Senior Care is a Complex Ecosystem

The Attack Surface Area

The operational ecosystem of a Senior Care Facility, as depicted in Figure 1, is complex. It's worth noting that almost all external entities that come in contact with these facilities are in multiples (many pharmacies, many doctors, many hospitals, etc.), and they interact with the residents of the Senior Care facility multiple times every day.

This implies that the attack surface area (a terminology from the cyber security domain - the size and shape of the zone that exposes vulnerability) though which the infection can attack our residents, which the facilities must be concerned with, is therefore very large.

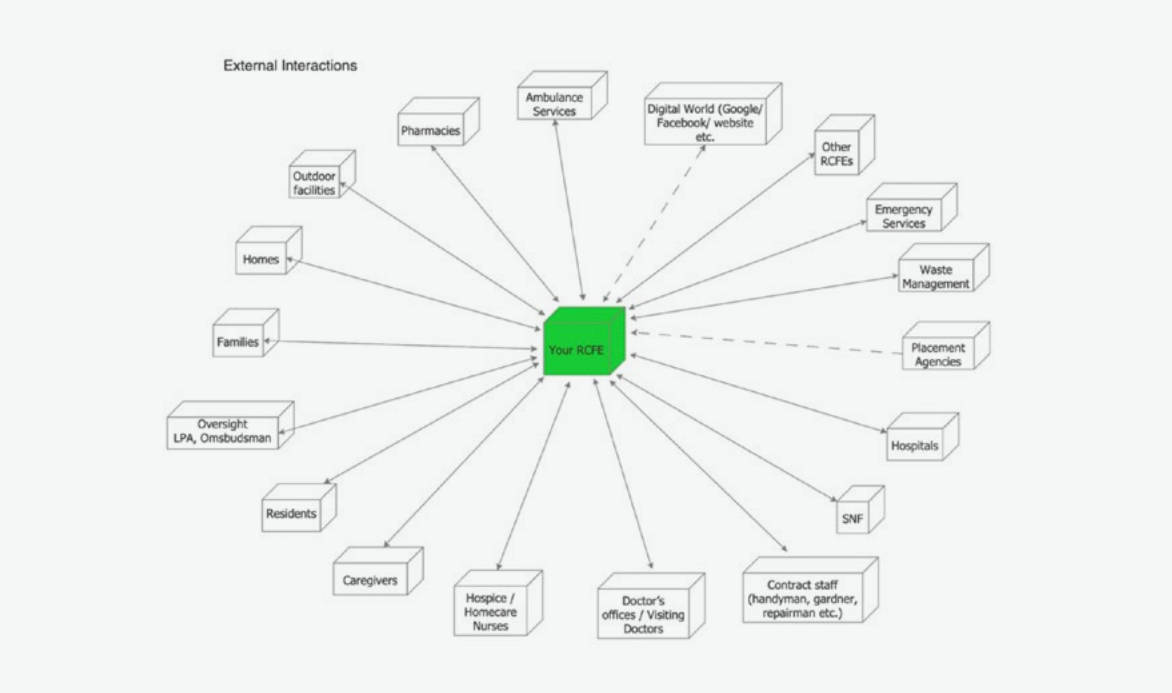


Figure 1: *A complex operational ecosystem*

While some industries can boast of the automatic benefits of remote working, Senior Care facilities will continue to be a hi-touch industry. While there will be opportunities to use remote examination via 'tele-health-visits', the bulk of caregiving will remain hi-touch, requiring physical contact.

If we dig deeper to understand a facility's level of exposure, we find that we can think of it in three parts:

- From the outside-in
- When the bug is already inside
- Transmission pathways
    - Via surface contact
    - Via aerial pathway

Each of the above exposure categories can result in an infection to a once healthy senior.

From Outside

Every interaction with the outside world represents an infection transmission vector – a pathway along which infection can travel. In Figure 1, only the dotted lines represent interfaces that are not involved in possible infection transmission.

The number of ways in which infection can come from outside is:

(number of residents) x (number of visitation events from outside)

This grows geometrically as the bed capacity increases.

When the Bug Is Inside

To go deeper, Figure 2 represents the interactions between the insiders. On the inside, we have two types of actors:

- Human (residents, caregivers, visiting professionals, staff, contract workers, family members, etc.).
- Non-human (care equipment like wheelchairs and walkers, cleaning equipment, faucets, doorknobs, etc., which once contaminated with a bacteria or virus can lead to spread).

