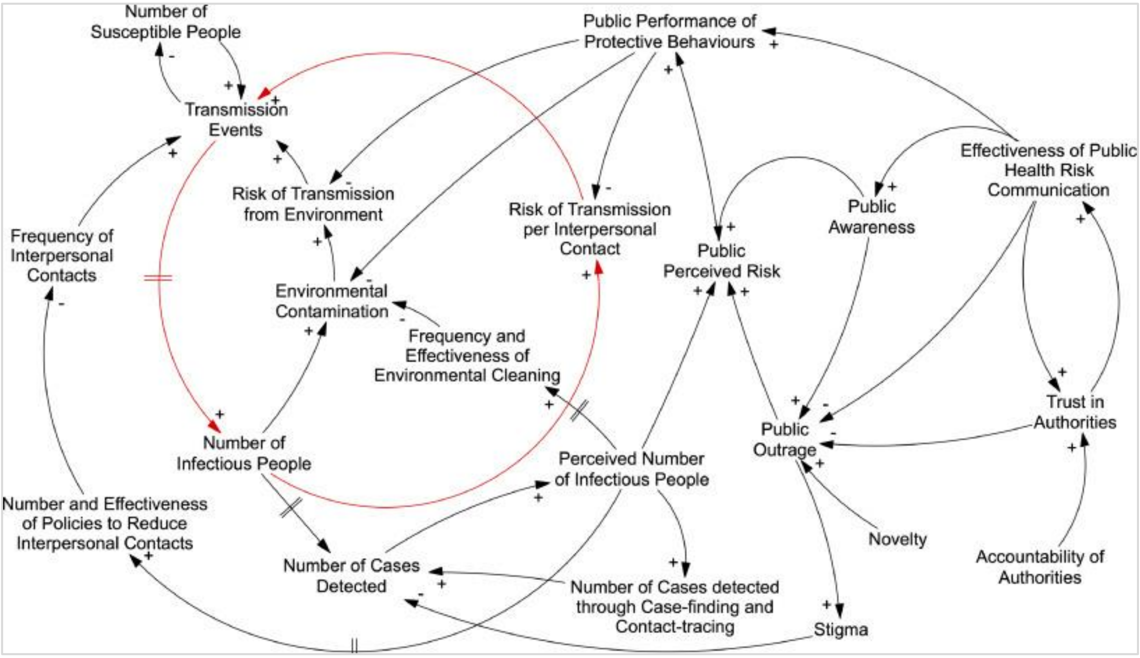

Figure 3: *Feedback loop diagram for design of COVID-19 strategies (Bradley et al., 2024).*

This focus on designing a strategy to limit the exponential effects of feedback loops explains at least in part the WA success in addressing COVID-19 compared to the adverse consequences in other jurisdictions such as New South Wales where Covid-19 control was delayed or weak and the consequences for the population were severe.

2. *New South Wales*

In contrast to Western Australia's strategies to quickly and completely control Covid-19, the New South Wales government's strategies to control COVID-19 were philosophically, politically, and socially different. The result was the strategies were functionally considerably less effective, substantially slower in their implementation, and had significantly worse outcomes. Under the NSW government's COVID-19 strategies, COVID-19 spread rapidly throughout the New South Wales population, statewide economic activity, and many businesses collapsed. The NSW population was subjected to multi-month-long harsh lockdown measures. Over four million people in NSW caught Covid-19 and there were between 6000 and 8000 deaths depending on the criteria (Australian Bureau of Statistics, 2024; Covid Live, 2024).

The NSW government adopted a medical approach to designing strategies to manage COVID-19 that assumed linear causality and substantially ignored the feedback loop effects. This fitted with their political priority to maintain business activity and the adoption of advice from the Burnet Institute (https://www.burnet.edu.au/research/health-themes/covid-19/). However, the slow development and implementation of the design of the NSW modelling and control intervention for Covid-19 resulted in substantially worse consequences compared to the Western Australian approach. The primary approach used in NSW was based on the linear COVASIM modelling of the Burnet Institute (which was also used to inform policy decision in the State of Victoria, in the US, the UK, and in many other countries that also had significantly adverse outcomes compared to Western Australia).

In contrast, planning for COVID-19 intervention by the NSW government was deliberately delayed and followed the kind of simple linear causal planning thinking exemplified by Figure 4, 5, & 6 below. The political and philosophical aim was to choose the minimal COVID-19 protection measures that would help avoid any adverse effect on businesses and delay response to community infections. The result was that the feedback loops shown in Figure 3 had the opportunity to take hold and exponentially increase the infection pathways, the subsequent number of live COVID-19 cases in the community, and the number of potential contacts. The delays to the first lockdown to control COVID-19 meant that NSW residents and workers were subjected to extensive long term stay at home (lockdown) restrictions that were harsher and longer than those of WA, many new COVID-19 cases were identified each day and NSW citizens were restricted from travel across several state boundaries. For the 2019-2020 year of which COVID-19 occupied approximately a quarter, NSW Gross State Product fell by 0.7% (i.e., a fall of around 2.8% per annum). This compares with the positive outcome for WA over that period of 1.4% (equivalent of an increase in GSP per annum of around 5.6%).

A detailed explanation of COVASIM software used for predicting the outcomes of design decisions on COVID-19 strategies is available from Kerr et al. (2021). The linearity of it can be seen somewhat in the graphics provided by the authors.

