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OVER-THE-COUNTER DATA

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OVER-THE-COUNTER DATA

THE HEROICS OF WELL-DISPLAYED INFORMATION
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Let's consider some heroes, starting with Jon Snow. For those of you not addicted (yet) to HBO's *Game of Thrones* series or George R.R. Martin's books, Jon Snow is a sword-wielding Northman of semi-noble birth who slays the undead, woos a wildling princess and wins fans' hearts. I mean to discuss, however, John Snow: meeker in appearance but equally heroic in deed.

HERO #1

Dr. John Snow was an accomplished English physician when, in the summer of 1854, people in London started becoming mysteriously – and fatally – ill. Inside a few square blocks of Soho, 500 people died in just 10 days, and no one knew why. The city was in a panic. With no clear enemy, residents fled and officials fought over who or what was to blame.

That's when Dr. Snow convinced local authorities to remove the handle from the Broad Street water pump, arguing the water it distributed was to blame for the deaths. With this seemingly simple move, Dr. Snow ended what was on its way to being a devastating cholera epidemic. (Previous cholera outbreaks in the United Kingdom claimed thousands and even tens of thousands of lives.)

Attributing the spread of disease to the pump's well was an unorthodox move at a time when miasma theory prevailed, owing the spread of disease to "foul air." However, Dr. Snow had a secret weapon: He knew how to make data user-friendly.

Dr. Snow turned an ordinary map of the neighborhood into an early example of data visualization.
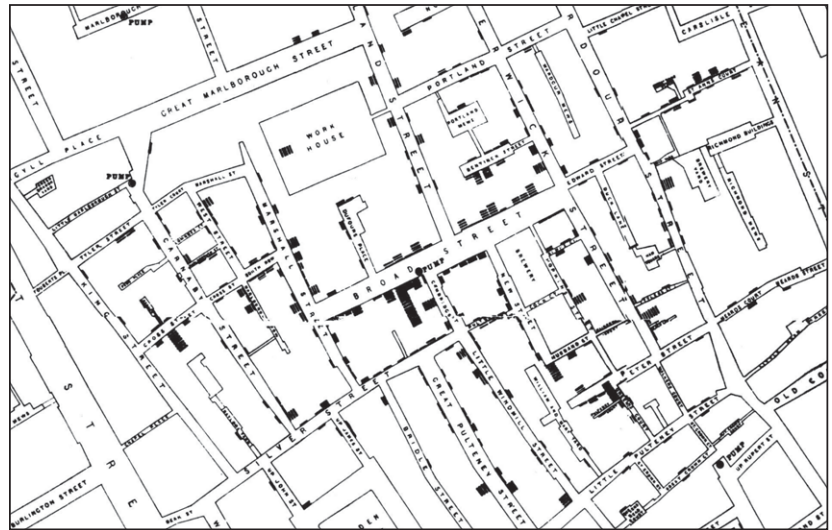
Dr. John Snow's data visualization of London's 1854 cholera outbreak helped identify its source.

He drew a small black mark where every death occurred, with marks stacking up where many people died. This map illustrated that most deaths occurred where people lived or worked near the water pump. The one exception was the Broad Street Brewery, as it seems drinking beer instead of water is sometimes the healthier choice.

Dr. Snow's map became a key piece in the acceptance of germ theory, a move that saved countless lives. He wasn't a hero because he had important data; many had access to the same information, yet it gave them no insight. Rather, Dr. Snow was a hero because he could communicate data in a way that made implications clear.

HERO #2

Another hero is Florence Nightingale. Am I talking about her building the foundation for modern nursing, her strides for invaid women and social reform, or the ministering for which Henry Wadsworth Longfellow's poetry immortalized her as "the lady with a lamp"? Not here. I mean to talk about something subtler but arguably as heroic: Nightingale's ability to make data user-friendly.

The U.K., France, Sardinia and Ottoman Empire lost hundreds of thousands of soldiers battling Russia in the Crimean War from 1853-1856. The vast majority of deaths, however, were not the enemy's doing but the result of disease.

