GAMES, EXERCISES AND SIMULATIONS

LEVERAGING STRUCTURED ANALYTIC TECHNIQUES TO RECOGNIZE PERSONAL AND GLOBAL HEALTH CRISES

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Abstract:

The US medical system suffers from serious structural flaws that make it hard for patients to get a proper diagnosis. Currently, doctors are highly incentivized to order tests and initiate treatments and often fail to take the time needed to diagnose a problem. If doctors had more time to engage with their patients and apply critical thinking techniques, both parties would reach a more satisfactory outcome. Moreover, incorporating Structured Analytic Techniques into the practice of medicine writ large would benefit the global community as recognition of—and reaction to—looming health security crises. Structured Analytic Techniques help doctors recognize lead indicators of an emerging health security crisis and overcome well-entrenched mental mindsets. The techniques provide a ready „tool kit" for doctors practicing the emerging discipline of health security intelligence[1].

Keywords: *Public Health, Health Security Intelligence, Diagnosis, Structured Analytic Techniques.*

Introduction

In the American medical system, most physicians are under pressure on many fronts—temporal, financial, and legal—to start treating an illness instead of taking time up front to diagnose it. For most doctors, the default usually is to first test and treat—often skipping over any serious effort to diagnose the problem. Doctors

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[1] Most of the information in this article is based on experiences of the author – a career intelligence analyst – who visited 17 specialists, received countless treatments, and failed to get a diagnosis of his condition for over five years. The article is derived largely from a chapter in the book, *How to Get the Right Diagnosis: 16 Tips for Navigating the Medical System*, 2021.

instead prescribe a series of medications or treatments in the hope one of them will cure the patient. If these treatments fail, the individual may experience a worsening of their condition or die without ever receiving a true diagnosis or the right treatment.

In most cases, this strategy is successful because, as many doctors attest:

- In a high percentage of cases, the human body will eventually cure itself. On the first visit to a doctor, a treatment is usually prescribed, but at best it may only be expediting the recovery process.
- Most illnesses can be treated successfully with just one or two treatments.

Doctors are under extreme pressure from the insurance industry to make decisions as quickly as possible to keep costs to a minimum. Generating a workable and accountable metric to validate the time a doctor would take to sit down, research, and diagnose what is causing a patient's problem is a difficult problem. If doctors had more time, however, to engage their patients and partner with them in applying Structured Analytic Techniques (SATs) in seeking a diagnosis, both parties would reach a much more satisfactory outcome.

For patients with complicated or hard-to-diagnose medical problems, the disincentive to diagnose can have major negative consequences—and even lead to the patient's death. According to a report issued in 2015 by the Institute of Medicine, an arm of the National Academy of Sciences, as many as 12 million Americans may be receiving erroneous or late diagnoses every year (Balogh, 2015). This is far more than the estimated 100,000 deaths per year attributed to errors in hospital treatment.

Moreover, the error rate for diagnosing illnesses is likely to worsen as the diagnostic process and health-care delivery become more complex.

This article presents a testable hypothesis that as many as 95 percent—or two standard deviations—of people who experience medical problems will recover because they self-heal or, after receiving two or three common treatments, the problem is cured. The remaining

5 percent of the population, however, may have more complicated issues, requiring a more thorough diagnosis.[2]

What should people do if their condition is not easily diagnosed? Given the strong financial incentives to treat and not diagnose, many individuals who have unusual and hard-to-diagnose conditions become frustrated by the failure to get a proper diagnosis. Few tools or techniques are available to address the problems encountered by undiagnosed or misdiagnosed patients. The thesis of this article is that many people in this group would have been better served if they had 1) used structured techniques to help them navigate the medical care system and 2) actively engaged their doctor as a partner in seeking a diagnosis of their problem. Anecdotal evidence suggests that those who have succeeded in getting a diagnosis and effective treatment usually had to take direct responsibility for managing their own health care. By proactively engaging with their doctors, they could manage their care more effectively.

For example, techniques such as questioning one's assumptions can play a critical role in helping doctors recognize anomalies and overcome well-entrenched mindsets, allowing them to respond quickly to an emerging health crisis or pandemic. Often the indicators of a potential outbreak of an infectious disease are ambiguous. If recognized early on, however, a major public health crisis can be avoided, or the damage minimized. (Wilson, 2016; Wilson, 2018)

Six Structured Analytic Techniques (SATs) are reviewed in this article that doctors and patients can use to challenge entrenched mindsets and focus more attention on the need to begin treatment of a patient's problem by first seeking the correct diagnosis (Pherson and Heuer, 2011). Examples are given showing how these SATs were used correctly in treating patients as well as when they were not applied—resulting in serious negative consequences. The article describes when the techniques are most useful and what cognitive biases they help to correct. The techniques are also useful in helping doctors and nurses recognize, and quickly react to, emerging threats to global health security. In the Appendix, readers will find step-by- step instructions

[2] This thesis is offered as a hypothesis to be validated or disproved by those much more proficient in medical research than the author.

for applying the techniques. By integrating these techniques into the emerging discipline of health security intelligence, the recognition of – and reaction to – public health threats will be greatly advanced.

Structured analytic techniques: new arrows for the doctor's quiver

SATs were developed in the late 1990s to provide more rigorous, transparent, and collaborative methods for analysing a problem, resolving differences, innovating solutions, and anticipating the future. The techniques have proven highly effective in supporting the analytic process in the intelligence community as well as in the corporate world (Pherson and Heuer, 2021; George and Bruce, 2014)[3]. They are a subset of a variety of practices in the intelligence community that can – and have been – adapted to the medical profession to reduce errors and improve the quality of health care (see Figure 1).

[3] A description of the origins of Structured Analytic Techniques and their role in the analytic process can be found in Pherson and Heuer as well as George and Bruce.

The following key practices or concepts in intelligence analysis have the potential to help medical professionals reduce error rates:

- Recognize how mental mindsets and past *experiences* can bias a diagnosis (Cognitive Bias and Intuitive Traps)
- Develop more than one explanation for an illness during the initial diagnosis (Multiple Hypothesis Generation)
- Challenge preconceived notions generated by a patient's appearance, age, or race (Key Assumptions Check)
- Focus on disconfirming evidence to quickly eliminate incorrect diagnoses (Analysis of Competing Hypotheses)
- Seek out and value the opinions of others working the case (Coordination and Peer Review)
- Know when to expect deception (Deception Detection)

Figure 1: Intelligence tradecraft for Medicine
(Source: Pherson and Heuer, 2021)

SATs came into prominence following the terrorist attacks on 11 September 2001 and the flawed 2002 National Intelligence Estimate on weapons of mass destruction in Iraq as a way to improve the overall quality of analysis in the U.S. Intelligence Community. Over the years, use of the techniques has spread to other parts of the U.S. government, foreign intelligence services, major corporations, and academia. The techniques have universal value and utility. Analysis of Competing Hypotheses (ACH), for example, is similar to differential diagnosis in the medical profession.