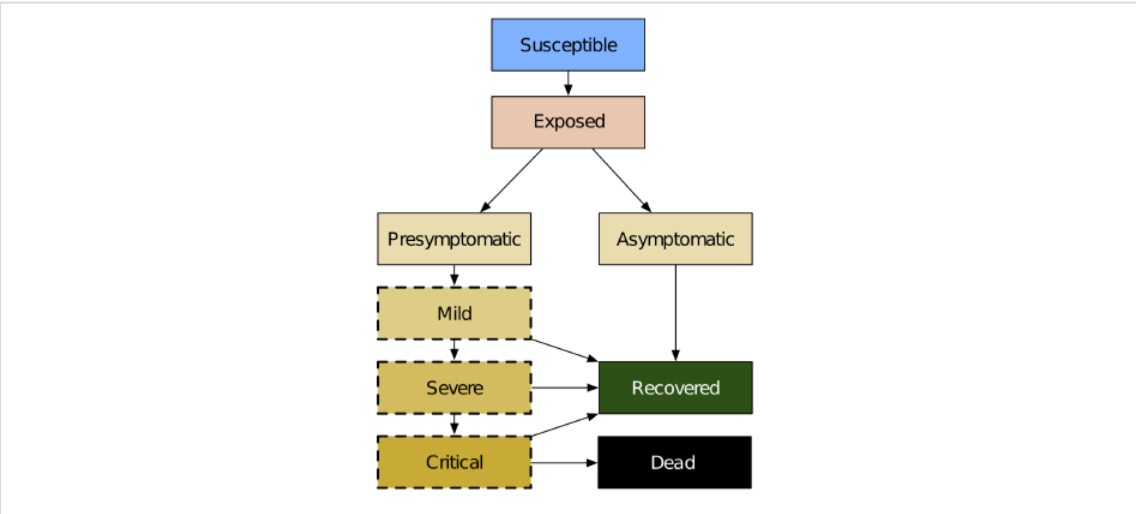

Figure 4: *COVASIM model structure (Kerr et al., 2021).*

Of relevant note, perhaps, is that according to those involved, the COVIDSIM software was developed after Covid-19 had taken hold for over a year, and that a primary role for most of the modelling software was for decision-makers to identify the past history of a number of cases and deaths. In other words, the modelling software used in NSW was to identify new strategies after perceiving the effects of previous interventions. In other words, the pandemic itself was the primary force shaping the trajectory of infections. Similar linear thinking can be seen in the modelling of the need for critical care facilities as shown in Figure 5.

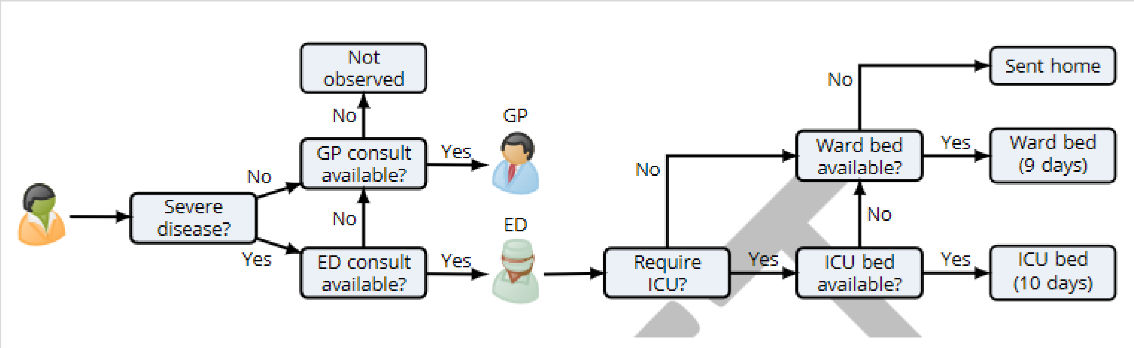

Figure 5: *Ritical care pathway COVID-19 model (Moss et al., 2020).*

The main design characteristics of the NSW government's strategy for managing the COVID-19 epidemic were.

- Slow response based on COVASIM and similar modelling that was undertaken following data collection about the progression of the COVID-19 epidemic as a basis for model configuration. This resulted in government strategy responses many weeks after those enacted in Western Australia.
- Minimal early constraints on the progression of COVID and a pandemic. This included initial minimization of lockdowns and mask wearing.
- Keeping open the borders internationally and interstate. The international borders were closed by the Federal government rather than the NSW State government.
- Minimal investment in testing and contact tracing.
- Minimal changes to policing priorities and activities.
- Encouragement of use of the Federal COVID Safe contact tracing app, which proved ineffective on many phones, and was distrusted by many with privacy concerns (Department of Health, 2021).

Differences in COVID-19 Outcomes from the WA and NSW Strategies

1. *Health Outcomes*

Outcomes from the WA government's design of COVID-19 strategies outcomes have been:

- Very low numbers of cases of COVID-19 in Western Australia.
- Minimal cases in quarantine and hospitals and typically zero active cases on any day.
- Total number of COVID-19 infections since March 2020 of around 950 by the end of the pandemic with typically zero new cases per day (https://covidlive.com.au/wa).
- 453 deaths due to Covid-19 (4% of total).

