Foundations of Safety

HAZARDS, CONTROLS, SWISS CHEESE AND RISK

Even though Senior Care was always a high consequence industry, it was rarely perceived as a high risk high consequence industry. This pandemic has changed that perception. Let us unpack this non-trivial topic (Figure 1) to really understand risk and how better safety can be achieved.

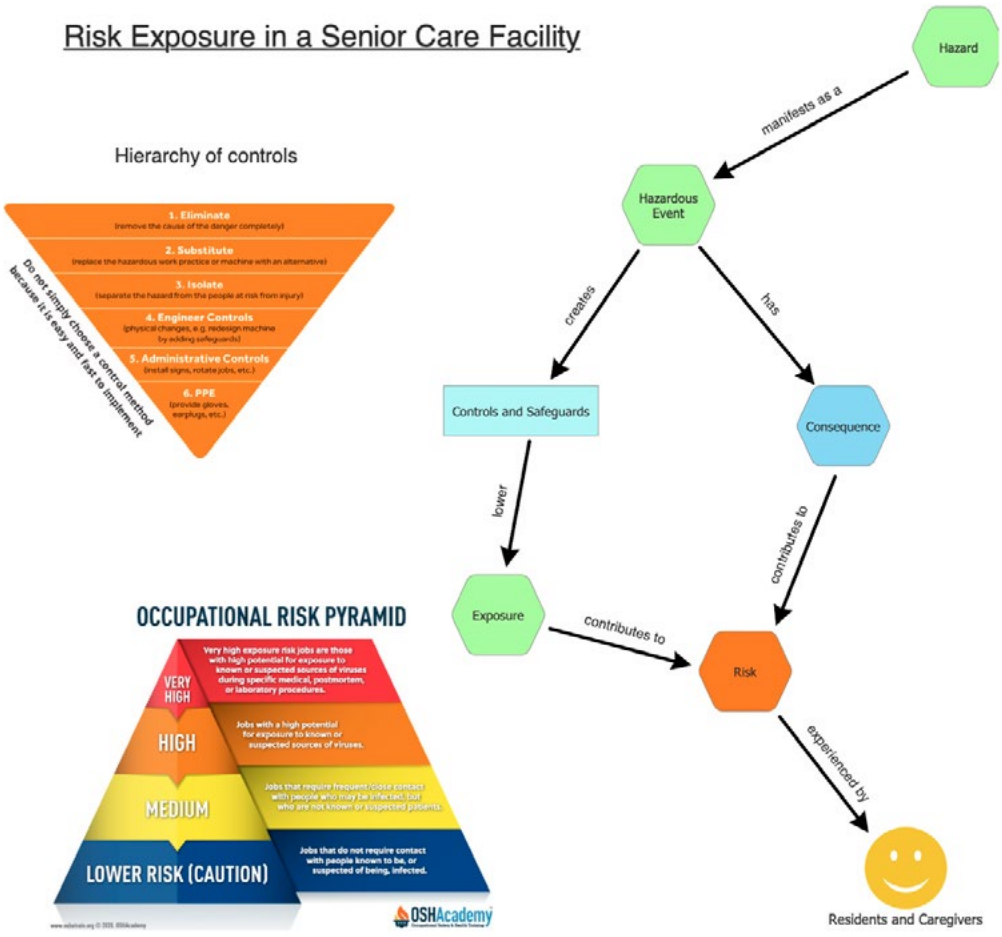


Figure 1: *Understanding Risk*

- A hazard is any agent that can cause harm or damage to humans, property, or the environment.
- A hazardous event is an instance of the hazard
- Consequence is the outcome of exposure to the hazardous event.
- Risk is defined as the probability that exposure to a hazard will lead to a negative consequence, or more simply, a hazard poses no risk if there is no exposure to that hazard.
- A safeguard or control is that which creates a space between us (humans/ property/our business) and the hazardous event.

For example, live electricity is a great hazard. In our homes, in every room, we are surrounded with live 220 V electricity flowing through all the walls. However, there are very strong controls and safeguards between us and that hazard, like insulation of the wires, UL certified switches, appliances with insulation, etc. that create a safe space between us and the hazard. The safety created is enough that we sleep peacefully on our beds and lose awareness that we are surrounded with a deadly hazard.