SATs can be leveraged to gain more knowledge about a person's condition while helping the doctor make a correct diagnosis. The six most effective techniques for prompting a doctor to diagnose a problem or challenge an entrenched mental mindset are:

(1) Multiple Hypothesis Generation
(2) Analysis of Competing Hypotheses
(3) Indicators
(4) Key Assumptions Check
(5) Premortem Analysis
(6) Structured Self-Critique

Step-by-step instructions on how to use these techniques are provided at the end of this article. Additional information on when to use them, the value added, their relationship to other techniques, and potential pitfalls to avoid can be found in *Structured Analytic Techniques for Intelligence Analysis* (Pherson and Heuer, 2021).

Multiple hypotheses generation: establishing a range of explanations

In *How Doctors Think*, Dr. Jerome Groopman argues that the practice of considering alternative explanations for a medical problem is one of the strongest safeguards against making cognitive errors (Groopman, 2007, p. 66). He quotes one of his colleagues as saying, „I learned to always hold back [and avoid jumping to a conclusion], to make sure that, even when I think I have the answer, to generate a short list of alternatives."

Multiple Hypothesis Generation is a technique for generating multiple alternatives for explaining a particular issue, activity, or behaviour. It is a key technique in the analyst's toolkit and is particularly useful when many factors are involved, a high degree of uncertainty exists regarding the diagnosis, and doctors and/or nurses hold different views.

The technique helps patients, patients' families, and their doctors avoid – or at least mitigate the power of – several analytic traps, including:

- Coming to premature closure.
- Being overly influenced by first impressions.
- Seizing on the first diagnosis or procedure that looks „good enough".
- Focusing on too narrow a range of alternatives.
- Selecting an explanation that replicates a past success or avoids a previous error.

The importance of first considering multiple diagnoses can be demonstrated with the case of dementia. Dementia can be caused by a wide variety of illnesses, injuries, or other factors. Narrowing down the type of dementia is critical to successful treatment. Individuals with Parkinson's disease, for example, may have symptoms similar to other types of dementia, but the treatment could be vastly different. The symptoms of dementia can be hard to assign to a specific type.

Failing to identify the type of dementia can result in paradoxical or unanticipated reactions to a medication or treatment. For example, individuals with a certain type of dementia called Lewy-Body typically have a paradoxical reaction to benzodiazepine medications such as Valium. When an agitated patient with Lewy-Body dementia is prescribed a benzodiazepine medication (which is a typical first-line medication for agitated behaviour), instead of calming the patient, the effect is to increase the level of agitation. For these reasons, an attentive doctor should first consider a range of possible forms of dementia and then narrow down the diagnosis to avoid prescribing an incorrect treatment.

The value of seeking multiple explanations for a medical condition is illustrated by the story of a patient with persistent back pain just below the shoulder blades. The patient rejected her doctor's initial advice to start taking a strong pain reliever because she first wanted to find the root cause of the problem. When a review of the patient's activities revealed no clues and blood tests yielded no useful insights, the doctor suggested the pain might be stomach related. The patient went to a gastroenterologist, who grudgingly ordered a CT scan, "only because my family had a history of pancreatic cancer". The CT scan, however, provided no clues. The gastroenterologist then suggested the problem could be orthopaedic, but an orthopaedic surgeon examined her back and found nothing wrong.

Next an MRI with contrast was ordered; the results revealed no back issues but did reveal a small cyst on the pancreas. An endoscopic procedure was ordered to image the pancreas and take a biopsy. The endoscopy revealed a small and benign cyst in the pancreas. The doctor said nothing could be done to make it go away and that he wanted to perform another endoscopy in two years. The doctor told the patient there was nothing she could do to get rid of the cyst, but he wanted her to check back in two years.

The patient did some research, decided to eliminate as much sugar as possible from her diet, and the ache eventually disappeared. Two years passed, and the cyst was smaller. After four years, the patient was told the doctor wanted to discontinue testing because the situation was sufficiently stable.

In some intelligence services, analysts are not allowed to present their conclusions unless they can demonstrate that they have considered alternative explanations for what has occurred or is about to occur. This approach is important during diagnosis of a health issue because the simple process of considering alternative explanations forces patients and their doctors to focus on all the available data, not just the information or the tests that are consistent with the lead diagnosis.

A knowledgeable patient will press a doctor to provide a list of possible alternative explanations for his or her condition. A good question often asked is: Who else has the doctor examined who exhibited the same symptoms, and what kinds of things turned out to be wrong with them?

Ideally, the diagnostic process should start with a brainstorming session involving the patient and the doctor. The objective would be to generate a list of all possible explanations for the patient's condition. The discussion would cover such questions as: "What is the most common cause of what the patient is experiencing, and what the most serious cause is?" (Nudson, 2019) In real life, this rarely happens because 1) doctors are too pressed for time, 2) the most obvious treatment is usually the right treatment, and 3) pricing structures in medicine prohibit running all potential hypotheses to ground. If a patient has grown tired of the standard testing procedures, he or she should show the doctor previous test results and challenge him or her to come up with some nonstandard alternatives.

Recommended procedures for patients include:

- Listening carefully for information that might suggest a medical history that is not "normal".
- Resisting the temptation to come to premature closure.
- Making a list of multiple possible explanations at the start of the diagnosis.

Analysis of competing hypotheses: identifying data that is inconsistent with the diagnosis

On the television program *House*, the lead doctor would frequently gather his medical team around a whiteboard, list the potential diagnoses across the top of the board, list the relevant test results and other information down the left side, and then check off which data was consistent—or inconsistent— with each diagnosis. The doctor would then order appropriate tests that would allow the team to dismiss candidate diagnoses until only the correct diagnosis was left standing.

Dr. House generates potential diagnoses, analyses symptoms and test results, and makes a diagnosis based on the evidentiary contradictions to the hypothesis. This technique is similar to a method many intelligence analysts use called Analysis of Competing Hypotheses (ACH). ACH involves generating a complete set of hypotheses (or potential diagnoses), the systematic evaluation of each based on the available evidence (or symptoms and test results), and the selection of the hypothesis (or diagnosis) that best explains the condition because little evidence can be found to refute it. In essence, the technique focuses attention to which explanations – or diagnoses – can be dismissed because of compelling inconsistent evidence, leaving the "last man standing" as the most likely explanation.