In contrast, the NSW government's COVID-19 strategies' outcomes have been:

- Very high levels of COVID-19 active infections in the community typically around 7,120 active cases.
- Around 25 new active COVID-19 cases per day (https://covidlive.com.au/wa) even in 2021 at the end of the epidemic.
- Between 3800 deaths due to Covid-19 (36% of total)

2. *Economic Outcomes*

The WA government's COVID-19 strategies resulted in the positive economic outcomes:

- 1.4% positive growth in Gross State Product (2019-2020).
- 3% growth of GSP (Gross State Product) in March quarter of 2021 (https://www.wa.gov.au/government/publications/highlights-of-the-wa-economy).
- May 2021 unemployment rate down to 4.7% (https://lmip.gov.au/default.aspx?LMIP/LFR_SAFOUR/LFR_UnemploymentRate).

The NSW government's COVID-19 strategies resulted in the following economic outcomes:

- 0.7% reduction in Gross State Product (2019-2020). This is the worst since start of official statistics in the early 1990s (https://www.treasury.nsw.gov.au/nsw-economy/about-nsw-economy/economic-outlook).
- May 2021 unemployment rate increased to 5.1% (https://lmip.gov.au/default.aspx?LMIP/LFR_SAFOUR/LFR_UnemploymentRate).

3. *Crime Outcomes*

In WA, over the period 2019-2021, property-related offenses fell by around 35% and drug offenses fell by 20%. However, family related offenses including domestic violence increased by 19% (https://www.police.wa.gov.au/Crime/CrimeStatistics#/).

In NSW, in the same period, crime outcomes were substantially stable. Sexual assault incident counts increased by 14% and domestic violence increased by 1.1% other crime category incident counts were stable or trended downwards (Kim & Leung, 2020).

Analysis

To recap, the focus of this paper is the potential for changes to design thinking for designers to be able to address complex situations involving feedback loops. Design thinking processes that take account of feedback loops enable designers to better predict the consequences of design decisions and avoid costly adverse outcomes. We have used, as an example, a comparison of two design approaches to developing COVID-19 strategies to demonstrate this.

The design thinking, planning, and implementation of COVID-19 strategies differed considerably in WA and NSW and led to very different outcomes in COVID-19 infection terms, economic terms, and employment terms. Interestingly, crime statistical trends were broadly similar in that some crimes rates, particularly property crime rates went down, and some crimes went up. However, the circumstances differed significantly in WA and NSW during COVID-19 due to differences in government strategies and outcomes, and this would have been expected to be reflected in differences in crime rates between the states.

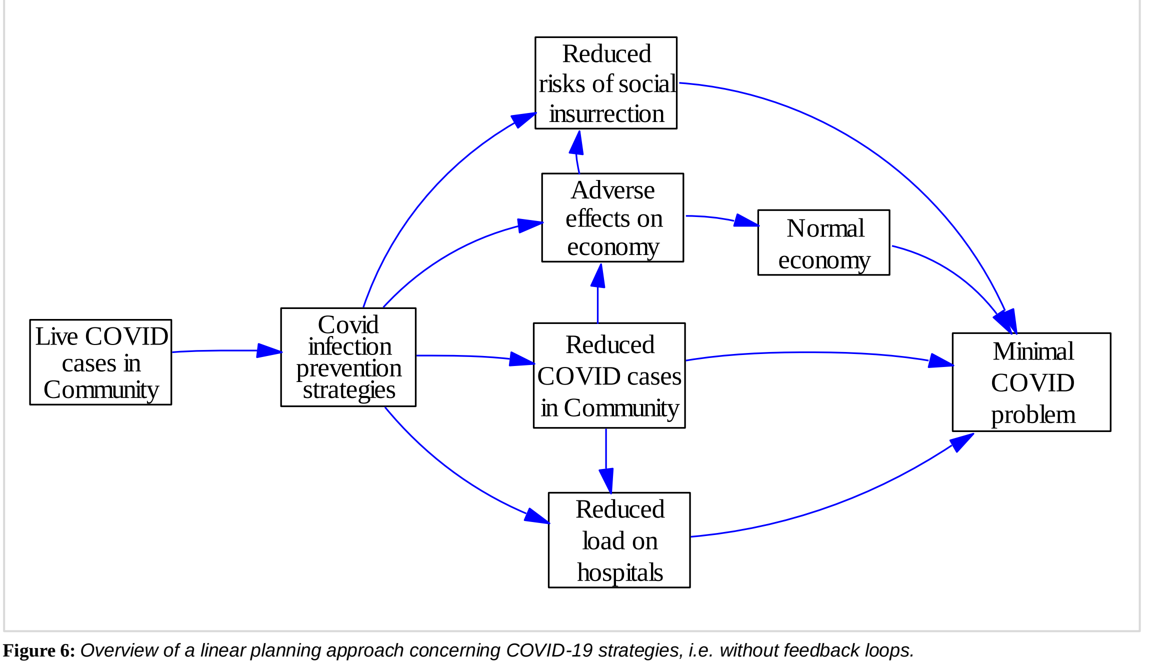

Figure 6: *Overview of a linear planning approach concerning COVID-19 strategies, i.e. without feedback loops.*

In New South Wales, the planning analyses and the strategies to contain COVID-19, the modelling of outcomes, and the communication of strategies to the public was essentially based on a view of the COVID-19 situation following a simple linear causal system model. A simplified representation of this is shown in Figure 6.

The general use of such linear causal approaches is indicated by various COVID-19 infection, transmission, and control models as catalogued, for example in Kerr et al. (2021), and the age and risk stratified transmission model of the Doherty Institute outlined by Moss et al. (2020).

Feedback loops could be initially introduced into the above design modelling of COVID-19 as shown below in Figure 7.

