Write an outline/framework to make sure that when I meet with Ellen Peters, what can I find out on my own, and what else specific questions can we try to answer and address in the literature?

* Try to make sure it’s not too long! 2 to 3 questions MAX??
* It might not even be there in general, but she can try her best!

What question do we want to address?

* How to communicate/convince low numeracy individuals
* Do low numeracy individuals follow a different mental process?
  + If so… what is it, why is it, and what can we do about it (is it good or bad?)

We saw that numeracy moderated the effect of the intervention!

Innumeracy in the Wild

Ch 15: Evidence-based information presentation matters!

* Forms and types of information presentation are critical and useful
  + We could create a simplified abstraction (that doesn’t directly reflect truth as closely) that is more useful as a model?
  + Baruch Fischhoff – What is the goal of the communicator?
    - Here, our goal is to ingrain an understanding of the necessary trade-offs in UHC, and by illustrating this, hopefully improve comprehensibility and perceptions of fairness.
    - We might be able to improve this by somehow ‘reducing cognitive effort’… Is there an important balance between ‘realism’ in simulation for our model, and applicability in terms of human use, engagement, and understanding?
    - Although the effort in and of itself might be part of what’s generating value??
* “We can make the Hurdle shorter, or the Runner stronger”
  + Implies that there isn’t a categorically different approach that may work better?
  + Note: We can’t make people numerically ‘stronger’ here.
  + Hurdle Shorter : Improve ‘information’ architecture. Similar to choice architecture in the JDM literature.

Reflections on Innumeracy in the Wild

* The less numerate rely more on compelling concrete stories, images, and emotions, to make their decisions.
* Numbers often neglected by less numerate or those using superficial heuristics (which heuristics would be used in our case here?)
* Subjective numeracy research indicates that low confidence in subjective numeracy tends to lead to less math ability being used, even if objective math skill is good
  + In our example, subjective numeracy had no effect, but objective numeracy had a large moderating effect!
* “Relying on a simple mental shortcut once is efficient and often produces a decision that is good enough. However, when employed again and again, heuristic use seems to be a risk factor that accumulates over time and causes worse outcomes.”
  + Really unsure if we agree with this quote, but could look into more about what Ellen actually means when we chat about it. Is time sensitivity one of the critical criteria? If so, heuristics improving decision making overall under time constraints could be a net positive, instead of just making a choice regardless without any time to choose.

Summary Table

* Choose information presentation formats strategically – Test communications
  + Implies that perhaps same material, presented in alternative fashion, would do well?
  + Look into literature about presenting numerical information, perhaps an alternative to trying a non-numeric method (as that doesn’t directly address our potential mediating factors)
* Reduce Cognitive Effort
  + Provide fewer options, less information. This means a simplified version of the exercise?
    - Perhaps reach out to original designers to see what we can do here.
  + Do the math for them.
    - In-built calculator not enough? Perhaps some example plans?
  + Use appropriate visuals.
    - Unsure, but perhaps designing different structure for the game or presentation itself?
* Perhaps add a column/exercise indicating how much individuals actually used the given health options in a year, and whether or not they would be happy if the plan selected was what they had?

Ch 16: Provide Numbers but Reduce Cognitive Effort

* Can correct people who have wrong facts
  + Is there a subset of people who don’t support UHC due to incorrect factual reasons?
  + If the ‘scope’ of facts is very large, providing information can be like drinking from a fire-hose, not particularly plausible.
* Can correct inappropriate interpretations: Not really sure how this applies here?
* Can help people avoid being surprised by an unexpected event and possible regret and anger that can follow
  + Perhaps adding in information about base rate of occurrence of various categories of harm, in ADDITION (or alternatively?) to information on what is covered.
  + Emotion can divert attention from unlikelihood of an event if numeric likelihood is not emphasized
    - Here would be the effect of affect on choices and priority setting in medical care
  + Perceived as more useful - ??? Unsure

Perhaps we can add a table translating meanings for probability (look at the IPCC 6 climate change report on how they used various terminologies)

* If so, would the ‘colloquial’ labels be more useful than hard numeric ones, if provided with an additional table?
  + Data shows that people CANNOT use the IPCC table to translate meaning, and estimate risk improperly.
  + Straight numeric information prevents this from occurring however.
* The less numeric can still make use of this provided numerical information
  + But not as well as those who are highly numerate
  + This may NOT be a categorical type issue regarding communication?