A similar process used in the medical profession is called differential diagnosis. A differential diagnostic procedure is a systematic process used to narrow down the probabilities of a candidate illness to negligible levels, by using evidence such as symptoms, patient history, and medical knowledge. A standard differential diagnosis has four steps (*Sharecare*, 2019). The physician:

(1) Gathers all information about the patient, focusing on the symptoms.

(2) Lists all the possible causes for the symptoms.

(3) Prioritizes the list by placing the most dangerous possible causes at the top of the list.

(4) Rules out or treats possible causes, beginning with the most dangerous condition and then working down the list. The physician removes diagnoses from the list by observing and applying tests that produce different results, depending on which diagnosis is correct.

If no diagnosis remains, then either the physician made an error, possibly by failing originally to list a potential cause or the condition is undocumented.

The value of looking for inconsistent evidence is illustrated by the story of a female athlete who played point guard on the basketball team but was having trouble with her breathing, especially when the team was under a lot of pressure. She also was on the swim team, where some of her friends were having the same problem during workouts. Their doctors gave those inhalers, believing they were suffering from exercise-induced asthma.

When the patient went to see her paediatrician, he asked her to run up and down the seven flights of stairs in his building and report if that exercise made it difficult for her to breathe. She did and reported no problems. The doctor said that running up and down the stairs with no problem was inconsistent with a diagnosis of exercise-induced asthma. He believed the more likely explanation was performance stress that constricted the vocal cords, narrowed the throat, and made it hard to breathe. He recommended some visualization exercises that the patient tried and was fine.

The ACH technique—or its twin in medical practice, differential diagnosis—works best when there is a robust flow of data and multiple test results to absorb and evaluate. It helps the patient and the doctors overcome several mistakes, including:

- Accepting information that confirms one's preconceptions or contradicts prior beliefs.
- Being overly influenced by first impressions based on incomplete data.
- Ignoring or discounting information that does not "fit" the lead diagnosis.
- Failing to generate a full set of explanations at the outset.
- Relying on evidence that tends to confirm one's favoured diagnosis but is also consistent with other possibilities and therefore has no diagnostic value.

Simultaneous evaluation of competing diagnoses is challenging to do. To retain five or seven potential diagnoses in working memory and process how each item of information fits with each diagnosis is extremely difficult. ACH overcomes these obstacles by making it easier to enter, sort, and evaluate the data by working through a matrix one cell at a time (see Figure 2).

Patient	Lead Diagnosis	Alternative Diagnosis 1	Alternative Diagnosis 2	Alternative Diagnosis 3
Inconsistency *Score*→→				
Symptom 1				
Symptom 2				
Symptom 3				
Test Result 1				
Test Result 2				
Assumption 1				
Information Gap 1				
Other Information 1				
Legend: II - Very Inconsistent I - Inconsistent N - Neutral NA - Not Applicable C - Consistent CC - Very Consistent				

Figure 2: ACH Sample Matrix (Source: the author)

Use of an ACH matrix also ensures that all the members of the medical team are working from "the same sheet of music" with shared information, arguments, and assumptions. It helps them gain a better understanding of why there are differences of opinion, and it helps depersonalize an argument when serious differences of opinion are present.

A downside in using the technique is when the range of diagnoses considered is not comprehensive. Doctors, however, must take care not to offer opinions or diagnoses that deal with issues that fall outside their specialties. Doctors, for example, could unduly alarm a patient by suggesting that one of many potential causes of their discomfort may be some form of cancer. This problem could be mitigated by limiting the number of alternatives to the two or three most viable diagnoses, or by stating that cancer is unlikely but impossible to totally rule out in most cases.

Indicators: tracking the progress of treatment

Indicators are observable phenomena that are periodically reviewed to help establish which explanations are most viable. Sets of indicators can be paired with each potential explanation to track over time which diagnosis is emerging as the most likely explanation for the medical condition. By establishing a set of objective criteria, doctors and nurses can track whether subsequent developments are reinforcing or undermining the various diagnoses.

Indicators provide an analytic baseline for instilling more rigors into the process and enhancing the credibility of the final diagnosis. They can be used to validate the lead diagnosis or alert one to unexpected developments that may focus attention on a less likely diagnosis. Indicators can also play a critical role in helping doctors and nurses to spot anomalies and nascent threats that could spark a major health security crisis.

The use of indicators can help the medical team overcome—or at least mitigate—several cognitive biases and intuitive traps, including:

- Continuing to hold to a judgment when confronted with a mounting list of evidence that contradicts the initial diagnosis.
- Basing a diagnosis on weak evidence or evidence that easily comes to mind.
- Accepting or rejecting someone else's ideas because the doctor or nurse likes or dislikes everything about that person.
- Claiming the key items of information, that turned out to be dispositive in making the diagnosis, were easy to identify at the start.

When creating a list of indicators, five rules of thumb apply. Indicators should be:

(1) Observable and collectible, ensuring that the observations are available to the diagnosing medical team.

(2) Valid, in that they accurately measure or reflect what is being reported.

(3) Reliable, in that they will be reported in the same way by different people.

(4) Stable, in that they can be used over time to allow comparable assessments.

(5) Unique, in that they point to only one diagnosis. This last condition is often the most difficult to achieve.

If someone is having difficulty running for a long period of time, for example, a good strategy would be for the doctor to say, "We are giving you an asthma medication. We expect it to have the following effect: it should increase how long you can run without having to stop immediately after you use it by *X*; it should add a set number of points to the readings you get on your spirometer; and over the next month it should increase the average amount of time you can run without stopping by *Y* and over the next three months by *Z*". The doctor would give the patient a set of indicators that the patient could monitor to see if the prescribed medication was doing its job.

Such sets of indicators can be used either to help confirm that a given diagnosis appears to be correct or to signal that the current diagnosis may well be wrong and alternative explanations should be explored. For example, if the lead diagnosis is that a patient is suffering from exercise-induced asthma, a simple procedure would be to use the spirometer to measure lung capacity before and after the patient exercised. Similarly, if the patient wanted to evaluate the viability of a diagnosis of stress-induced asthma, he or she could generate a set of indicators that anticipated when that person was under stress. As the days progressed, the patient could then monitor his or her body to see if these incidents made it harder for them to breathe. If they found no correlation, then the diagnosis was less likely to be correct. In that case, attention should be refocused on finding the real cause of the illness.