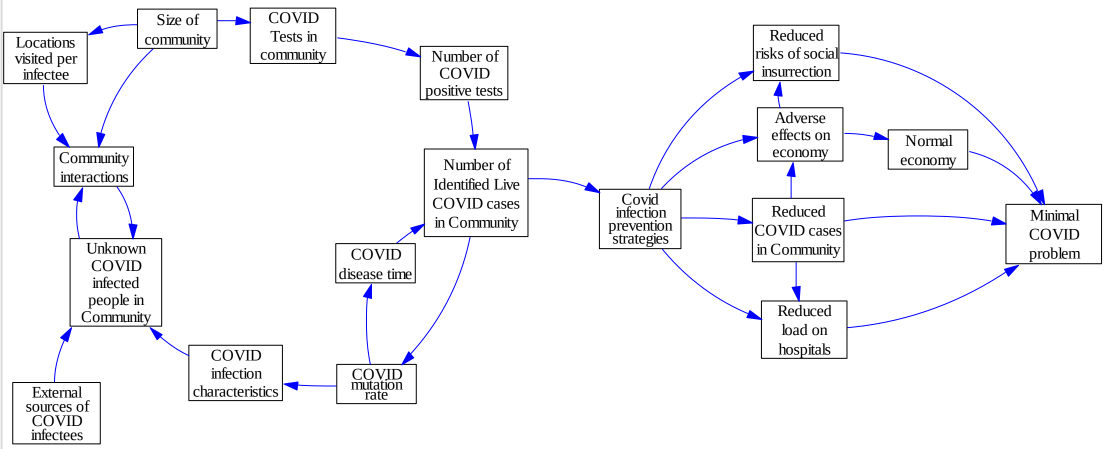

Figure 7: *Feedback model of COVID planning.*

The feedback loops in the left-hand side of Figure 7 provide designers with a basic indication of potential for non-linear rapid growth of live COVID-19 cases due to feedback, including feedback from changes to the fundamental characteristics of the replication, transmissivity, virulence, and infection time. All these potentially speed up the cycling through the feedback loops resulting in very rapid increases in identified cases.

A more complex feedback loop model of COVID-19 is that of Bradley et al. illustrated above in Figure 3 and for easier reference below in Figure 8.

For addressing COVID-19, a priority focus is to stop the reinforcing actions of the feedback loops that result in runaway infections, increased numbers of virus mutations, and the combination of high numbers of live cases in the community. Designing to reduce adverse economic and social effects and community-wide problems and improve health infrastructure are also of important.

One way of minimizing the feedback loop activity driving Covid-19 infections is to use lockdowns. They are over simplistically used in linear causal design thinking to reduce the rate of hidden community infection and provide time to undertake contact tracing to identify potential infected for more extreme isolation.

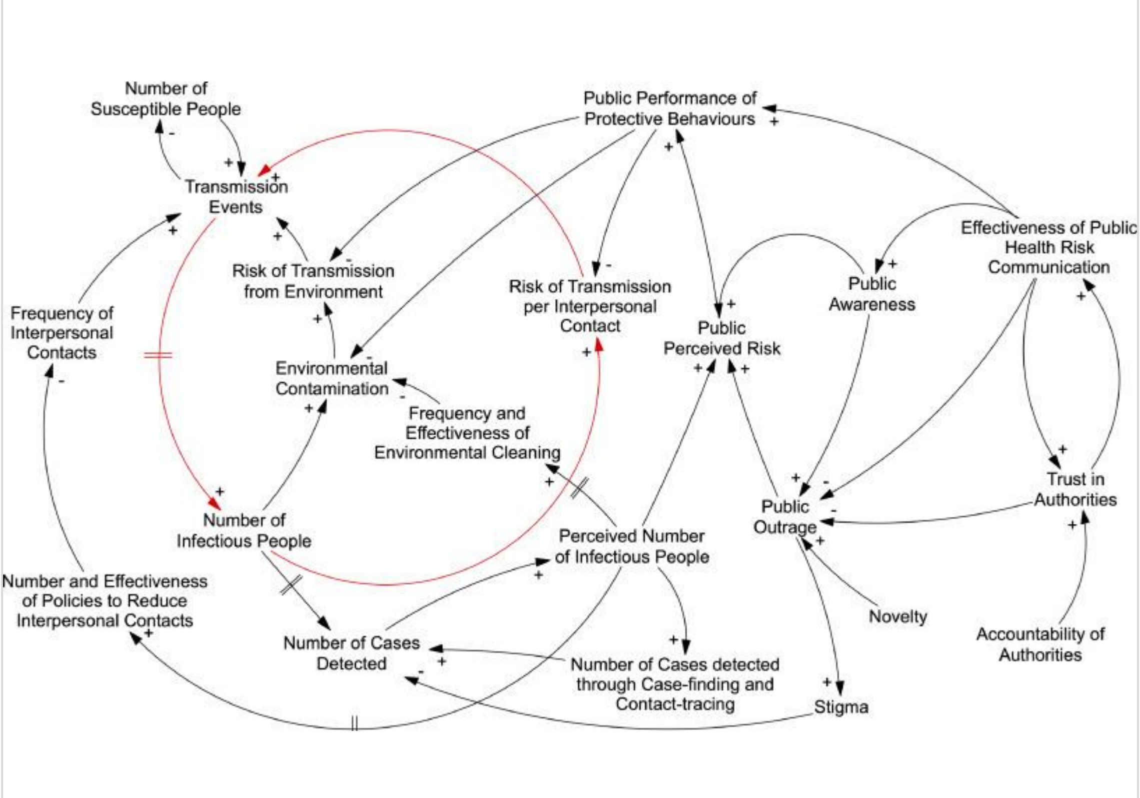

Figure 8: *Diagram showing main feedback loops in Covid-19 pandemic (Bradley et al., 2024).*

Design thinking that includes feedback loops, however, additionally includes the role of time. The effect of feedback loops on disease propagation and development rapidly increases over time. Hence, design thinking that includes of feedback loops, therefore, places more emphasis on minimizing the effect of time by minimizing disease propagation as fast and as early as possible and using the most powerful approaches to stop infection to ensure disease transmission is as close to zero as possible. Second to this, is immediate implementation of necessary disease controls at even the slightest sign of disease re-emergence, i.e., a single new case. This difference in design thinking is well demonstrated by the different approaches to control COVID-19 by the WA and NSW governments described above.