Risk can be seen as the product of severity of consequence times the probability of exposure. Consequently, risk assessment always starts with hazard identification.

Three important features depicted in the graphic tell an important part of this story:

- Predictable -vs- Unpredictable
- The occupational risk pyramid
- The hierarchy of controls

Predictable vs Unpredictable

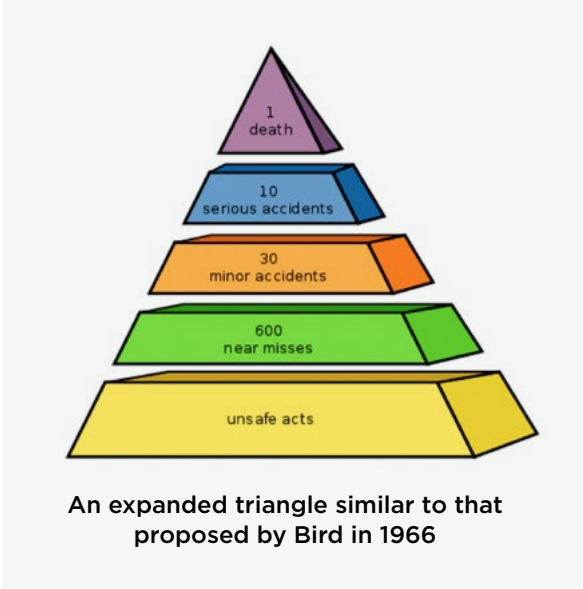
The credit for the deep insights in this section is attributed to Dr. Todd Conklin and his book "Workplace Fatalities – Failure to Predict".

Most set of industrial events in our business domain are predictable in nature. Hence, if a large enough data set of historical events is studied and signals recognized, we could predict the next occurrence with reasonable confidence. If we could predict, then we could work on prevention approaches. However, some events are complete outliers and of those some have very high consequence. These are called Black Swan events. A Black Swan event is easy to simplify after it happens, but remarkably hard to notice before it happens. events are These events are non-linear and non-predictive. The only thing we can do is build capacity in the system to minimize the consequences of such events.

Fatalities are not normal events. They happen as outliers to the way normal work happens. A fatality is not a logical ending of a bad safety program. Hienrich's accident pyramid does not apply to such high consequence events that are outliers.

The accident triangle, also known as Heinrich's triangle or Bird's triangle (Figure 2), is a theory of industrial accident prevention. It shows a relationship between serious accidents, minor accidents and near misses and proposes that if the number of minor accidents is reduced then there will be a corresponding fall in the number of serious accidents. The triangle was first proposed by Herbert William Heinrich in 1931 and has since been updated and expanded upon by other writers, notably Frank E. Bird. It is often

1. Industrial accident in Bhilai https://www.groundxero.in/wp-content/uploads/2019/04/compiled-BSP-report-pdf_pagenumber.pdf
2. Safety as a presence of capacity – Todd Conklin https://www.youtube.com/watch?v=_qo8hh_Rb1k



An expanded triangle similar to that proposed by Bird in 1966

Figure 2: *Hienrich's accident pyramid*

shown pictorially as a triangle or pyramid and has been described as a cornerstone of 20th century workplace health and safety philosophy. In recent times it has come under criticism over the values allocated to each category of accident and for focusing only on the reduction in minor injuries.

If you look at the pandemic like a normal failure because of a safety lapse, worst still the logical climbing of the accident pyramid (Figure 2), then you are likely to focus on that event alone and you will miss the entire opportunity for a deeper learning. You will work harder on the lower level events believing that the same approaches that solve the lower level events will solve the catastrophic events, you will just create wasted motion. Your organization will get better at low level events, you may have fewer falls, but you will not get more reliable around the high consequence events. In other words, you want to shift the thinking of your organization from solving for the failure to prevent the last event to solving for more effective matching of controls and safeguards for the next event discussion.

The body of knowledge around catastrophic events (like this pandemic) is purposefully different than the body of knowledge around lower consequence safety events. These Black Swan events are not simple events that we could prevent. These events are complex failures that happen on many levels of the organization and simply defy the ability to be predicted by the organization.