Provide uncertainty in data

* Unsure how to use this regarding the numerical information provided in the study

Reduce cognitive effort

* What choices are relatively important? Would a simplified version of the exercise make sense, with less options and less choices (commonly chosen items could be pre-selected as the ‘default’ for the majority of people?)
* Options can be presented sequentially?
  + This doesn’t work when doing a choose n problem, because each step requires trading-off and optimization, you can’t choose A over B if it affects your choices of C over D, unless you know about the 2nd choice.
* How to determine which elements here are ‘critical elements’?
  + Perhaps get some feedback from clinicians?
* Provide absolute risk
  + If we were going to add relative likelihood of risk of various occurrences under the chart, we need to do it in an absolute risks framework.
* Use a ‘fixed’ denominator when looking at risks – This plays into our absolute risk, 1 in 1000, 10 in 1000, 30 in 1000, etc.
* Use numbers in a direction consistent with people’s expectations

DO the math for them

* When presenting cumulative risk, communicate the cumulative amount outright
* Use graphs or some type of visual
  + Perhaps a moving scale or bar showing how relative expenditures are used, or how many resources are left?
  + Maybe simple icon arrays indicating how much something would ‘cost’ in resources?
* How to ‘experience’ hypothetical risk?
  + Could show various images of dealing with medical problems as part of the exercise?
  + Didn’t replicate for Ellen Peters… how and why, what elements? (ref 125)

Ch 17: Provide Evaluative Meaning and Direct Attention

* In unfamiliar domains, we must be able to identify correctly what a number is without having clues to what it means for your decision
  + ????
* Difference b/w comprehension and comprehendability = decision maker cannot map a numeric value onto good/bad scale.
  + Providing evaluability means data = meaningful information to make choices
* Can either ask individual to estimate a number, and then show them the real value, or just directly show them the real value
  + The contrast has some benefit, mainly active comparison changes how people process information (especially if they tend to over or underestimate the true value)
* Attributes that are difficult to evaluate (fertilization clinic distance vs success rate) without context, subjects might overvalue the thing that is at least somewhat comprehensible.
  + Highly numerate people SOMETIMES use comparative information more, but the research is mixed.
  + E.g. Graphical presentation of risk is useful for highly numerate, but not the less numerate (insensitivity to risk levels) (ref 34,35)
    - Unless it’s a highly simplified graphic? (ref 30, 36)
* Providing more risk information affects the perception of the numeric risk level
  + This ‘unpacking’ of risk factors affects only the less numerate, a potential alternative to increase perceived relevance and elaboration of numeric risk (or we can use narratives?) (ref 38)
* Numeracy effects are less likely to emerge when motivation is HIGH and when concrete, easy to evaluate comparisions are provided.
  + MORE likely to emerge when numbers are seen as less trusted, are complex, or require math calculation.

Carefully use evaluative labels/symbols

* Evaluative labels improves risk comprehension (high, low, med, instead of 15, 10, 5% which can be hard to contextualize)
  + It seems to do so by changing participant affect.
* But people can over-react to evaluative labels as well, which is likewise a problem.
  + Decreases understanding of specific information; can lead to value-inconsistent choices and risk perceptions.

Frequency vs Percentage formats

* Less numerate finds that medicine is less risky when side effect info presented using percentage instead of frequency.
  + Perhaps b/c frequency formats = greater emotional feelings vs percentage formats?

Use other more Imagineable data formats

* Instead of presenting disease risk change, perhaps present life expectancy change? This is more comprehensible to average person and directly relevant as well.
* Analogies are very useful because they are very comprehendible for most people if well formed.
  + Lead to improved understanding of medical problems

Leverage Emotion to get attention, information, and motivation.