Crime

Design of strategies to address COVID-19 included management of crime. Similar to other design thinking, in crime prevention, there is a difference between designing intervention using the simple linear causal design thinking and design thinking that includes feedback loops.

Police statistics in WA and NSW show similar trends in reduced crime rates, particularly in property crimes (Freeman, 2020; Kim & Leung, 2020). Incidentally, this similarity in crime rate trends between WA and NSW is surprising because the changes in routine activities from the COVID-19 protection strategies in WA and NSW were dramatically different in terms of how much people stayed at home, how much the population's routines changed, and when. Lockdowns and business closures in WA were intense and primarily limited to the first 3 weeks immediately following the global declaration of the COVID-19 as a pandemic in March 2020. In contrast, the COVID-19 strategies of NSW were aimed at maintaining the NSW economy and avoiding the potential for civil reactions. In part this was likely because for NSW, the COVID-19 pandemic followed a serious bushfire and widespread flooding events.

Figure 9 shows typical crime management design thinking in COVID-19 following a linear approach.

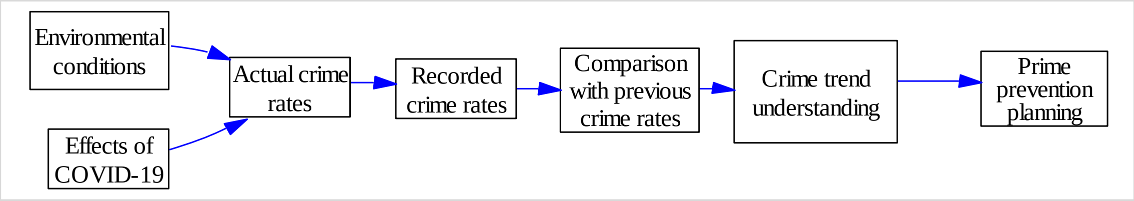

Figure 9: *Simple Planning model of COVID-19 crime prevention thinking.*

This linear causal thinking can be seen in the design of strategies to reduce domestic violence in both WA and NSW. In both cases, police recorded incident data was combined with call data from domestic violence hotlines. The analysis and underlying thinking follow the above model which can be expressed more specifically for domestic violence as shown below in Figure 10.

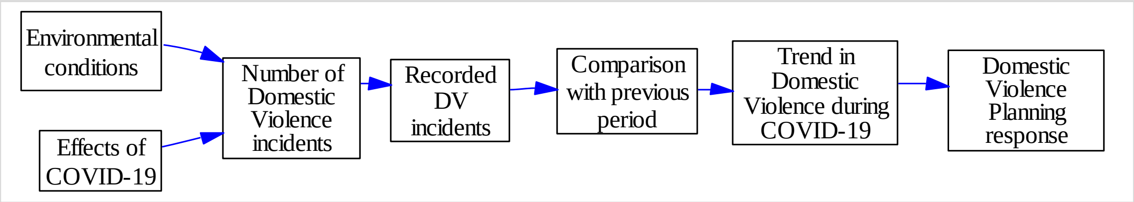

Figure 10: *Simple linear causal domestic violence planning response.*

The conclusion from such design thinking was there had been no change in domestic violence risk during COVID-19 and hence no need for any additional crime prevention or victim support.

However, other domestic violence data such as surveys of Australian women indicate that domestic violence and associated crime risks significantly increased during COVID-19 in Australia and other countries e.g., (Boxall et al., 2020; Carrington et al., 2020; Neil, 2020; Piquero et al., 2021; Richards & Nix, 2021; Sharma & Borah, 2020; WHO, 2020)

An approach to design thinking about domestic violence that includes feedback loops as shown in Figure 11 provides better prediction of outcomes and better understanding than the above linear causal approach, and provides a better basis for designing interventions that will lead to positive outcomes.