The value of listening to your body is illustrated by a woman in her early 40's who was enjoying a relatively healthy life. She began to experience severe shoulder and neck pain, especially in the morning.

She first thought she was sleeping poorly and changed her pillow, but to no avail. The woman then began to suffer from severe fatigue. Her primary care physician diagnosed her as having hypothyroidism despite laboratory tests showing normal levels of thyroid function. She took thyroid medication for a month, but the pain and fatigue got worse.

She developed excruciating headaches and a feeling of numbness on the left side of her face and feared she might have a brain tumour. One evening, the patient observed some deer walking through her backyard and thought she might have Lyme disease. Her primary care physician insisted on the diagnosis of hypothyroidism and probably should have sought out a second opinion from an infectious disease specialist. When she began to develop neurological symptoms, she was treated aggressively for Lyme disease and now has fully recovered.

Key assumptions check: challenging assumptions

Assumptions are something that people accept as true or certain to happen, but without any proof. They are beliefs or ideas that underpin an argument or a diagnosis. Often a doctor will refer to them as "common wisdom". When teaching critical thinking skills, students often are asked to list the key assumptions they are making about a situation or event. Invariably, about one out of four assumptions turn out to be incorrect when subjected to critical examination. That is a high error rate, but in daily life people often do not notice these errors. They are more likely to focus on the 75 percent of assumptions they made that are correct.

Challenging one's assumptions is one of the most important habits a person can develop. If an unsupportable assumption is identified early in the process, substantial time can be saved by avoiding going down blind alleys. For this reason, much can be gained by conducting a Key Assumptions Check before trying to diagnose what is ailing the patient.

An example of an assumption that has been overturned in recent years relates to fatty liver disease. Before 1980, many physicians called it alcoholic fatty liver disease because they assumed it was caused by consuming too much alcohol. Even if a patient told a doctor he or she did not drink alcohol, the doctor would assume the patient was lying to cover up a bad habit. In 1980, doctors began to recognize the presence of the disease in patients who did not drink. Doctors now differentiate between alcoholic fatty liver disease and non-alcoholic fatty liver disease.

This faulty mental mindset was exposed in a 2009 National Institutes of Health (NIH) study that reported that 20 percent of the U.S. population had one or the other form of fatty liver disease (Almeda-Valdes, Cuevas-Ramos and Aguilar-Salinas, 2009, p. 518-524; Alise, Manci, Vania and Nobili, 2009, p. 469-474). More recently, the American Liver Foundation estimates that the number of individuals affected by fatty liver disease has increased to 25 percent and it includes many children (American Liver Foundation, 2017).

A Key Assumptions Check is an explicit exercise to list and challenge the key working assumptions that underlie the basic analysis or diagnosis. When the available evidence is incomplete or ambiguous, the interpretation of the symptoms will be influenced by the assumptions patients and their doctors make. By critically examining these assumptions and making them explicit at the start, doctors and patients will:

- Increase their understanding of the basic dynamics at play.
- Uncover hidden relationships as well as links between assumptions.
- Generate new ideas and perspectives.
- Reduce the chances of surprise should new information render old assumptions invalid.

Conducting a Key Assumptions Check can help mitigate several powerful cognitive biases such as Satisficing and Premature Closure. Satisficing is pursuing the minimum satisfactory outcome for the moment (Merriam-Webster, 2019) or, more simply put, selecting the first answer that appears "good enough" (Pherson and Pherson, 2021, p.192). Premature Closure is a form of Satisficing, defined as providing a satisfactory answer before collecting sufficient information and performing a proper analysis. Given the time pressure that doctors are under, they must process the available information quickly and render an opinion on the likely cause of the problem or the most appropriate next steps to take, often within a matter of minutes.

The process of challenging assumptions can also provide an effective check to counter the cognitive bias called Anchoring. Anchoring is defined as accepting a given value of something unknown as a proper starting point for generating an assessment (Pherson and Pherson, 2021, p. 69). In this case, a doctor may have insufficient data to make a solid assessment and compensates by adopting his or her best guess as the likely diagnosis. The doctor then proceeds to make decisions based on that initial, possibly incorrect, diagnosis. The danger of Anchoring is that, once people arrive at a conclusion, it is exceedingly difficult to convince them they may be wrong.

A Key Assumptions Check can also help guard against Confirmation Bias. This occurs when additional evidence, information, or test results are seen as confirming the initial conclusion or diagnosis. In this case, the doctor is less likely to focus on information that is contradictory to the diagnosis, opting instead to ignore or dismiss it.

Taking time to explicitly challenge key assumptions can help patients and their doctors avoid intuitive traps, including the tendency to:

- Project past experiences onto the current case, assuming that the patient is suffering from a condition previously (or recently) treated in other patients.
- Overemphasize small samples by drawing conclusions when insufficient information is available.
- Not consider multiple explanations for the problem.

The value of challenging initial assumptions is illustrated by the story of an intelligence analyst who started to develop large, round, silver-dollar-sized bleeding sores on the back of her hands shortly after the terrorist attack on 11 September 2001. The patient bandaged them but at meetings people would gasp when they saw blood trickle out from under the bandage and drip onto the conference table. The wounds bled unpredictably, like "Stigmata."

The first doctor the analyst saw guessed that she might have been infected with Anthrax, because there was an Anthrax scare after 9/11. He ordered tests, but they came back negative. A second doctor thought the patient had "impetigo", a bacterial infection of the skin and started her on an intense course of full-spectrum antibiotics, but the "Stigmata" were untouched. The third doctor incorrectly decided the patient was a "Catholic" psychosomatic whose religious sensibilities were creating the bleeding. A fourth doctor thought her laundry detergent was giving her "contact dermatitis" but the patient was already using unscented, non-phosphate laundry soap.

The patient had started to lose faith in the medical system; each diagnosis had been presented within minutes of her explaining the problem without any kind of rigorous analysis. The solution presented itself when, after reading a book, the patient decided to avoid eating soy products. The aftermath of 9/11 had forced the patient, and many others working in the Washington DC area, to forgo sit-down meals because of the demands of their jobs, and they resorted to consuming food bars that contained soy-protein. Eliminating soy from her diet allowed her to live a normal life again. But, whenever she eats a meal at a restaurant that uses soy, the backs of her hands will itch or blister the next day.

In *How Doctors Think,* Groopman provides a telling example of a doctor who made a bad assumption (Groopman, 2007, p. 55). The doctor recounts the story of a young man who was brought to an emergency room in the wee hours of the night. He had been found wearing dirty clothes and sleeping on the steps of a museum. He was uncooperative when approached by police. The doctor initially assumed he was another homeless hippie who simply needed a good meal and could be sent back out on the street.