The Coronavirus pandemic was one such event. The last such event was a century ago. Systems built in the last hundred years had no capacity to minimize the consequences of it. That covered a wide variety of systems – transportation systems, healthcare systems, financial systems, aviation systems only to name a few. With the absence of capacity, it is not surprising that the impact of this pandemic has been so catastrophic. Because these catastrophic events are not predictable, not only must we implement robust safety programs to address prevention issues, but we must also expand our thinking to work on a program to implement controls and safeguards that provide recovery when such events happen. For example, in 2020, we would not want to drive a car with no seat belts. The chances of you getting in a wreck are slim, but the recovery that the seat belts provide in case a wreck happens, is priceless. This is particularly true if your family is riding with you in that car.

For the Senior Care business ecosystem, no one can predict when the next such event may happen.

For such events, we must manage the event probability as well as event recovery in parallel. There may be no way to predict

the entry of a Coronavirus infection (or other infections) that can be deadly to our vulnerable senior residents, hence we must have a robust recovery program. Given that, it is incumbent upon us to build capacity in our system to make sure that when this happens next time, we have the capacity to prevent uncontrolled harm.

The Occupational Risk Pyramid

The occupational risk pyramid grades different occupations based on the exposure the worker has to a different level of hazard e.g. an IT worker working remotely using Zoom has a far lower exposure that a utility lineman working on high tension transmission wires. OSHA classifies occupations into 4 categories based on the expected exposure to hazard Very High, High, Medium and Low. For healthcare workers, OSHA classifies as follows:

Very High Exposure Risk

Very high exposure risk jobs are those with high potential for exposure to known or suspected sources of COVID-19 during specific medical, postmortem, or laboratory procedures. Workers in this category include:

- Healthcare workers (e.g., doctors, nurses, dentists, paramedics, emergency medical technicians) performing aerosol-generating procedures (e.g., intubation, cough induction procedures, bronchoscopies, some dental procedures and exams, or invasive specimen collection) on known or suspected COVID-19 patients.
- Healthcare or laboratory personnel collecting or handling specimens from known or suspected COVID-19 patients (e.g., manipulating cultures from known or suspected COVID-19 patients).
- Morgue workers performing autopsies, which generally involve aerosol-generating procedures, on the bodies of people who are known to have, or suspected of having, COVID-19 at the time of their death.

High Exposure Risk

High exposure risk jobs are those with high potential for exposure to known or suspected sources of COVID-19. Workers in this category include:

- Healthcare delivery and support staff (e.g., doctors, nurses, and other hospital staff who must enter patients' rooms) exposed to known or suspected COVID-19 patients. (Note: when such workers perform aerosol-generating procedures, their exposure risk level becomes very high.)
- Medical transport workers (e.g., ambulance vehicle operators) moving known or suspected COVID-19 patients in enclosed vehicles.
- Mortuary workers involved in preparing (e.g., for burial or cremation) the bodies of people who are known to have, or suspected of having, COVID-19 at the time of their death.

Medium Exposure Risk

Medium exposure risk jobs include those that require frequent and/or close contact with (i.e., within 6 feet of) people who may be infected with SARS-CoV-2, but who are not known or suspected COVID-19 patients. In areas without ongoing community transmission, workers in this risk group may have frequent contact with travelers who may return from international locations with widespread COVID-19 transmission. In areas where there is ongoing community transmission, workers in this category may have contact with the general public (e.g., schools, high-population-density work environments, some high-volume retail settings).

Lower Exposure Risk (Caution)

Lower exposure risk (caution) jobs are those that do not require contact with people known to be, or suspected of being, infected with SARS-CoV-2 nor frequent close contact with (i.e., within 6 feet of) the general public.

Workers in this category have minimal occupational contact with the public and other coworkers.

It is reasonable for us to see how caregivers in Senior Care facilities will fall into the Medium – Very high spectrum. As for our healthy residents they may get classified in Medium to High risk spectrum. However, since our residents are in the 65+ age bracket and often have several underlying health conditions that lower their immune system, they represent a group with higher vulnerability.