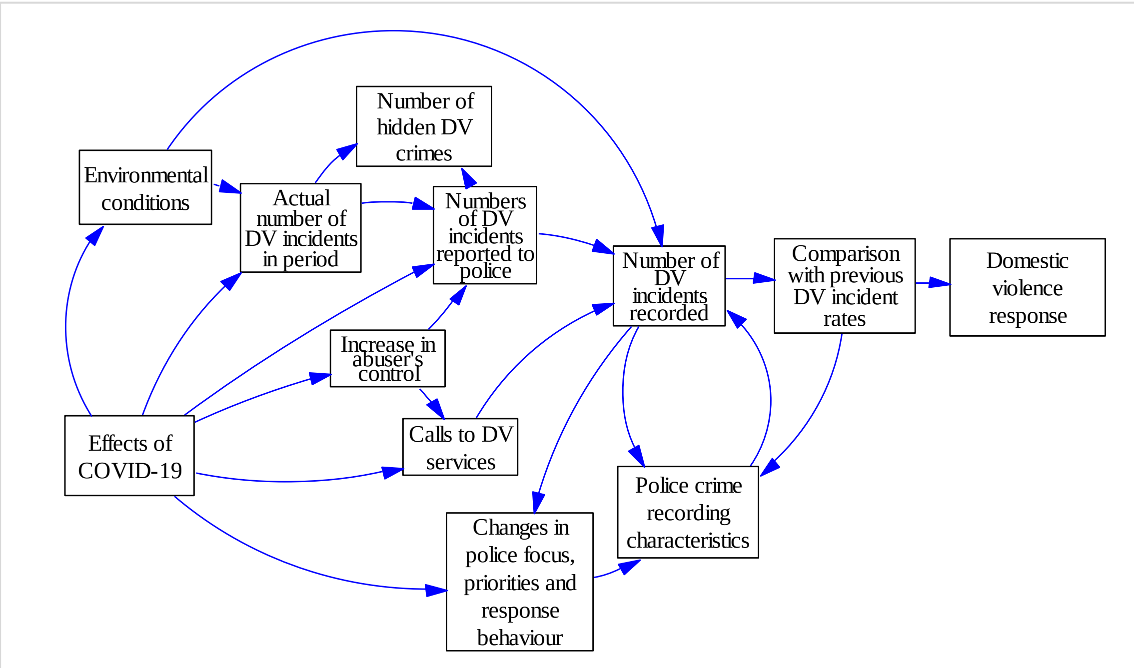

Figure 11: *Feedback loop model of domestic violence.*

The above feedback loop model offers an increased understanding of the effects of COVID-19 on changes in abusers' control of victims and changes to police and others' behaviors. It offers a way of viewing the above situation through the lens of routine activity analysis and routine activity theory (RAT; Cohen & Felson, 1979). Given the COVID-19 changes to routines, associated with locking people down at home, RAT suggests an increase in DV abuse likely. The feedback loop diagram above in Figure 11 offers design thinking advantages in explaining how and why such increases in domestic violence didn't in recorded crime incidents or increased calls to support services and what designed interventions would have been likely successful.

Conclusions and Summary

This paper has demonstrated how focusing on feedback loops in complex design thinking situations offers potential for considerable benefits over the more conventional and commonplace linear causal approaches. The paper has used as an example comparison of government strategies of Western Australia and New South Wales to address the COVID-19 pandemic and associated crime.

The WA government addressed the implications of feedback loops and its implications for time in the factors shaping COVID-19 and its consequences. In contrast, the NSW government interventions were based on linear causal thinking and utilized more conventional operations research modelling approaches of the sort used in hospital planning and policy.

The paper reviews the success or otherwise of the two approaches to design thinking in terms of the outcomes in each state. The WA approach of including feedback loops in their design thinking resulted in significantly better outcomes compared to NSW linear causal strategies.

Causal Loop Diagrams have been used to illustrate the differences between the two approaches in terms of COVID-19 and crime, particularly domestic violence.

We suggest that design thinking, design decision making, design practices, and design education would benefit from the increased inclusion of feedback loops in design theories and methods. This especially applies to improving the outcomes of design in complex contexts.

The analyses of this paper suggest there is potential for significant improvement in design outcomes, reduction in design decision making risks, and improved confidence in professional design and design thinking. The analyses imply there are likely to be significant benefits in changes in design education that emphasize the role of causal feedback loops and the development of tools for addressing them to provide predictions of changes outcomes resulting from differing design decisions. Both have deep implications for design practices, especially related to stakeholder involvement and community participation in design.

The authors declare no conflicts of interest.

No funding was received for this project.

References

ABS. (2021). *Australian national accounts: State accounts*. Key National Accounts aggregates by state and territory. Reference period 2019-20 financial year. Canberra: Australian Bureau of Statistics.

Australian Bureau of Statistics. (2024). *COVID-19 Mortality in Australia: Deaths registered until 31 January 2024*.

Beames, T. (1850). *The rookeries of London: past, present and prospective*. London: Thomas Bosworth.

Binder, T., Vox, A., Belyazid, S., Haraldsson, H. V., & Svensson, M. (2004). *Developing system dynamics models from causal loop diagrams.*

Boxall, H., Morgan, A., & Brown, R. (2020). *The prevalence of domestic violence among women during the COVID-19 pandemic*. Canberra: Australian Institute of Criminology.

Bradley, D. T., Mansouri, M. A., Kee, F., & Garcia, L. M. T. (2024). *A systems approach to preventing and responding to COVID-19*. eClinicalMedicine Lancet, 21(100325). doi:DOI:https://doi.org/10.1016/j.eclinm.2020.100325

Briggs, L. (2012). *Tackling wicked problems: A public policy perspective*. Canberra: Australian Public Service Commission.

Carrington, K., Morley, C., Warren, S., Harris, B., Vitis, L., Ball, M., & Ryan, V. (2020). *The impact of COVID-19 pandemic on domestic and family violence services and clients: QUT centre for justice research report*. Brisbane: QUT Centre for Justice.

Chang, M. J., A., & Egbutah, C. (2015). *Public health in planning good practice guide: Town and country planning association*. TCPA.

Cohen, L., & Felson, M. (1979). *Social change and crime rate trends: a routine activity approach*. American Sociological Review, 44, p. 588-608.

Covid Live. (2024). Retrieved from https://covidlive.com.au/nsw.