After being prodded by an observant nurse, the doctor examined him and discovered he was on the brink of a diabetic coma. The doctor later determined that he was a student who had fallen asleep because he was weak and unable to make it home. His difficulty in responding to the police and the nurses stemmed from the metabolic changes that typified his out-of-control diabetes. A standard procedure for mitigating the risk of an erroneous treatment resulting from a faulty assumption is to run a battery of tests — in this case for blood glucose levels and a toxin screening — on arrival at the ER.

The medical profession is well aware of its susceptibility to cognitive bias and intuitive traps as well as its tendency to not examine basic assumptions. One of the best antidotes is to involve many specialists from diverse backgrounds and areas of expertise in the diagnostic process. This realization provides one of the intellectual foundations for the establishment of the NIH's Undiagnosed Diseases Program. Some 50 to 100 patients with undiagnosed conditions are invited annually to the NIH Clinical Centre in Bethesda, Maryland, to receive a thorough evaluation and engage in consultations as part of the program.[417] Such a procedure would not be feasible in regular medical practice because the insurance industry would not cover the high costs of the program.

A key factor in the success of the NIH program is that doctors are encouraged to challenge each other's assumptions in a nonthreatening, collaborative environment. The purpose is not to advance anyone's reputation in the profession but to come up with a proper diagnosis that had previously escaped discovery and required more imaginative or systematic thinking.

Premortem analysis and the structured self-critique: asking "what if we are spectacularly wrong?"

Many of us are familiar with the concept of a post-mortem. The purpose of a post-mortem is to review the historical record and evaluate where and why things went wrong. This usually is a prolonged and painful process that can consume considerable resources. Gary Klein wrote an article in the September 2007 *Harvard Business Review* that poses a thought-provoking question: "Why not conduct a premortem type of exercise before we publish our paper or implement our decision to avoid having to initiate a much more embarrassing and labour-intensive process after the fact, should we have turned out to be wrong?" (Klein, 2007)

In *How Doctors Think*, Groopman describes how one of his colleagues, Dr. Karen Delgado, a specialist in endocrinology and metabolism, has intuitively adopted this approach (Groopman, 2007, p. 171). She relates that when she was an intern and would admit a

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[4] For more information on the program, go to https://rarediseases.info.nih.gov/Undiagnosed.

patient with what seemed to be a clear and obvious diagnosis, she would ask herself, "What if we are wrong? What else could it be?" Sometimes she could rearrange the data in her mind to come up with a credible alternative diagnosis that was also consistent with the patient's symptoms. If she could not come up with an alternative diagnosis, she could be more confident the original diagnosis was correct.

A Premortem Analysis is conducted to assess whether a key decision, diagnosis, or action could turn out to be spectacularly wrong.[5] A Structured Self-Critique is a systematic procedure that an individual or a small group can use to identify similar weaknesses in its own analysis or recommendations. Both should be conducted midway through the diagnostic process, just as the doctor or the medical team is starting to converge on a single, most likely diagnosis. Premortem Analysis involves brainstorming, which is more of a right-brain or intuitive process. Structured Self-Critique is a more left-brained, analytic process involving checklists.

The primary purpose of these techniques is to reduce the chance of surprise and the subsequent need for a post-mortem should the diagnosis prove wrong. It helps the doctor or the medical team identify potential sources of error that may have been overlooked. Two creative processes are involved:

(1) **Reframing the issue.** The exercise typically elicits responses that are different from the original ones. Asking questions about the same topic, but from different perspectives, opens new pathways in the brain.

(2) **Legitimizing dissent.** Members of a group will often not speak out if they think most of the group would not agree with them. With Premortem Analysis, all the members of the group are asked to come up with a positive contribution to the session by identifying weaknesses in the previous analysis.

A major benefit of the technique is that it empowers those who have unspoken reservations (for example, a nurse or doctor who has

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[5] In *Structured Analytic Techniques for Intelligence Analysis*, Pherson and Heuer adopted Klein's concept and expanded it into a more robust two-stage process involving a right-brained Premortem Analysis and a left-brained Structured Self-Critique.

just joined the team) to speak out in a context that is consistent with perceived group goals. The approach embraces two different methods to explore all the ways a diagnosis could be incorrect, using a totally unbounded as well as highly structured process. By legitimizing dissent, the techniques offer a strong defence against the challenges of Groupthink. Groupthink is choosing the option that most members of the group agree with or ignoring conflict within the group due to a desire for consensus.

Premortem Analysis protects doctors, the medical team, and their institutions against the Vividness Bias, which involves focusing attention on a single vivid scenario or diagnosis while other possibilities or potential alternative hypotheses are ignored. Vividness Bias can also come into play if the doctor is deluged with promotional materials and media advertisements for medicines that treat a particular ailment. As a result, doctors could become more susceptible to asking if their patients suffer from an ailment that gets a lot of public attention.

An intuitive trap that Premortem Analysis helps correct is Relying on First Impressions (defined as giving too much weight to first impressions or initial data, especially if they attract our attention and seem important at the time) (Pherson and Pherson, 2021, p70). This is a trap that is hard to escape, given the current state of medical care in the United States. Doctors are under extreme pressure from the insurance industry to make decisions as quickly as possible to keep costs (as measured by a doctor's time) to a minimum.

The value of integrating the Premortem Analysis and Structured Self-Critique techniques into a diagnostic process was demonstrated by a paediatrician who vetoed the decision to dismiss a patient from a hospital and saved his life. The patient was a high school student who was recuperating from a bad cold when he and several of his friends were thrown into a heated swimming pool on a cold evening in May.

On Monday after school, he lay down in bed saying he felt "weird"; his legs "were warm on the sides and cold on top". He had a fever, but his hands were icy cold. His mother called her paediatrician who examined her son, noticed some minuscule dots on his chest, and arranged for him to be admitted to the hospital. On arriving, the doctors performed a spinal tap to test for bacterial meningitis. When the father arrived at the hospital, the entrance to the emergency room was blocked by a long ribbon of yellow tape. The security guards told him no one could cross the line because the facility was quarantined. He said, "My son is in there", and they asked for his name. When they heard it, they told him, "You are allowed to proceed".

The patient's fever and the tests turned out to be negative. The ER doctor started to release the patient when the paediatrician called in to check on the patient's status. The doctor's concern was: What if the diagnosis was wrong? He knew that bacterial cultures from the spinal tap fluid can take two or three days to show positive results and that the patient was still at risk. In the worst case, how could the doctor explain why the patient died after medical personnel had said all was well?