The Hierarchy of Controls

In safety literature, the hierarchy of controls is an inverted triangle (Figure 3) and it grades controls and safeguards from the most effective to the least effective from top to bottom.

- **Elimination** - Physically remove the hazard
- **Substitution** - Replace the hazard
- **Engineering controls** - Isolate people from the hazard
- **Administrative controls** - Change the way people work
- **Personal protective equipment** - Protect the worker with PPE

It is interesting to note that the PPE (personal protective equipment) is the least effective control to be employed because it is the last line of defense between the hazard and the caregiver or healthy resident.

Businesses and workplaces often use a combination of controls classified at different levels to make the location safe. The more that we can incorporate controls and safeguards of the higher categories, the lower the risk of exposure to hazard. In the section titled "Classifying controls and Safeguards in InfeXBloc™" we will categorize our recommendations.

Figure 3: *Hierarchy of Controls*

The Swiss Cheese Model

In 2000, James Reason described a model of how failure can propagate in a complex system by using the metaphor of layers of swiss cheese. Figure 4 shows multiple layers of barriers that exist between a hazardous event and our residents/caregivers/staff/ facility/business. Each barrier can be perceived as a safeguard/ procedure/ protocol/engineering control/administrative control/PPE layer. The model describes how each layer is not bullet-proof all the times. Each has its own weaknesses which appear and disappear momentarily. A hole in the swiss cheese layer can represent a weakness that can manifest momentarily. Almost all the times, the holes in all the layers do not align and thus there is a separation maintained between the hazardous event and our residents/caregivers/staff/facility/business. This way, most of the time harm cannot propagate through.

However, on an unpredictable occasion, the holes in multiple layers (weaknesses in different layers of the barriers) can align and when that happens the energy of the hazardous event can propagate through and impact our residents/caregivers/staff/