Cozens, P. (2015). *Crime and community safety: Challenging the design consensus*. In H. Barton, S. Thompson, M. Grant, & S. Burgess (Eds.), Handbook of Planning for Health and Well-Being, p. 162-177. London: Routledge.

Cozens, P. (2015). *Crime as an unintended consequence: Planning for healthy cities and the need to move beyond crime prevention through environmental design.* In J. Glasson & J. Brunner (Eds.), Contemporary Issues in Australian Urban and Regional Planning. p. 230-250. Routledge.

Cozens, P. (2016). *Think crime! using evidence, theory and Crime Prevention Through Environmental Design (CPTED) for planning safer cities (2nd Ed.)*. Quinns Rocks: Praxis Education.

Cozens, P., & Greive, S. (2009). *Designing crime precipitators in Northbridge after dark: Urban governance in slumber*. Paper Presented at the Annual State of Australian Cities Conference (SOAC): City Growth, Sustainability, Vitality and Vulnerability, University of Western Australia, Perth.

Cozens, P., & Love, T. (2009). *Permeability as a process for controlling crime: A view from western Australia*. Special edition of the built environment journal. Security versus safety: How to deliver less crime and more sustainable design. Journal of the Built Environment., 35(3), p. 346-365.

Cozens, P., Neale, R. H., Whitaker, J., & Hillier, D. (2003). *Managing crime and the fear of crime at railway stations*. A case study in South Wales (UK). International Journal of Transport Management, 1(3), p. 121-132.

Cozens, P., Pascoe, T., & Hillier, D. (2004). *The policy and practice of Secured by Design (SBD)*. Crime Prevention and Community Safety: An International Journal, 6(1), p. 13-29.

Dawson, C. J. (2020). *Emergency management act 2005 (WA) sections 61, 67, 71 and 72A outbreak restrictions (circuit-break lockdown - level 3).* Directions: Police and State Emergency Coordination, Western Australian Government.

Del Carmen, A., & Robinson, M. (2000). *Crime prevention through environmental design and consumption control in the United States*. The Howard Journal, 39(3), p. 267-289.

Department of Health. (2021). *Final report: Evaluation of the operation and effectiveness of COVIDSafe and the National COVIDsafe datastore*. Canberra: Department of Health.

Drabek, T. (1986). *Human system responses to disaster: An inventory of sociological findings*. New York: Springer-Verlag.

Duhl, L. J., & Sanchez, A. K. (1999). *Healthy cities and the city planning process*. World Health Organisation.

Felson, M., & Clarke, R. V. (1998). *Opportunity makes the thief. Practical theory for crime prevention*. London: Policing and Reducing Crime Unit.

Felson, M., Jiang, S., & Xu, Y. (2020). *Routine activity effects of the Covid-19 pandemic on burglary in Detroit, March 2020*. Crime Science, 9(10), p. 1-7. http://doi.org/10.1186/s40163-020-00120

Freeman, K. (2020). *Monitoring changes in domestic violence in the wake of COVID-19 social isolation measures*. NSW: BOCSAR.

Home Office. (2004). *Safer places the planning system and crime prevention*. Queen's Printer and COntroller of Her Majesty's Stationery Office.

ISO. (2021). *Security and resilience - Protective security - Guidelines for crime prevention through environmental design ISO 22341:2021 (E)*. Switzerland: International Standards Authority.

Kerr, C., Stuart, R., Mistry, D., Abeysuriya, R., Rosenfeld, R., Hart, G., & Klein, D. (2021). *Covasim: An agent-based model of COVID-19 dynamics and interventions*. Computational Biology.

Kim, M.-T., & Leung, F. (2020). *COVID-19 pandemic and crime trends in NSW*. NSW: BOCSAR.

Li, F., Sun, Y., Li, X., Hao, X., Li, W., Qian, Y., Liu, H., & Sun, H. (2016). *Research on the sustainable development of green-space in beijing using the dynamic systems model*. Sustainability, 8(10), 965.

Love, T. (2001). *Distributing requisite variety in systems: The roles of human affects, feelings and associated neurological processes*. Retrieved from Perth, WA.

Love, T. (2002). *Complexity in design management: Layered system dynamics graphs*. In P. Ledington & J. Ledington (Eds.), Management Approaches to Complex Systems. Mooloolaba, Qld: University of the Sunshine Coast.

Love, T. (2007). *System dynamics modelling of national design infrastructure development*. In K. Fielden & J. Sheffield (Eds.), Systemic Development: Local Solutions in a Global Environment. ANSYS 2007 Proceedings, CDROM. Auckland: Unitech.

Love, T. (2008). *Design for improving hospital stroke unit processes: Reducing complex systems failures leading to adverse patient outcomes*. In C. Rust (Ed.), Design Research Society International Conference 2008: Undisciplined! p. CDROM. Sheffield, UK: Sheffield Hallamn University and Design Research Society.

Love, T. (2009). *Complicated and complex crime prevention and the 2-feedback loop law*. In T. Cooper, P. Cozens, K. Dorst, P. Henry, & T. Love (Eds.), Proceedings of iDOC'09 *What's Up Doc* International Design Out Crime Conference. Perth: Design Out Crime Research Centre.

Love, T. (2010). *Design guideline gap and 2 feedback loop limitation: Two issues in design and emotion theory, research and practice*. In J. Gregory, K. Sato, & P. Desmet (Eds.), Proceedings of the 7th Design and Emotion Conference 2010 Blatantly Blues. Chicago: Institute of Design and Design and Emotion Society.