The doctor insisted that the ER doctor start a heavy dose of intravenous antibiotics as if the patient had bacterial meningitis. The patient recovered, but it took many months before he could attend a full day of school without taking naps. The after-effects of the episode affected him for many years, but the doctor's attentive intervention almost certainly saved his life.

A key challenge to conducting a Structured Self-Critique is making time in a busy doctor's schedule to review an appropriate set of checklists. Even more difficult is finding the time to get a "team' together to conduct a Premortem Analysis brainstorming exercise. At a minimum, a partial solution to consider would be for doctors to take a minute at the end of an appointment to ask them, "What are the consequences if my diagnosis is wrong, and how could that have happened?"

These structured techniques provide useful strategies to refocus attention on the need for diagnosis, to challenge assumptions, and to look for lead indicators of looming health crises. Care must be taken, however, to use them correctly. The remainder of this article defines each technique and describes the role each can play. It also provides a step-by-step process for using each technique.

Appendix: six structured analytic techniques multiple hypothesis generation

Multiple Hypothesis Generation is a structured way to generate a comprehensive set of mutually exclusive hypotheses for explaining a particular problem, condition, or behaviour.

Multiple Hypothesis Generation is part of any rigorous analytic process because it helps people avoid common pitfalls such as coming to premature closure or being overly influenced by first impressions. It helps one think broadly and creatively about a range of possibilities. The goal is to develop a Mutually Exclusive and Comprehensively Exhaustive (MECE) list of hypotheses that can be scrutinized and tested against existing symptoms, test results, other information, and any new data that may become available in the future.

The Multiple Hypothesis Generation technique is a useful tool for broadening the spectrum of plausible hypotheses. It is particularly helpful when there is a prevailing, lead hypothesis and little thought has been given to alternative possibilities. It is also helpful when there are several members of the medical team, none of whom can agree on what should be the lead diagnosis.

The Process

Step 1: Succinctly define the medical case, illness, problem, activity, or behaviour that is under examination.

Step 2: Establish the lead diagnosis or "hypothesis" for explaining this problem, activity, or behaviour.

- The lead hypothesis could be the one you were given, the most obvious explanation, orthe conventional wisdom.

Step 3: Critically examine the lead hypothesis by identifying and listing its key components.

- Use the journalist's classic list of "Who, What, How, When, Where, and Why" to evaluate all critical dimensions of the lead hypothesis.
- Some of these questions may not be appropriate for the particular problem or behaviour you are examining.

Step 4: Generate plausible alternative explanations for each key component.

- Once this process is complete, you should have lists of alternative explanations for several components of the lead hypothesis.
- Strive to keep the alternative explanations on each list mutually exclusive.

Step 5: Identify all the possible permutations that can be generated using these lists.

Step 6: Discard any permutation that simply makes no sense.

Step 7: Evaluate the credibility of the remaining hypotheses by challenging the key assumptions of each component.

- Some of these assumptions may be testable themselves.
- Assign a "credibility score" for each hypothesis, e.g., using a 1– to 5-point scale.

Step 8: Re-sort the remaining hypotheses, listing them from most to least credible.

Step 9: Select from the top of the list those alternative hypotheses most deserving of attention (and inclusion in an Analysis of Competing Hypotheses matrix, if appropriate).

Analysis of competing hypotheses

Analysis of Competing Hypotheses (ACH) is a tool to aid judgment on issues requiring careful weighing of alternative explanations, hypotheses, or diagnoses.

ACH involves the identification of a complete set of alternative explanations (presented as hypotheses or diagnoses), the systematic evaluation of each, and the selection of the explanation that fits best by focusing on information that tends to disconfirm rather than confirm each of the explanations.

Doctors face the perennial challenge of working with incomplete, ambiguous, anomalous, and sometimes deceptive information. In addition, strict time constraints and the need to "make a call" often conspire with natural human cognitive biases and intuitive pitfalls to produce inaccurate diagnoses. ACH improves the doctor's chances of overcoming these challenges by requiring her or him to identify and refute all but one credible alternative explanation based on known symptoms, laboratory tests, assumptions, knowledge gaps, and other pertinent information.

The Process

Step 1: Create a matrix.

Step 2: Identify all the possible diagnoses or hypotheses and list them at the top of each column in the matrix. Be sure that they are mutually exclusive and comprehensively exhaustive.

Step 3: List all significant pieces of relevant information (symptoms, test results, validated assumptions) in the rows going down the left side of the matrix. (Include any conspicuous absence of evidence.)

Step 4: Indicate in each cell whether the relevant information is highly consistent with, consistent with, inconsistent with, highly inconsistent with, or is not applicable to each diagnosis. Consider information as highly inconsistent if the item makes a compelling case that the diagnosis must be incorrect. Similarly, list information as highly consistent if a compelling case can be made using this information to show the diagnosis is correct.

Step 5: Discount all diagnoses where the listed inconsistent information makes a persuasive case for dismissing the hypothesis.

Step 6: Determine how sensitive the lead diagnosis (es) is to a few critical items of relevant information. Consider the consequences for the analysis if that finding were wrong, misleading, or subject to a different interpretation.

Step 7: Identify key facts or future actions the team should explore to distinguish between the lead diagnoses or increase confidence that the chosen diagnosis is correct.

Indicators

Indicators are a pre-established set of observable phenomena (or symptoms) that are monitored and assessed to confirm or disconfirm the viability of a diagnosis.

Preparation of a detailed list of indicators or symptoms to track provides a useful learning experience for all participants. It facilitates the exchange of knowledge among those on the medical team and can spur a decision to order new tests or conduct additional research. The identification and monitoring of confirming and disconfirming indicators can spur early warning of untoward developments or unanticipated changes in the condition of the patient. The human mind tends to see what it expects to see and to overlook the unexpected. Indicators take on meaning only in the context of a specific diagnosis with which they have been identified.

The Process

Step 1: Working alone, or preferably in a small group, brainstorm a list of indicators that would confirm the validity of the diagnosis (es). Also, create a list of indicators that would demonstrate that the favoured diagnosis is incorrect.

Step 2: Review and refine both sets of indicators for each diagnosis(es), discarding in each set any that are duplicative and combining those that are similar.

Step 3: Examine each indicator to determine if it meets the following five criteria. Discard those that are found wanting.