* Emotion has value! Emotion is information, informing perceptions of risk quickly and efficiently
  + Spotlight in 2 stage process, emotion highlights information, then information affects decisions.
* Order information such that the most IMPORTANT item is FIRST or LAST
  + Effect MAY be greater amongst the less numerate?
  + For very complex information, ordering plans lead to greater comprehension only for the more subjectively numerate (e.g. ordering medicare plans by benefit and generosity)
* ONLY highlight the most IMPORTANT information using symbols
  + If you highlight everything, even the unimportant stuff, the less numerate do worse.
* Summaries can provide an overview
  + BUT it harms comprehension of outside of framework information
  + Summary evaluation can work instead?
    - Summary of each hospitals evaluation helps make choices for the less numerate, when looking and comparing multiple hospitals along many axis.
* Improve visual salience (UI stuff)
  + Greater contrast, larger font, etc.

OVERALL

* Use presentation approaches for things that people SHOULD care about more (quality of health insurance for example)
* Use graded performance standards
  + But this requires expert judgement / consensus
* Pop short in general education based numeracy skills (arithmetic, cumulative risk, etc.)
  + But ALSO short on emergent decision-based numeracy skills (finding numeric information, deriving affective meaning from it)

Peters 2007: Numeracy Skill And The Communication, Comprehension, And Use Of Risk-Benefit Information

* Informed consumer choices are good, but uncertainty exists! How do we deal with innumerates who are not well calibrated.
* Why is numeracy important to health care decisions SPECIFICALLY?
* A good chunk of smart people incorrectly answered questions about risk magnitude (what’s greater, 1%, 5% or 10%?)
  + Similar questions might be a good tool to use to gauge… attention? This seems almost too obvious to get wrong.
* Types of uncertainty for health decisions
  + Uncertainty in health care settings: Uncertainty about magnitude of risks and benefits. Uncertainty about strength of evidence.
    - People accept or reject information fully, without adjustments for data quality or thinking on a continuum.
    - Uncertainty about how to weigh risks/benefits in choices
  + Skill needed to understand risk-benefit info
    - Information needs to be available, accurate, and timely.
    - Patient has to be able to asses tables, charts, and text.
    - Patient has to make calculations and inferences from this information.
    - Needs to know how to weight their needs/values.
    - Has to make choices under context of high affect.
* Difficulty evaluating risks and benefits of health options
  + Conceptually, this is a plausible explanation for why the non-numerate had less effect, that is NOT related to the more numerate being more engaged or attentive.
  + Quantitative descriptions are necessary, because qualitative descriptions are TOO ambiguous.
* Weighing short-term against long-term benefits
  + Could be impactful… but it assumes that the innumerate are thinking about and able to evaluate the relative cost and benefits of the selections at all, and THEN also have a perception of short vs long term.
* Best practices in presenting numeric health information
  + Less is More!
    - Can present simplified version of tasks?
    - Perhaps a sequence of left or right, this or that, and eventually after the carousel of choices has finished, the plan is there and the person made it over an aggregate of choices?
    - ALSO! Only simplifying the important elements, instead of the less relevant choices, generally leads to better choices (b/c subjects will upweight the simpler, but more important, information?)
    - Can mark the solid or easier to evaluate/more important section w/ symbols, like color coding, check marks, stars, etc.

Numeracy and the ACA: Opportunities and Challenges

* Numeracy levels in the US are super low
* Three main questions

Question 1: What does research show about people’s Numeracy Skill Levels?

* Different levels and scales of quantitative literacy, from below basic, basic, intermediate, and proficient
  + Proficient is seen as what is needed to make good health care choices in the marketplace??
  + 22% are below basic, 33% basic, 33% intermediate, and 13% are proficient.
* Dual process theory: Effect of time pressure, stress, illness on health numeracy
  + Affective engagement can change ability and resources available to engage in critical thinking.
  + Health problems can both directly and indirectly impact the capacity for thinking in the dual process concept.
  + Numeracy is measured under NORMAL circumstances, if ABNORMAL circumstances are standard for health concepts, then there is a risk of this reduced numeracy hurting people specifically making health choices.

Question 2: What Numeracy skills are needed to select health plans, choose treatments, and understand medication?

* Understanding of numeric information is necessary, arithmetic, basic computational skills, frequencies, etc.
* Less numerate are vulnerable to format effects, changing ratios and such.
* Probabilistic reasoning is needed for calculation of risk and likelihood
* Greater attending to numeric information is something for highly numerate as well.
  + Generally, the original task seems to need at LEAST basic information, and perhaps even as much as proficient?
* The less numerate have additional pessimism regarding factual information provided – in the form of cancer risk and perceptions.
  + E.g. the more numerate were also pessimistic, but their odds hewed closer to the true value.