Love, T., & Cooper, T. (2007). *Complex built-environment design: Four extensions to ashby*. Kybernetes, 46(9/10), p. 1422-1435.

Love, T., & Cooper, T. (2007). *Digital eco-systems pre-design: Variety analyses, system viability and tacit system control mechanisms*. In E. Chang & F. K. Hussain (Eds.), 2007 Inaugural IEEE International Conference on Digital Ecosystems and Technologies 21-23 February 2007 Cairns, Australia, p. 452-457. Los Alamitos, CA: IEEE.

Love, T., & Cooper, T. (2008). *Machiavelli with extra variety: Taking organisational power and control*. Paper presented at the Institute of Enterpreneurship and Terprise Development, Management School, Lancaster University, Lancaster, UK, Lancaster, UK.

Love, T., & Cooper, T. (2011). *Digital ecosystems: Conceptual optimisation to manage complexity, interoperability and viability (working paper)*. Love Services Pty Ltd. Quinns Rocks.

Love, T., & Cooper, T. (2011). *Using variety analyses to improve educational sustainability and liveability (working paper)*. Love Services Pty Ltd. Quinns Rocks.

Megahed, N., & Ghoneim, E. (2020). *Antivirus-built environment: Lessons learned from Covid-19 pandemic*. Sustainable Cities and Society, 61, p. 1-9. http://doi.org/10.1016/j.scs.2020.102350

Moss, R., Wood, J., Brown, D., Shearer, F., Black, A. J., Cheng, A. C., & McVernon, J. (2020). *Modelling the impact of COVID-19 in Australia to inform transmission reducing measures and health system preparedness (pre-print).* Doherty Institute.

Neil, J. (2020). *Domestic violence and COVID-19. Our hidden epidemic*. Aust J Gen Pract, 49(25). DOI: 10.31128/AJGP-COVID-25

Northridge, M. E., & Sclar, E. (2003). *A joint urban planning and public health framework: Contributions to health impact assessment.* American Journal of Public Health, 93(1), p. 118-121.

Piquero, A. R., Jennings, W. G., Jemison, E., Kaukinen, C., & Knaul, F. M. (2021). *Impact report: COVID-19 and domestic violence trends. Evidence from a systematic review and meta-analysis*. Washington, DC: National Commission on COVID-19 and Criminal Justice.

Proust, K., Newell, B., Brown, H., Capon, A., Browne, C., Burton, A., Dixon, J., Mu, L., & Zarafu, M. (2019). *Human health and climate change: Leverage points for adaptation in urban environments*. Int. J. Environ. Res. Public Health 2012, 9, p. 2134-2158. https://doi.org/10.3390/ijerph9062134

Richards, T. N., & Nix, J. (2021). *Domestic violence calls for help increased during the pandemic – but the answers haven't gotten any easier*. Conversation.

Rittel, H. W. J. (1972). *On the planning crisis: Systems analysis of the first and second generations*. Bedriftsokonomen, 8.

Rittel, H. W. J. (1972). *Son of RittleThink, DMG Occasional Paper No. 1 (Jan 1972)*. In Design Methods Group 5th Anniversary Report, p. 5-10. Design Methods Group.

Rittel, H. W. J. (1984). *Second generation design methods*. In N. Cross (Ed.), Developments in Design Methodology. London: John Wiley and Sons Ltd.

Rittel, H. W. J., & Webber, M. W. (1972). *Dilemmas in a general theory of planning, working paper, institute of urban development*. Berkely, USA: University of California. No 194.

Rittel, H. W. J., & Webber, M. M. (1974). *Wicked Problems*. In N. Cross, D. Elliot, & R. Roy (Eds.), Man-made Futures. London: Hutchinson and Co (Publishers) Ltd. p. 272-280.

Rittel, H. W. J., & Webber, M. M. (1984). *Planning problems are wicked problems*. In N. Cross (Ed.), Developments in Design Methodology. London: John Wiley and Sons Ltd.

Sharma, A., & Borah, S. V. (2020). *Covid-19 and domestic violence: an indirect path to social and economic crisis*. Journal of Family Violence. https://doi.org/10.1007/s10896-020-00188-8

Shipway, C., & Homel, P. (1999). *Safer cities and towns: Crime prevention planning in rural New South Wales*. Sydney: Crime prevention division, NSW Attorney-General's Department.

Sterman, J. D. (2002). *All models are wrong: Reflections on Becoming a Systems Scientist*. System Dynamics Review, 18(4), p. 501-531. Retrieved from https://web.mit.edu/jsterman/www/All_Models_Are_Wrong_(SDR).pdf

Stickle, B., & Felson, M. (2020). *Crime rates in a pandemic: the largest criminological experiment in history*. American Journal of Criminal Justice, 45, p. 525–536. https://doi.org/10.1007/s12103-020-09546-0

WHO. (2020). *COVID-19 and violence against women What the health sector/system can do*. World Health Organisation, Human Reproduction Programme.

WHO. (2020). *Integrating health in urban and territorial planning: A sourcebook*. UN-Habitat and World Health Organization.

Yiftachel, O. (2001). *Introduction: Outlining the power of planning*. In O. Yiftachel, I. Alexander, D. Hedgcock, & J. Little (Eds.), The Power of Planning: Spaces of Control and Transformation. KluwerAcademic.

Yiftachel, O., & Huxley, M. (2000). *Debating dominance and relevance: Notes on the communicative turn in planning theory*. International Journal of Urban and Regional Research, *24*(4), p. 907–913.