- **Observable and Collectible.** There must be some reasonable expectation that, if present, the indicator will be observed and reported to the medical team. If an indicator is used to track whether change has occurred over time, it must be collectable over time.
- **Valid.** An indicator must be clearly relevant to the stated diagnosis and accurately measure the problem, illness, or phenomenon at issue.
- **Reliable.** Data collection must be consistent when comparable methods are used. Those observing and collecting data must observe the same things. Reliability requires precise definition of the indicators.
- **Stable.** An indicator must be useful over time to allow comparisons and to track events. Ideally, the indicator should be observable in the near future so that the doctor has time to react accordingly should contrary indicators prove the diagnosis to be incorrect.

- **Unique**. An indicator should measure only one thing, and in combination with the others, should only point to the selected diagnosis and never to any alternative diagnoses previously considered.

Key assumptions check

A **Key Assumptions Check** is a group exercise to list and challenge the working assumptions that underlie a key judgment or diagnosis.

Assumptions are unavoidable and necessary.

- It is reasonable to take certain things for granted.
- It is sometimes necessary to make assumptions until confirmation comes.
- Estimations and complex problems often require simplifying assumptions to make them manageable.

The quality of an assumption, however, can range from poor to good. Much depends on the basis of the assumption. Over the years, facilitators have observed that approximately one in four key assumptions usually collapses on careful examination.

The Process

Step 1: Assemble a small group. Gather a small group of people who are familiar with the case, along with one or two "outsiders' who can come to the table with an independent perspective. An "outsider" is not informed about the patient or the case but understands what the group is trying to accomplish. Ideally the group would include a few doctors and nurses, the patient, one or two family members, and an intern or health professional not familiar with the case.

Step 2: Define the key objective. If necessary, provide the participants with a short summary of the case one or two days before the session. Ask them to identify two or three assumptions that are likely to underlie the analysis. When the group is assembled, briefly review the case and answer any questions. Develop a consensus on the objectives of the session.

Step 3: Ensure agreement on the definition of an assumption. An assumption must be true for another condition or development to be valid; it can also be a fact or statement that people will take for granted. The latter are often generated by cultural bias or reflect an entrenched mindset.

Step 4: List your key assumptions. On a whiteboard or an easel, list all the assumptions identified by the participants. Resist the temptation to critique the assumptions as you list them.

Step 5: Evaluate the assumptions. After developing a complete list, go back and critically examine each assumption. Encourage the participants to ask themselves the following questions. You may want to display these questions on another easel, on a whiteboard, or provide it as a handout.

- How much confidence do I have that this assumption is valid?
- Why do I have this degree of confidence?
- Under what circumstances might this assumption prove untrue?
- Could it have been true in the past but is no longer true today?
- If it turns out to be invalid, how much impact would this have on the diagnosis?

Step 6: Categorize the assumptions. Place each assumption in one of three categories:

(1) Basically solid or well-supported (i.e., self-evident or common sense).

(2) Correct, with some caveats (i.e., based on history, doctrine, or "normal" behaviour).

(3) Unsupported or questionable (i.e., entirely hypothetical or even far-fetched—I could wake up tomorrow to find out it was wrong and understand why).

Step 7: Identify key uncertainties. Some Unsupported Assumptions may turn out to be Key Uncertainties. These uncertainties should be noted for follow-up testing or research.

Step 8: Organize the list of assumptions. Group the assumptions into three categories—Solid, Caveated, and Unsupported. Prioritize the assumptions in each group.

Step 9: Consider next steps. Ask the group if it would be appropriate to take the list of Key Uncertainties and possibly some of the caveated assumptions and generate a list of things to do to resolve the uncertainty. What additional tests should be ordered, what questions should be asked, and what new research is needed?

Step 10: Generate a final product. After the session, circulate a list of prioritized assumptions and any future actions that the group is spurred to take as a result of the brainstorming session.

Premortem analysis

Premortem Analysis is conducted prior to finalizing an analysis or diagnosis by a doctor or, preferably a medical team, to brainstorm how the chosen diagnosis could be spectacularly wrong.

The goal of Premortem Analysis is to challenge — actively and explicitly — an established mental model or analytic consensus in order to broaden the range of possible explanations or diagnoses that are being seriously considered. This process helps reduce the risk of analytic failure by identifying and analysing the features of a potential failure before it occurs.

The Process

Step 1: Gather in a room all those who are involved in the process of making a diagnosis or have a vested interest in the diagnosis being correct.

Step 2: Tell the group to imagine that some time has passed since the diagnosis was made and the patient has since died or his or her condition has deteriorated in a totally unexpected and dramatic way. No one now challenges the conclusion that the diagnosis was wrong—it was a spectacular mistake!

Step 3: Engage the team in using a brainstorming technique — such as Cluster Brainstorming or Circle boarding™ — to explore plausible explanations for this unexpected outcome. Try to identify all the possible ways the analysis could be wrong. Encourage everyone to come up with ideas. Sometimes a silent brainstorming technique is preferable, such as passing out notecards and asking each participant to write down one or two ideas. Then collect all the cards and write the ideas on a whiteboard or an easel. Challenge the group to see who can come up with the best idea of how a misdiagnosis came about.

Step 4: Look for patterns or groups of ideas and revisit your conclusions and evidence to see if you have overlooked, misinterpreted, or ignored key information.

Step 5: Decide if any alternative diagnoses merit attention, and whether any new tests should be administered, or additional research conducted.

If sufficient time is not available to work through this entire process, a fall-back strategy would be to add the following question to a list the doctor uses before he or she comes up with a diagnosis:

"Six months has gone by and the patient has died. What would explain how this happened?" **Structured self-critique**

A **Structured Self-Critique** is a systematic procedure that a small team or group can use to identify weaknesses in its own analysis.

When conducting a Structured Self-Critique, all members of the medical team don a hypothetical "black hat" and become critics of their own analysis. From this perspective, the medical team responds to a list of questions about sources of uncertainty, the analytic processes used to arrive at the conclusion(s), assumptions made, the diagnosticity of evidence, information gaps, changes in the broad context in which events happened, alternative decision models, potential deception, and cultural expertise.

When questions are asked about the same topic but from this critical perspective, team members often give a different answer than they gave before. For example, if a team member is asked if he or she supports the team's conclusions, the answer will usually be "yes". However, if all team members are asked to look for weaknesses in the team argument, the same team member may give a quite different response.

This change in the frame of reference is intended to change the team dynamics. The critical perspective should always generate more critical ideas. Team members who may have previously suppressed questions or doubts because they lacked confidence are now empowered by the technique to express divergent thoughts. If this change in perspective is handled well, each team member will know that they have added value to the exercise by being critical of, instead of supporting, the previous judgment.