Example – Skills needed for Health Plan Selection

* Consumers need to know what the terminology itself means.
* Basic skill allows for lowest cost plan based on premium and deductible
* Intermediate skill allows for evaluation of co-insurance costs and costs of treatments.
* Complex calculation, estimating annual costs and estimated out of pocket expenses require significant proficiency.

Example – Skills needed to select Treatment for self

* Some ambiguity behind treatment costs and difficulty to obtain them.
* Below Basic allows for comparison between generic and name brand price
* Basic allows for estimation of survival rates when given percentage survival
* Intermediate allows medication cost comparison between different dosage and units
* Proficient allows cumulative risks and benefits accurately

Question 3: What do we know about how providers should communicate with those with low numeracy skills?

* Ancker et al., 2006; Apter et al., 2008; Berkman et al., 2011; Fagerlin and Peters, 2011; Fagerlin et al., 2007a; Hibbard and Peters, 2003; Lipkus, 2007; Lipkus and Hollands, 1999; Peters et al., 2007a).
  + Various compilation of papers describing how to communicate numeric information
  + Mostly coming to the same conclusion



* Provide numeric information
* Reduce effort
* Provide evaluative meaning
* Draw attention to important information
* Set up appropriate systems
* Fewer options
  + if only certain options are valuable or important, you should maybe try presenting only them
* Provide less information
  + Any information that isn’t important should be removed
  + Perhaps try a ‘slimmed’ down version of the experience?
* Use appropriate visuals
  + Pictographs or icon arrays can indicate how much likelihood of having an issue
  + For common outcomes, bar charts are good!
* Use evaluative labels when you want to get some action happening!
* Order information such that the most important information is first or last
  + Important meaning here… largest cost or potential for cost?
* Use fonts that draw attention to important information
  + Mostly UI and visual design choices for our intervention itself?
* Ensure and Identify the goals of the communication
  + Make sure to clearly re-iterate what this is, and have it inform the core of the design itself
* Use defaults?
  + Provide a ‘default’ plan with most of the selections already made, and then see if the person themselves wants to alter the plan??

Panel 5: Strategies for Effective Communication

Krughoff – Consumers Checkbook

* Key features for communication about the ACA
  + Single dollar amount actuarial estimate of average total cost
    - INCLUDING premium and out of pocket costs for people with SIMILAR characteristics to the consumer, MUST be provided.
    - INCLUDING ‘range of risk’, how much a cost could be for a good or a bad year, and relative likelihood of having those years.
    - Summary rating for each plan’s care and service quality, but adjustable based on what the patient themselves values
    - Overview showing which doctors are available under which plan.
  + ‘Benefits description model’ is most common cost comparison tool
    - However, many consumers CANNOT understand the terms and CANNOT do the calculations required, when provided deductibles, copayments, etc.
  + Known-usage model is alternative.
    - Compares plans by having consumer estimate their actual use of provider visits and prescriptions
      * Is there a much simpler way of doing this? Perhaps just pro-rating for a given week, or a month, out to an entire year?
    - Model estimates costs of these services, but it’s VERY time consuming to do for the entire household.
  + Enroll UX2014 another options
    - Asks consumer preferences, then filters plans based on those preferences
    - HOWEVER, a consumer might not know how their answers cut off or prioritize different things, with false assumptions by the consumer a very common issue.
    - It is VERY challenging to design a quality comparison tool that does not require strong literacy or numeracy skills!
  + Consumer Checkbook uses 5 star rating system
    - However, two plans that are very different in some categories may still be the same star rating.
    - Some plans might have small differences b/w things and end up in DIFFERENT star ratings!
  + Too much detail leads to consumers being ‘disengaged’
    - Tyranny of choice
  + Consumer’s Checkbook Tool
    - Asks total health status (is a strong predictor of health services usage)
    - Asks for predictable procedures (childbirth, hip replacement, etc.)
    - C.f. names of doctors that are currently being seen, to see if they are ‘in plan’
    - Presents results by highlighting average yearly costs (combo of yearly premium, tax subsidy, and out of pocket costs).
      * Also presents minimum and maximum range that a consumer could pay.
    - This is what people’s surveys and ratings claim that they want, in the way they want it?
    - Can specifically request particular services, or ignore plans that have certain categories of characteristics.
  + Key element: Allows consumers to keep the format simple and allowing THEM to decide the level of personalization and detail