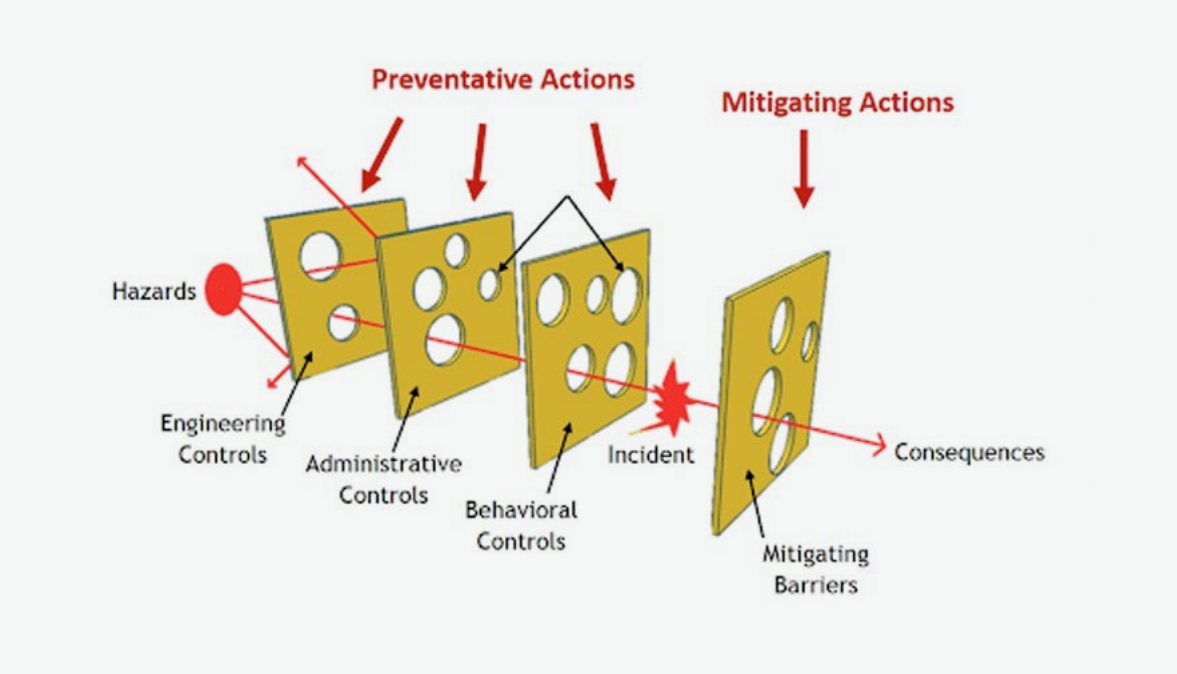


Figure 4: *James Reason's Swiss Cheese Model of failure in Complex Systems*

facility/business. This model of how failure can propagate in complex systems and lead to uncontrolled harm has been observed in multiple noted examples like the sinking of the Titanic, the Three Mile Island nuclear accident, the Challenger Space Shuttle accident, the Shuttle Columbia disaster, September 9-11 terrorist attacks and Hurricane Katrina.

There is no solution to these weaknesses that appear momentarily in different layers. By keeping on building multiple layers of barriers, we lower the probability of the harm passing through, thus lowering the risk.

Safety as Capacity

I have a personal connection with this topic of safety. I grew up in the 60s in a little town called Bhilai in India. It is a town built around a massive integrated steel mill. I remember seeing bill boards like Figure 5 throughout the town and noticing signs, in the mills when we would go on field trips (the Coke Ovens, the Blast Furnace, the Plate mill, the Rail mill etc.), with messages like "Safety Awareness Week", "248 days without an accident" or "Congratulations to Blast Furnace Team! Celebrating 100% on safety inspection" etc. That was my first initiation into the importance of safety measures. Many decades later, on 9th October 2018, my childhood friend, Uday Pandey, fell victim to an industrial accident at the same plant.

Safety is a feeling. Technically it is defined as a dynamic non-event. It cannot be measured directly. Safety is not the absence of accidents, but the presence of capacity. That notion of capacity in this context is interesting. While often we use that term to indicate a physical property of an object (e.g. a 5 gallon bucket), here we use it to refer to a system's property that allows that system to absorb uncertainty of an accident.

Several examples are quite illustrative:

- When building and safety department mandates earthquake code compliance, they are creating capacity in the structure to deal with the uncertainty of seismic

Figure 5: *Safety signs in my childhood town*

shaking. Compliance with this code requires extra design, engineering, materials and construction effort and a significant extra cost. But when an earthquake happens, the structure has the capacity to deal with it without causing irreparable harm.

- In the non-fire season, the department of fire must diligently implement activities like dry brush clearance, dead wood removal in forests, training of fire fighters, developing equipment and infrastructure like air tankers, their fire-retardant supplies, staging airports, etc. If these capacity building activities are adequately funded and executed in years before a fire ravages a certain section of California, then the system has capacity to deal with a fire without it causing uncontrolled harm.
- In Silicon Valley are some of the giants of the digital economy (e.g. Google, Amazon, eBay, Netflix etc.). In a short period, they have significantly altered the composition of economic activity. When you rely on cloud based computer systems to carry out billions of dollars of business 24X7, you must think hard about disaster preparedness to deal with uncertainty of emergent events. Netflix has invested years and a very large budget with a continuously improving effort to build capacity to deal with such uncertainty. That program is called Chaos Engineering and some of the products out of this program (called Chaos Monkey simulations) have been open sourced.

In the Senior Care domain, accidents could be falls leading to injury to residents or a case of infection entering the facility etc. These unpredictable events will always happen. Developing safety, then, is not their absence, but developing a capacity to deal with them without leading to catastrophic and unwanted outcomes. When analyzed from this perspective, it becomes clear that

Senior Care as an industry lacked capacity to deal with the virulent bug (Coronavirus). Once it entered several facilities, it burned through their populations like dry brush as we experience every summer with forest fires in California. It is not so much that people made bad choices, but people had bad choices.

It is easy to understand that when you have to build capacity, it is expensive, takes diligent well directed effort and takes time, when you don't have capacity, coping with the effects of it is really expensive and takes a very long time (not to mention the loss of precious life). Just like buying insurance is a hedge against financial risk, building capacity is a hedge against systemic risk.

Capacity building, then is a deliberate, well planned and continuously executed activity. Regaining trust after this Covid-19 storm and fostering the feeling of safety will be a capacity building activity. Most importantly, as in the case of insurance, capacity must be built before the risk materializes.