A Structured Self-Critique exercise is helpful when a Premortem Analysis raises unresolved questions about the viability of the original diagnosis. Doctors find the Structured Self-Critique a helpful double-checks when dealing with a particularly difficult diagnosis. It can also help them resolve issues when members of the team have conflicting opinions.

The Process

Step 1: Remind all participants that they are now wearing a "black hat" and their job is to be a critic — not an advocate — of the team's analytic conclusions. Their job is to find weaknesses in their analysis. Can the diagnosis stand up to brutal scrutiny? Ask the following questions in conducting the critique:

- **Sources of Uncertainty.** Should we expect to find: (a) a single, obviously correct answer; (b) a most likely answer, together with one or more alternatives that should also be considered; or (c) a number of possible explanations that merit attention?
- **Analytic Process.** In the initial analysis, did the team do the following: Did it identify potential alternative diagnoses and seek more information on these diagnoses? Did it seek a broad range of diverse opinions by including others not familiar with the case in the deliberations? If not, this increases the odds of the team having a faulty or incomplete analysis. Either consider doing some of these things now or lower the teams' level of confidence in its judgment.
- **Critical Assumptions.** How recent and well-documented is the evidence that supports the assumptions made in this case? Brainstorm circumstances that could cause each of these assumptions to be wrong and assess the impact on the team's analytic judgment if an assumption is wrong. Would the reversal of any of these assumptions support any alternative diagnosis?
- **Diagnostic Evidence.** What lead diagnosis did we identify, and what are the most diagnostic items of evidence that have enabled the team to reject the alternative diagnoses? For each item, brainstorm one or more reasonable alternative

interpretations of the evidence that could make it consistent with an alternative diagnosis.

- **Information Gaps.** Are there gaps in the available information, or is some of the information so dated that it may no longer be valid? Is the absence of information readily explainable? How should it affect the team's confidence in its conclusions?
- **Missing Evidence.** Is there any evidence that one would expect to see in the interviews of the patient and the tests performed if the diagnosis is correct, but which is NOT there?
- **Anomalous Evidence.** Is there any anomalous item of evidence that would have been important if it had been believed or could have been related to diagnosis but was rejected as unimportant or not significant? If so, try to imagine how this item might be a key clue to an emerging alternative diagnosis.
- **Changes in the Broad Environment.** Might any social, technical, economic, environmental, or political changes play a role in why this particular diagnosis was chosen?
- **Alternative Decision Models.** Were any judgments based on a rational actor assumption? If so, consider the potential applicability of other decision models specifically that the action was the result of standard organizational processes, or the whim of a close-minded or overly stressed doctor. If time to do a more thorough analysis is lacking, consider the implications of that for confidence in the team's judgment.
- **Cultural Expertise.** Is the team or one of its members unduly influenced by cultural factors or ignorant of cultural norms that may be associated with the problem?
- **Deception.** Would the patient or anyone on the team have motive, opportunity, or means to engage in deception to influence what diagnosis was made? Does the patient have a history of engaging in deception or lying about his or her past behaviour?

Step 2: Based on the answers to the themes of inquiry outlined above, list the potential deficiencies in the evidence and logic that support the diagnosis in order of their potential impact on the correctness of the diagnosis.

Step 3: Discuss what the group could have done to avoid any of the potential flaws in thinking discovered during the Structured Self-Critique exercise.

References:

1. Alisi, Anna, Melania Manco, Andria Vania, and Valerio Nobili. (October 2009). Pediatric Nonalcoholic Fatty Liver Disease in 2009. *Journal of Pediatrics,* 155, no. 4. Accessed at: http://www.jpeds.com/article/S0022-3476(09)00568-X/fulltext

2. Almeda-Valdes, P., D. Cuevas-Ramos, and A. Aguilar-Salinas. (2009). Metabolic Syndrome and Nonalcoholic Fatty Liver Disease. *Annals of Hepatology,* 8, no. 1, Accessed at: https://www.academia.edu/20136452/The_metabolic_syndrome_and_nonalcoholic_fatty_liver_disease

3. *American Liver Foundation.* (26 October 2017). *Liver Disease Statistics*. Accessed at: https://www.liverfoundation.org/liver-disease-statistics/#non-alcoholic-fatty-liver-disease-non- alcoholic-steato-hepatitis

4. Balogh, Erin P., Bryan T. Miller, and John R. Ball, eds. (2015). *Improving Diagnosis in Health Care.* Washington, DC: National Academies of Sciences, Engineering, and Medicine.

5. *George, Roger Z. and* James B. Bruce. (2014). *Analyzing Intelligence: National Security Practitioners' Perspectives*, 2nd edition. Washington, DC: Georgetown University Press.

6. Groopman, Jerome M.D. (2007). *How Doctors Think* (Boston: Houghton Mifflin Company.

7. Klein, Gary. (September 2007). Performing a Project Premortem. *Harvard Business Review.* Accessed at https://hbr.org/2007/09/performing-a-project-premortem.

8. *Merriam-Webster.* (2019). Accessed on March 4, 2019 at: https://www.merriam- webster.com/dictionary/satisfice

9. Nudson, Rae. (6 March 2019). The Smartest Questions to Ask Your Doctor: What to bring up to be a more informed, proactive patient. *Medium.* Accessed 31 March 2019 at: https://medium.com/s/story/the-smartest-questions-to-ask-your-doctor-b12757820524

10. Pherson, Katherine H. and Randolph H. Pherson. (2021). *Critical Thinking for Strategic Intelligence*, 3rd edition. Washington, DC: CQ Press/SAGE Publications.

11. Pherson, Randolph H. (2020). *How to Get the Right Diagnosis: 16 Tips for Navigating the Medical System*. Coral Gables, FL: Mango Media, Inc.

12. Pherson, Randolph H. and Richards J. Heuer, Jr. (2021*). Structured Analytic Techniques for Intelligence Analysis*, 3rd ed. Washington DC: CQ Press/SAGE Publications.

13. *Sharecare.* (2019). *What Is Differential Diagnosis?* Accessed March 4, 2019, https://www.sharecare.com/health/diagnostic-procedures/ what-is-differential-diagnosis.

14. Wilson, James W. (16 November 2016). Signal recognition during the emergence of pandemic influenza type A/H1N1: a commercial disease intelligence unit's perspective. *Intelligence and National Security*. DOI: 10.1080/02684527.20o16.1253924

15. Wilson, James M. (9 May 2018). The use of intelligence to determine attribution of the 2010 Haiti cholera disaster. *Intelligence and National Security*. DOI: 10.1080/02684527.2018.1464430