Brian Zikmund Fisher: Why are you giving me this number? Communicating quant info for decision making:

* Person could find information about themselves, that they have 14.52% chance of cardiovascular disease – Is this number GOOD or BAD?
  + It could be the most accurate estimate in the world, but this does not provide the person the information they actually want.
    - Integer risk (15%) would be perceived as more believable and easier to remember.
  + There is a lack of ‘information evaluability’
    - The meaning of this number depends on context, the number itself cannot be evaluated without context or reference standards.
    - Health professionals are trained to have contextual knowledge for numbers, but patients are NOT.
    - Not everything is hard to evaluate, expensive things, time, etc, are all things that a person themselves can consider.
    - Hard to evaluate data without a reference is GENERALLY ignored
      * Make sure the important elements have reference standards then?
      * Could we just give a topline – compared against health availability in other countries, for other citizens?
    - Perhaps give harm thresholds, or anchors for action given certain values.
    - Iconarray.com is a tool to make some icon arrays for comparison?
  + Risk communication CAN be simple when describing all possible risks, however, risk that adds motivation to ask, means categorical communication that aligns with that goal!
    - Give people the ‘right tool at the right time’
  + Ensure that there is not TOO Much information
    - What numbers are needed, what is necessary, what is important, especially if there is a trade-off b/w two courses of action!

Thompson 2022: Leveraging Math Cognition to Combat Health Innumeracy

* Natural number bias, tendency to apply knowledge about natural numbers to all numbers, is underlying other biases behind decision making.
  + Automatic processing of natural-number magnitudes and not ratio magnitudes
  + Advise some alternatives when presenting information
* Ratio bias, 1-in-x phenomenon, or denominator neglect, is very common
  + AKA the natural number bias in math cognition.
* We can prevent innumeracy downsides by implementing interventions that help individuals think more deeply about the magnitude of rational numbers.
* Generally – Natural number bias is due to lack of training on *relative* magnitudes vs *absolute* magnitudes.
  + Natural number bias can affect even highly numerate!

What underlies natural number bias?

* Perceptual limits – A person can see 4 > 2 much faster than 104 > 102, even if objective difference is the same.
  + More distance b/w numbers, easier to discriminate b/w them.
* Natural numbers are very common
  + ½ are seen much more often than 15/30 for example, as 1 and 2 are super common numbers!
  + Even in adults, 300 pennies is seen as worth more than 3 dollars

Natural number bias is the overarching phenomenon

* Various biases are in fact the result of natural number bias.
* Inability to engage in relational reasoning (considering concepts in isolation rather than in relation to each other)
* Subjects directly mention that they focus on numerators in isolation, and that covid lethality was undersold as it compared absolute numbers to flu deaths.
* 1 in x phenomena likely due to the heuristic, smaller components = larger magnitude, simply that larger denominators are smaller magnitudes.

Is natural number bias always bad?

* Can some contexts be such that automatic processing of natural number components = a better strategy/more efficient than computing the ratio magnitude?
  + Choice of strategy to use can and will change over time
  + Comparing two unit fractions in pure numerical context, ½, 1/3, ¼, 1/5, etc. smaller components = larger magnitude quite clearly here.
  + Can ask people to compare unit fractions to each other instead of other types of fractions?
* Misperception of risk can still prompt someone to adhere to recommendations for health??
* 1 in x format can lead to overestimation of personal risks
  + Which again… may be good if it spurs patients into action?

Percentages

* A solid alternative to 1 in x
* Involves a common denominator (by the 100)
* Percentages perceptually look like whole numbers (even tho they represent fractions)
  + Allows for benefits in natural number processing!
* However… can’t add up multiples of percentages so easily, 10% then 20% off is not 30% off.