InfeXBloc™ is an operational architecture for a Senior Care facility that will build a capacity to absorb uncertainty of a pandemic. It will make the facility pandemic resistant. Moving Senior Care facilities to be InfeXBloc™ enabled will then be a capacity building activity.

Classifying the Safeguards and Controls of InfeXBloc™

Earlier in the section titled "Hierarchy of Controls" (Figure 3) we ranked the type of controls and safeguards in order of their effectiveness. We also noted that PPE are the lowest form of effectiveness against the Coronavirus and other infections. They are the last line of defense.

It is worth noting that as a facility's process matures, it can add more controls belonging to each of these 5 hierarchy sections. The more safeguards and controls that are incorporated in the higher sections the higher the level of safety the facility can offer. We expect this to be an continuous improvement list as newer processes, technologies and PPE become available.

We now will classify the controls and safeguards in the InfeXBloc™ architecture that are proposed to improve the effectiveness of safety.

Type of Control	Control or Safeguard
Elimination	No known way to eliminate the Coronavirus or any of the other infections that harm our senior residents
Substitution	No known way to substitute Coronavirus or any of the other infections that harm our senior residents with other less harmful bugs. Vaccines have some promise, but the efficacy of vaccines in our context is questionable at best. Vaccines are known to be less effective for the senior age group who may have many underlying comorbidities and conditions that compromise their immune systems. Many of the infections we experience in our facilities have had vaccines available for decades and we still experience outbreaks.

Engineering Controls	• Negative HVAC rooms designed to prevent the escape of the bug outside of the resident's room • Touch free doors • Touch free faucets • Plexiglass visitation booths • UVC lights sweep every 24 hours cycle • Universal entrance complex • InfeXPASS™ entrance criteria • Thermal scanners • Access keycards for caregivers • PPE enforcement using scanners • Facility has a real time InfeXCON designation • Encrypted event streams are published in real time • Video surveillance • RTLS (Real time location services) • Circadian Lighting • Pool fencing • Magnetic door locks • Smoke control sections • Fire exit doors • ADA compliance characteristics • All ADL events, caregiving events, medication delivery events are logged • Only facility mobile phones are used on the premises • Self-service visitation appointments using Calendly™ • Robotic tele-visitation with Physicians • In room group activities (e.g. Intercom-Bingo) • Enforcement of least privilege principle • Micro-segmentation of the facility
Administrative Controls	• Safety dashboards are published in real time • Caregiver-buddy system to validate PPE usage • Sick leave provisions for caregivers • Group dining / In room dining option • Mandatory immunization program for caregivers
PPE	• Masks • Face shields • Protective Gowns • Booties • Gloves • Alcohol disinfectants • Soap and water

HFACS

Our industry is light on service automation and primarily delivers it services by way of human rendered care, hence, the occurrence of human error is unavoidable. Sometimes this can combine with other weaknesses in the senior care ecosystem and produce severe undesirable outcomes.

The Human Factors Analysis and Classification System (HFACS) is a general human error framework originally developed and tested within the U.S. military as a tool for investigating and analyzing the human causes of aviation accidents. Based on Reason's (1990) model of latent and active failures, HFACS addresses human error at all levels of the system, including the condition of aircrew and organizational factors.

The HFACS framework was used to analyze human error data associated with aircrew-related commercial aviation accidents

that occurred between January 1990 and December 1996 using database records maintained by the NTSB and the FAA.

Investigators were able to reliably accommodate all the human causal factors associated with the commercial aviation accidents examined in this study using the HFACS system. In addition, the classification of data using HFACS highlighted several critical safety issues in need of intervention research.

These results demonstrate that the HFACS framework can be a viable tool for use within the civil aviation arena. Developed originally in the military and aviation industries, these methodologies have been used by numerous fortune 500 companies including many well-renowned healthcare organizations. These innovative tools and methods are also espoused by many accrediting agencies and patient safety organizations within the healthcare industry.

INFEXBLOC™ PILOT SITE

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
Product School	Product Management
BWW	Network Marketing
Oren Klaff	Pitch Mastery

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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/