In 1854, Nightingale convinced the British government to move funds away from the war effort and instead spend those funds on erecting a new hospital and improving living conditions and health care for soldiers. Nightingale's argument was that preventable disease was killing far more allied soldiers than Russia's military was. The request was unorthodox; however, Nightingale had a secret weapon: She knew how to present data clearly.
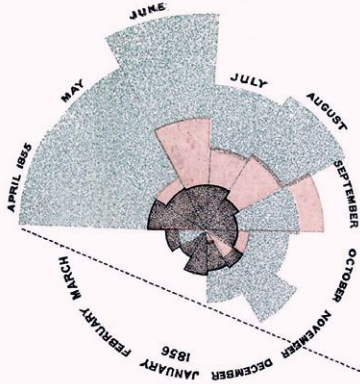
A renowned statistician, Nightingale, like Snow, drew a data visual-
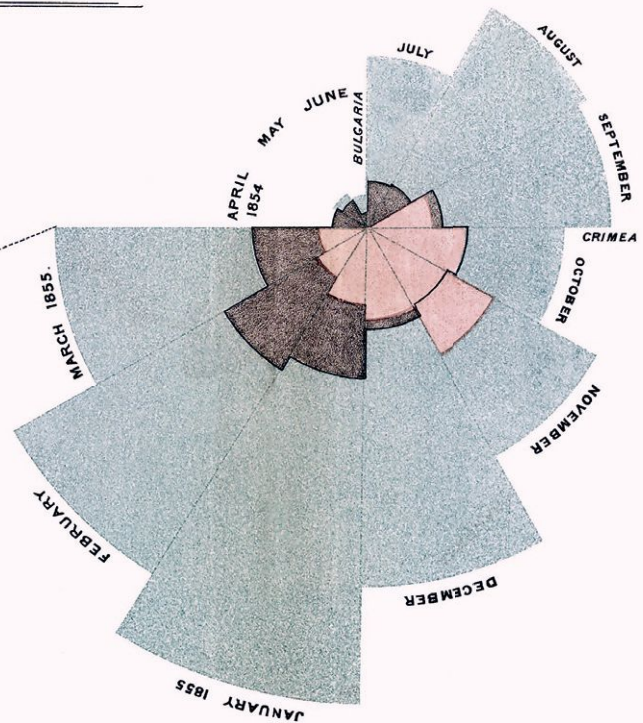
The Areas of the blue, red, & black wedges are each measured from the centre as the common vertex.

The blue wedges measured from the centre of the circle represent area for area the deaths from Preventible or Mitigable Zymotic diseases; the red wedges measured from the centre the deaths from wounds, & the black wedges measured from the centre the deaths from all other causes.

The black line across the red triangle in Nov.^r 1854 marks the boundary of the deaths from all other causes during the month.

In October 1854, & April 1855, the black area coincides with the red; in January & February 1856, the blue coincides with the black.

The entire areas may be compared by following the blue, the red & the black lines enclosing them.

Florence Nightingale's visualization of the causes of British soldier deaths during the Crimean War helped convince her government to invest in military health care.

izization: Polar-area diagrams representing one-year periods during the war clearly illustrated that a large portion of deaths – approximately 81 percent – were due to causes that could be prevented by better health care and living conditions.

Britain built the hospital and implemented Nightingale's suggested sanitation improvements, drastically reducing her side's death rate, from as much as 42 percent to 2 percent, according to some historians. Some critics have tried to downplay Nightingale's role in this reduction, but just as many experts have defended Nightingale's pivotal influence. She was not a hero because she had important data; many had access to the same information, yet nothing became of it. Rather, Nightingale was a hero because she could communicate data in a way that made implications clear.
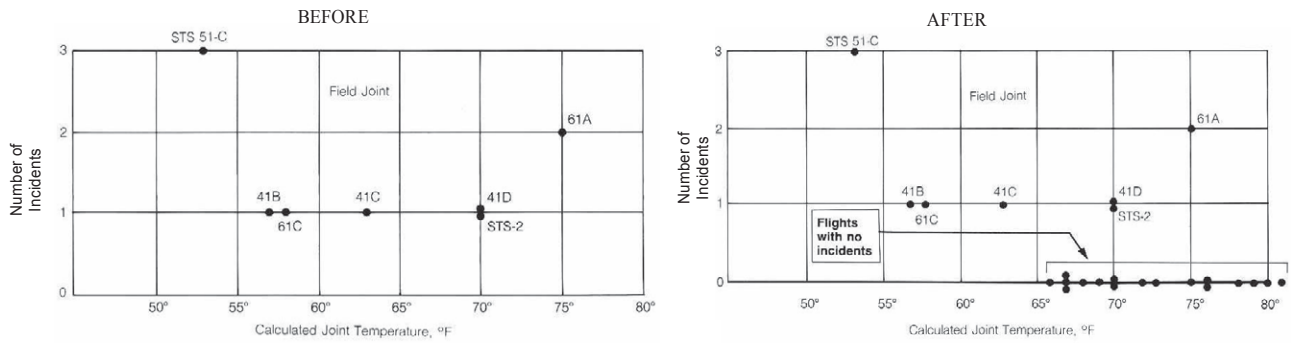
CHALLENGER