Consistency in Measurement and Accounting for Individual Differences

* Some of our measures of objective numeracy require math solving problems
  + Which can tilt some people out, regardless of their actual math skill
  + Objective numeracy scales often have WORD problems as well, which isn’t necessarily good either.
* Subjective Numeracy is faster to get, and is correlated w/ objective numeracy
* These predict health decision making exactly b/c they relate to understanding of ratio
  + Obj = ability to calculate ratios
  + Subj = willingness to work with fractions/percentages
* Measures of math skills MUST incorporate knowledge of ratios!
* Some other measures from the field of math cognition could work well!
  + Number-line estimation task, estimation the location of numbers on a number line
  + Measures adult’s symbolic number mappings (Peters & Bjalkebring 2015) from 0-1,000
  + More useful to have number lines that include fractions, b/c rational number understanding is EXACTLY how health statistics works!
* Directly can measure math anxiety
  + Apprehension around math that occurs in the presence of numbers. Can reliably be assessed with one item (see Ashcraft, 2002; Núñez-Peña et al., 2014)

Educational Interventions to Improve Risk Interpretation

* Visualizations are good, e.g. icon arrays and risk ladders
  + Because these visuals allow to view statistics as percentages, which can be interpreted very easily.
  + Works well in ‘isolated’ situations, but how do you evaluate health info without visuals or cognitive supports??
* Health decision-making literature “recognizes that clinicians do not have time to teach patients about math”
  + Instead, they prevent activation of numerical biases
  + Promote use of non-cognitive processes (visual perception and icon arrays)
* Teaching how to do math is a long-term strategy, that is a societal type issue.
  + Does not rely on needing a well-designed visual display

Magnitudes are the GIST of rational numbers

* Understanding of magnitude is the building block of math
* Gist of magnitude allows people to estimate what is needed for good decisions.
* GIST usage increases with age.
* Reasoning w/ fractions.
  + Strategic and effortful reasoning is needed
  + Thus, learning goes from the gist understanding (rough magnitudes) to exact information, to using gist reasoning by considering approximate magnitudes.
* Number lines illustrate magnitude
  + Thus both primes subjects to use the ‘correct’ skills
  + Also allows for comparison of magnitudes to each other very easily
  + Leverages spatial-numeric relationships.

Interventions for Adults

* Combination of procedural instruction (step by step how to do activity) as well as conceptual instruction (what is relative to what, base rates and other numbers, etc.)
* Conveying conceptual information to explain why the procedures work the way they do Thompson et al. (2021)
  + Could we expand this even further when explaining our goal??
  + Could we add some basic costs and see if this is realistic to address?
    - Would people want less or more than the ‘pre-set’ budget, would knowing the monthly cost and value of each service in and of itself help drive decision making?

Gakumo 2016: A Qualitative Study on Health Numeracy and Patient–Provider Communication of Laboratory Numbers in Older African Americans with HIV

* How health numeracy affected patient’s ability to deal with their HIV
* Lab numbers are important to understand health status
  + Numbers are often confusing though!
  + Mutual communication b/w patient and provider is critical
  + USE LESS DETAIL!
* 20 older patients (55 yr avg), 10 male and 10 female
* Most were relatively poor, and had HIV for 12+ years
  + What elements could a dr. explain more easily?
  + Are there any top-line simplifications that people could understand?
* Some numbers are good if they go up, some are good if they go down
  + Should ideally make it so that the goal is to either shoot for high numbers up, or high numbers down?
  + Could we ask individuals to a-priori rate how important things are, then spend the least resources needed to obtain as much as they can that is objectively highly rated?
* Do individuals even directly understand what various things could benefit them?
  + Why not try to ‘simplify’ the benefits of various categories of care???
  + Would using simpler language and clear emphasis on the differences between levels instead of EXACTLY describing them be better?
  + People want to know what is GOOD and what is BAD
    - Perhaps some subjective ratings and opinions on stuff may be helpful?
    - Would several categories of additional opinions be good??? (young risk taking doc, older fixed income, foreigner, etc. as various categories of action)
      * Would directly address the critical intercommunication issue?
* Is it possible/likely that HEALTH LITERACY is also correlated and LOW amongst whoever we’re examining?
  + If this is the case… and numeracy differences are masking literacy differences, this could be concerning and useful to address.
  + Perhaps directly measure health literacy??
  + Actually…. Is numeracy, and health numeracy specifically, different groups of concepts?
* Clearly show that lower health-literacy is correlated strongly with poorer treatment adherence and viral load suppression.
* Fuzzy-Trace theory might explain some of the reasoning behind why lower numeracy/literacy thinking has less effectiveness
  + How do we fire up and activate the ‘gist’ representation of something to be as positive and full of understanding as possible??
  + Many patients make judgements based on the crudest gist representation that they have.
  + However…. Just getting a thumbs up, while good, might leave some patients using that as justification to become less adherent to clinical treatment.