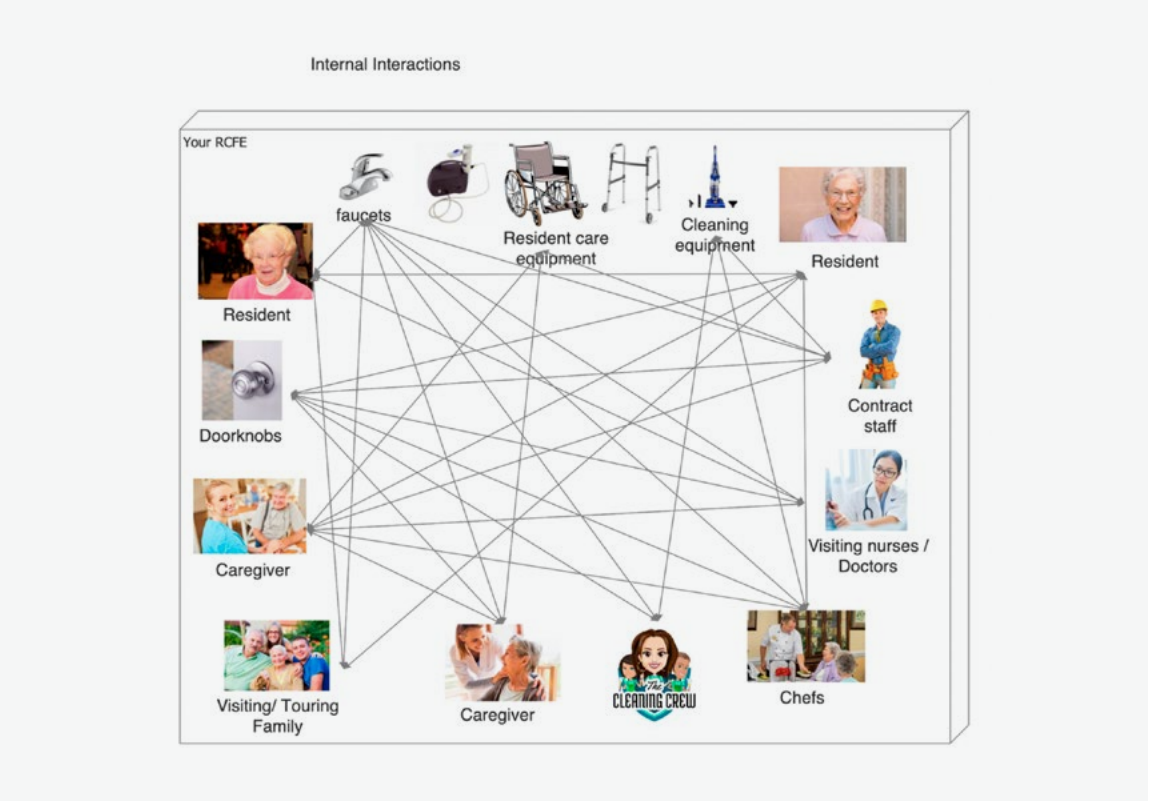


Figure 2: *The complexity multiplies on the inside*

Every interaction represents another infection transmission vector and like before, each entity is in multiples. Inside the Senior Care homes, the attack surface area grows exponentially.

Quantitatively, we can look at the number of transmission vectors activated (not including the aerial route) in the daily care of just one resident. We assume that:

- Each resident requires a care visit by a caregiver once every two hours. Thus daily, the care giver visits the resident's room 12 times. For each visit, the caregiver opens and closes the room door twice (once during entry and next during exit). Thus, daily the number of touches that caregiver has with the door knobs = 48
- Each resident leaves the room for breakfast, lunch, dinner, and one additional activity. So, the number of times the resident may interact with the door knob will be = 16
- Each resident uses the restroom once every 3 hours. Thus daily the number of touches = 32. (If the caregiver is assisting in restroom / showering activities, then these interactions may be executed by the caregiver.)
- Each resident uses faucets 16 times daily, flushes toilets 8 times daily, and uses grab bars 8 times daily.

Altogether, we can easily assume that the number of times that an infection transmission vector is invoked = 128 times.

Now for a facility that had 20 beds (as in Golden Springs Ranch):

- The total number of active infection transmission vectors = 20*128 = 2,560

Figure 3: *The Aerial Route*

Figure 4: *Man sneezing*

Figure 5: *Micro-droplets linger on for a long time*

The Aerial Pathway

In an eye-opening simulation[6] (Figure 3) of infection spread, the aftermath of an infectious person coughing in a grocery store aisle was presented.

In this time-lapse, we see the droplet- cloud spread rate via the aerial pathway. In this case, no contact disinfection methods (disinfectant sprays, wiping surfaces, UV lights, etc.) may be effective.