It takes great bravery to journey into outer space. On Jan. 28, 1986, seven U.S. crewmembers lifted off in the Space Shuttle Challenger, despite NASA engineers' expressed concerns about the launch's safety. The engineers had conferred with supervisors the night before the launch and viewed charts and diagrams concerning the booster rocket's O-ring function. The O-ring is a seal that prevents hot gasses from escaping. The engineers' charts, however, did not compel NASA managers to delay or cancel the launch on that cold January day. Seventy-three seconds into flight, the Challenger exploded, resulting in the deaths of all crew members.

Sadly, NASA had data that could have supported the argument not to launch. That data, however, was not displayed clearly during the debate over whether to proceed. Data

design experts have since redrawn NASA's graph depicting the test launches' incidents of O-ring thermal distress, arranged by launch temperature. As the *Report of the Presidential Commission on the Space Shuttle Challenger Accident* (the Rogers Report) demonstrated, the chart used the night before the disaster depicted data from failed launches. This graph offered no insight into how the O-rings functioned because it failed to include data from the 17 successful launches.

Viewing the original chart, which shows the outside temperature during launches that had O-ring incidents, nothing jumps out to indicate the January launch would fail. The improved chart, which includes data when O-rings functioned properly, tells another story.

Notice where all 17 cases of flights with no incidents land on the graph. This chart clearly illustrates that

BEFORE AFTER

NASA had data that could have cautioned against a Challenger launch at certain temperatures, but the data was not presented clearly.

O-rings functioned properly only when the outdoor temperature at launch was 66 degrees or warmer. When the Challenger launched, the temperature was 31 degrees – so cold it does not even fit on the graph. Imagine how data could have saved crewmembers' lives if it was communicated in a way that made implications clear.

DATA TRANSLATED

Data is misunderstood in every major field where it is used. For example, when teachers use data to inform decisions that impact students, teachers draw correct inferences from only 11 to 48 percent of that data, depending on the study referenced. Statistics on the intellect of teachers supports what you might also guess of NASA leaders: They are of above-average intellect and education levels. So, if intelligent people cannot understand data displays, you have to consider what is wrong with the data displays.

When I was researching data misunderstandings in education, my daughter got sick with the flu. She didn't need a doctor, but she did need medicine. Looking at over-the-counter medicine, it was easy to understand what the different products were and find what my daughter needed. This was because being "over-the-counter" means the item is easy to understand and use without the help of an expert. For example, key components are in place so someone using over-the-counter

medicine is likely to use the product appropriately, and the product is likely to do what it's supposed to do without a doctor's help.

A thought struck me: This is exactly what we need for high-stakes data. We need key components in place so someone using a data display is likely to use the data appropriately. That way, the data can fulfill its potential without the help of a statistician standing by to translate. We need data to be over-the-counter.

THE RESEARCH

Some of my heroes are those who research data use. I compiled more than 300 of the most noteworthy studies and expert sources from varied fields concerning best practices when reporting data. To fill gaps in available research, I conducted a 211-participant quantitative study in which I tested how best to display data so it is over-the-counter and thus easy to understand and use. I synthesized this research as a set of Over-the-Counter Data Standards that can be used to visualize data effectively and accompany the data with embedded data use guidance where appropriate.

When testing a sampling of these standards, I was stunned by the extent of their impact. With just one change to the way data was communicated, the accuracy of participants' inferences from that data more than doubled. Applying other standards tripled participants' accuracy. Additional standards caused participants

to correctly infer the data's meaning four times as often. I tested these standards in select sets to isolate variables, but together one could conceivably make data misunderstandings significantly unlikely by adhering to all Over-the-Counter Data Standards. High-stakes data *can* be made over-the-counter and thus easy to understand without a data expert present.