The issue is further compounded by the fact that in closed spaces, like in an Senior Care home, the HVAC system, which is traditionally not designed to disinfect, recirculates air. Theoretically, this makes the attack surface area hyper large and any human actor can be the source, with anyone in the vicinity becoming a target.

Another study in Japan (NHK) published a 'micro-droplet' infection transmission mechanism report[7]. Figures 4 and 5 depict the pictures from a high-speed infrared camera after a sneeze.

The latest headlines from WHO[26] claim that data exists that Coronavirus is airborne (Figure 6).

While we do not have much data about this aerial infection spread, it suffices to say that this dramatically increases the attack surface area needing defense.

Telemetry of the Spread

One example of telemetry is how scientists track the movement of whales in ocean documentaries. Telemetry can also be used to track the spread of infectious viruses and bacteria.

Using these methods, if one were to track the sequence of:

- Door handles touched to enter the resident room,

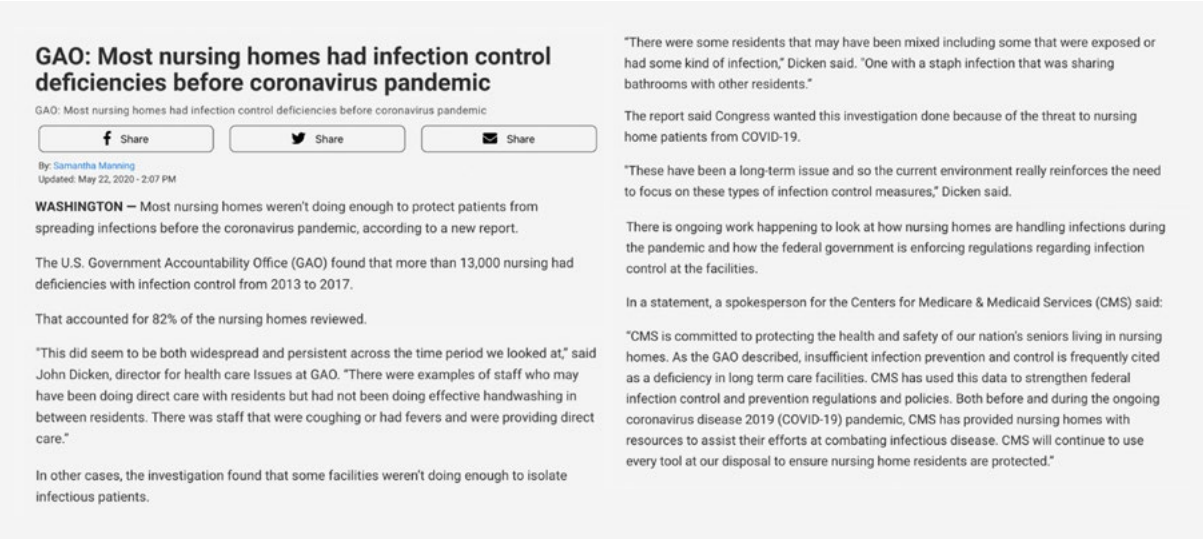
- The equipment touched (walkers, wheelchairs, breathing oxygen tubes, CPAP masks, etc.),
- The body contact during caregiving events (incontinence care, toileting, bathing, tooth brushing, etc.),
- Meals delivery (food plates, bowls, delivery presentation, milk pouring, etc.) as well as post-meal cleanup activity,

we could theoretically arrive at the detailed telemetry of the infection spread.

An eye-opening (and scary) video8, compiled by CNN, showed a black light simulation (Figure 7) of a dinner table setting and how quickly and completely germs can spread in a short time.

Figure 6: *WHO claims Coronavirus is airborne!*

Figure 7: *Black light simulation of spread telemetry*



GAO: Most nursing homes had infection control deficiencies before coronavirus pandemic

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By: Samantha Manning
Updated: May 22, 2020 - 2:07 PM

WASHINGTON — Most nursing homes weren't doing enough to protect patients from spreading infections before the coronavirus pandemic, according to a new report.

The U.S. Government Accountability Office (GAO) found that more than 13,000 nursing had deficiencies with infection control from 2013 to 2017.

That accounted for 82% of the nursing homes reviewed.

"This did seem to be both widespread and persistent across the time period we looked at," said John Dicken, director for health care Issues at GAO. "There were examples of staff who may have been doing direct care with residents but had not been doing effective handwashing in between residents. There was staff that were coughing or had fevers and were providing direct care."

In other cases, the investigation found that some facilities weren't doing enough to isolate infectious patients.

"There were some residents that may have been mixed including some that were exposed or had some kind of infection," Dicken said. "One with a staph infection that was sharing bathrooms with other residents."

The report said Congress wanted this investigation done because of the threat to nursing home patients from COVID-19.

"These have been a long-term issue and so the current environment really reinforces the need to focus on these types of infection control measures," Dicken said.

There is ongoing work happening to look at how nursing homes are handling infections during the pandemic and how the federal government is enforcing regulations regarding infection control at the facilities.

In a statement, a spokesperson for the Centers for Medicare & Medicaid Services (CMS) said:

"CMS is committed to protecting the health and safety of our nation's seniors living in nursing homes. As the GAO described, insufficient infection prevention and control is frequently cited as a deficiency in long term care facilities. CMS has used this data to strengthen federal infection control and prevention regulations and policies. Both before and during the ongoing coronavirus disease 2019 (COVID-19) pandemic, CMS has provided nursing homes with resources to assist their efforts at combating infectious disease. CMS will continue to use every tool at our disposal to ensure nursing home residents are protected."

Figure 8: *GAO Report*

This is Not New Knowledge

Surprisingly, the huge attack surface area of germs and their spread telemetry not only existed but were assessed well before Coronavirus and have been highlighted in the GAO report[1,2] (Figure 8).

However, before Coronavirus, no one attempted to quantify the level at which MRSA, C-Diff, Influenza, and other diseases had ravaged senior living communities, simply because these other infectious diseases did not have a high fatality rate. The appearance of Coronavirus, a highly virulent bug exposed the chink in our armor.

The statistics in Los Angeles County (Figure 9) are eye-opening.

Complex Systems Are Gnarly!

Complex Systems is indeed a complex science. While simplifying it may seem futile, we will attempt to do just that, in relation to the Coronavirus threat.

Most of us think of cause and effect as a linear process and we tend to draw it 'left to right' using bubbles and arrows. However, in complex systems, circular causality, feedback loops, time delays, exponential escalation or decays are the norm. The result is that causes and their effects can be very non-linear and widely separated in space and time. The more interconnected the systems are the more the ripples travel. Societies are classic examples of complex ecosystems.

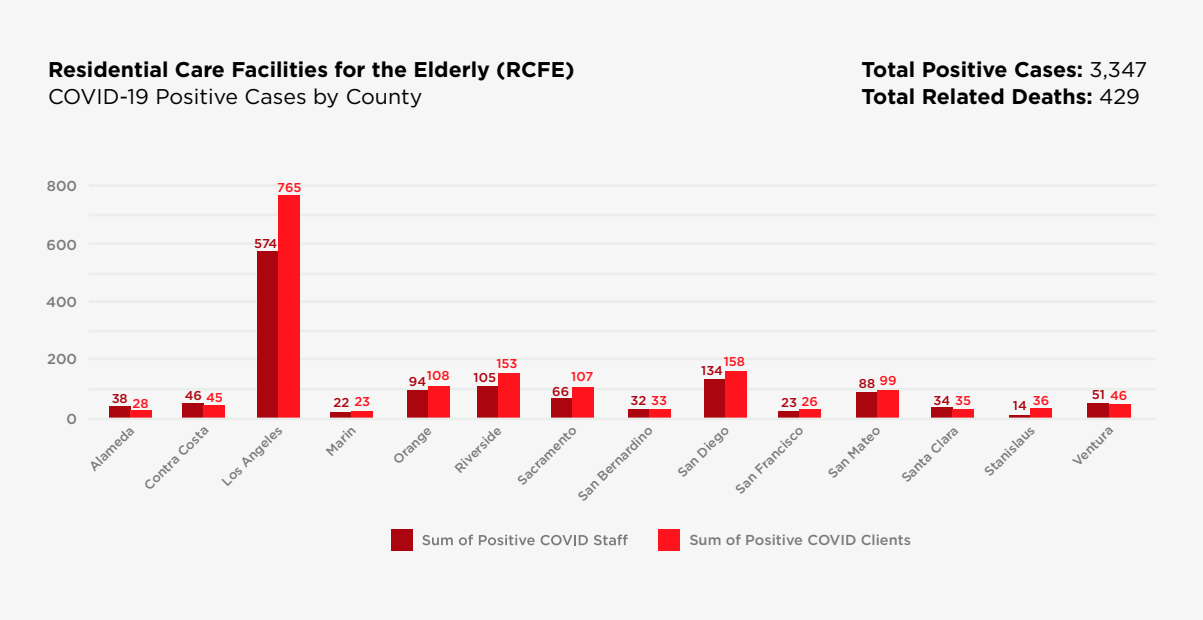

Figure 9: *Los Angeles County (source CDSS)*[20]

One of the diagramming techniques used in this science is the causal loop diagram (CLD). These are very intuitive to read and comprehend. A CLD for the impact of Coronavirus on our society appeared in a Lancet article19 (Figure 10).