COMPONENTS OF OTC DATA

Each component that informs the use of over-the-counter products translates to making data use productive, as well:

CONTENT Medicine's content has to include ingredients that work. For example, a pill containing only sugar and food coloring could not have relieved my daughter's flu symptoms. Likewise, as seen in the Challenger tale, a data display's content is vital to the display's value.

LABEL Effective labeling tells you how to use a bottle of over-the-counter medicine. It has directions for use, ingredients, warnings and more. Likewise, data displays function best with clear titles and with annotations that offer warnings and guidance to stop viewers from misunderstanding the data that is displayed.

PACKAGE/DISPLAY Appropriate packaging helps you understand the nature of a box of over-the-counter medicine. For example, if a label has an image of a child on it, yet the medicine is intended for only adults,

that would be dangerously misleading. Likewise, data can be visualized so the design actively encourages understanding of the data's meaning. Dr. Snow and Nightingale both used appropriate displays to get their messages across.

SUPPLEMENTAL DOCUMENTATION A pamphlet is often tucked inside a package of over-the-counter medicine. This gives the user added explanations and details that cannot fit on the label. Likewise, an enclosed (or web-based) reference sheet or guide can walk viewers through how to understand a particularly complex data report.

HELP SYSTEM An online help system can supplement understanding the use of over-the-counter medicine. Approximately 50 million people per year use WebMD, one of many online help tools where people can search for information by topic or keyword. Likewise, a help system can be embedded within a computerized data system so users are aided in employing the technology but also in using its data.

In these ways, when something is over-the-counter, it is easy to understand and use without the help of an expert – be that a doctor or a statistician.

REAL-WORLD IMPACT

Adhering to best practices when displaying data can benefit all the lives affected by people's use of that data. Using the field of education as an example, where institutions apply these free standards on their own to ultimately help students:

» On a local level, Metro Nashville Public Schools in Tennessee applies Over-the-Counter Data Standards, and this single school district's presentation of data affects 82,000 students. MNPS Business Intelligence Coordinator Dr. Margie Johnson said, "Implementing these standards helped

us build capacity throughout the district to ensure the data is used appropriately to make informed decisions about increasing student achievement."

» On a state level, South Dakota Department of Education (SDDE) applies Over-the-Counter Data Standards, and this single organization's embedded guidance for data use affects approximately 150,000 students. SDDE found the data guides it implemented for its SD-STARS data system helped SDDE facilitate education stakeholders' analysis and use of this data to improve instruction and student performance.

» On national and international levels, Illuminate Education applies Over-the-Counter Data Standards, and this single company's data systems affect 5 million students. Because I served as the company's chief education and research officer while conducting my study, and my husband is the company's founder and CEO, the standards are deeply embedded within its data systems. These enhancements were met with extensive, positive feedback from data system users. As an example, teacher Carol Bright said, "There's a world of information in our data system, but teachers feel overwhelmed just thinking about it. If teachers aren't afraid to access the data reports – which is something Over-the-Counter Data Standards help with – think of how that information can help us help our students."

Over-the-Counter Data Standards for improved data reporting were written with education data in mind, but the standards summarize research from various fields and hold implications for displaying any type of data when it is imperative that data be understood. As technology evolves, researchers should, of course, continual-

ly examine how we can best share data with others. When the data field advances, all data-using fields advance.

WE CAN ALL BE HEROES

As Dr. John Snow and Florence Nightingale have shown us, the ability to effectively visualize and communicate data can save lives. As we have learned from the Space Shuttle Challenger launch, poor data visualization can play an equally life-altering role, though with fatal repercussions.

It would be negligent to sell medicine without over-the-counter components that help ensure the product is used successfully. Data can prove just as life-changing a tool as medicine and is thus just as worthy of over-the-counter components to help ensure its proper use. We have hundreds of studies to tell us the best ways to display data, and it pays to consider this research if understanding our data matters.

Technology allows us to visualize information more than ever before, and data displays are increasingly becoming a universal language, understood across global boundaries, across cultural and language barriers, and across other obstacles that might hinder the written word. No matter your career or personal interests, there will likely be a time when you have important information to share. Information is power, and when we care to communicate that information in over-the-counter ways, we can ignite understanding, new ideas, cures and solutions.

We don't have to be sword-wielding heartthrobs to be heroes. All we need is data and regard for design.

Watch the author's TEDx Talk on this subject at goo.gl/78UUmo (case-sensitive).