Below, some simple notations are used:

- Arrows point " A impact B "
- A '+' sign at the end of the arrow means A and B move in the same direction, but a '-' sign indicates opposite movement
- Parallel bars imply a time delay
- Sometimes loops are formed which can result in accelerating or dampening behavior in the system (observe the red loop). This is often referred to as circular causality and can cause runaway effects

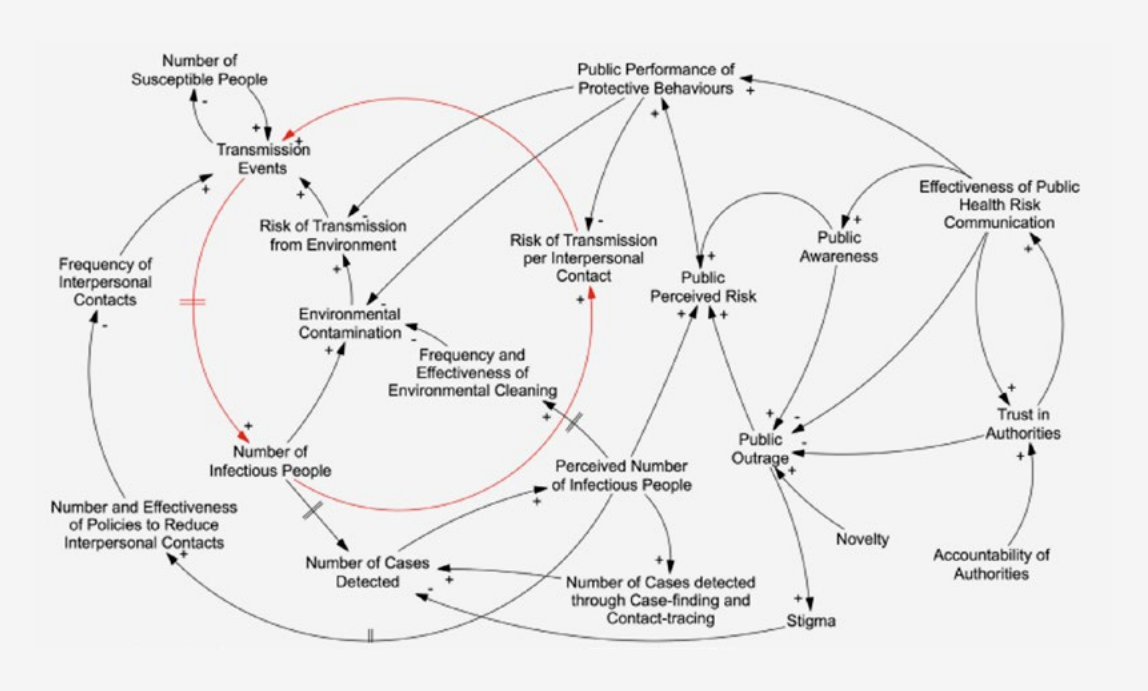

Figure 10 : *An example causal loop diagram for the COVID-19 threat*

As the Figure 10 makes obvious, causes and their effects are not so straightforward. Even though techniques (called systems science) to analyze and predict the behaviors exist, approaching in that manner is clearly out of scope for this paper.

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Golden Springs Ranch

About Ashish Warudkar

Ashish has worked in the software industry for 30+ years including 19+ years in the healthcare sector. He also has been an entrepreneur for over two decades and provides consultation to "Golden Springs Ranch" which is an upcoming InfeXBloc™ home in Palmdale, California which will introduce the innovations discussed in this paper to provide its precious residents with a safe happy home and their families with peace of mind.

Ashish Warudkar is trained at:

IIT Bombay	Mechanical Engineering
UCI	Predictive Analytics (7/8)
Harvard	Disruptive Innovation Strategy with Clayton Christensen
MIT	Advanced Certificate for Executives in Management, Innovation & Technology
	Architecture & Systems Engineering of Complex Systems
	Platform Strategy – Building & Thriving A Vibrant Ecosystem
	Business Dynamics – Diagnosing and Solving Complex Business Problems
	Executive Certificate in Strategy and Innovation
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Meetup: Monthly meeting (first Sunday 6pm CA time) of Senior Care Accountability Network https://www.meetup.com/Senior-Care-Accountability-Network-SCAN/