Thompson 2021: Math Predictors of Numeric Health and Non-Health Decision-Making Problems

* 90 adults answered health decision making problems, 90 answered nonhealth decision problems.
  + Objective AND subjective numeracy were measured.
* What aspects overall predicted performance in both categories?
  + Magnitude, multi-step arithmetic, math anxiety predicts health-decision accuracy.
  + Attention to math predicts nonhealthy decision accuracy.
* NOTE: Reliable and VALID measures from math cognition literature were more strongly related to health decision accuracy than commonly used subjective and objective numeracy measures.
* Do individual differences in math skills/attitudes/anxiety/strategies in pure numerical context ALSO account for variance in accuracy for health decision making.
  + Hypothesis: Health decisions involving numerical information should be solved similarly to pure numerical math problems.
  + Additional process may be engaged compared to neutral ‘pure’ math context.
* Directly measured: Math anxiety, Magnitude understanding, arithmetic fluency, calculation accuracy, math attitudes, and strategy use.
  + ALSO: Included measure of objective and subjective numeracy (used in health decision-making research).
  + NOTE: Number line estimation and magnitude comparison are QUICK to give and do not require participants to solve word problems
  + Also measured the ‘strategy report’ on how participants ‘solved’ each problem. I think this would be EXTREMELY useful when trying to determine what people prioritized in their health care, and might inform why and how the exercise changes thoughts on UHC.
  + Measures:
    - Objective
      * Magnitude understanding: Precision of number line estimation as percent absolute error.
      * Fraction number-line estimation: place 20 fractions one at a time on number lines ranging from 0 to 1, and 20 more fractions on a line from 0-5.
      * Number-line estimation in the 0-1,000,000,000 (1 billion) range: Participants estimates one at a time in a large numerical range. Percent absolute error is our measurement.
      * Magnitude comparison accuracy: look at 2 fractions, choose which fraction is the largest, percentage correct across all problems.
      * Arithmetic Accuracy – 2 sub tasks
        + Fraction arithmetic: Six problems for addition, subtraction, multiplication, and division. # of total correct answered questions is our measure.
        + Calculation Fluency Test, 3 minutes to complete 2 digit whole number arithmetic problems out of 180 total (1 min for 60 problems in addition, subtraction, multiplication). # of correctly answered question.
      * Multi-step Arithmetic Accuracy: 4 multi step fraction arithmetic problems that involve common denominators, adding and subtracting fractions.
      * Numeracy, Objective: Rasch-based objective numeracy scale (Weller).
    - Subjective
      * Subjective Numeracy Scale (Fagerlin).
      * Math Attitudes: 20 item math attitude survey regarding feelings on whole numbers, rational numbers, etc.
      * Math Emotions: 7 point likert scale (but not analyzed)
      * Math Anxiety: 10 point scale w/ higher = greater anxiety. Single-item measure was correlated from .49-.85 with scores on an abbreviated version of the 98 item Math anxiety rating scale.
    - Decision-making problems and reports. Either correct (1) or incorrect (0) aggregated across 4 problems.
* Discussion:
  + Mainly, the objective mathematical measures may be the ones to give, as the subjective ones did not indicate any difference, and the objective ones functioned better at predicting accuracy.
  + Improving attention to the mathematic elements may be helpful for our own activity
  + Somehow adding a clear or clean visual representation might simplify (stacking bars of various lengths, to hit a certain threshold) the exercise.
  + Really, REALLY make sure we have objective math skills
    - AND! NOTE! Math skills worked just fine in the ‘hot’ environment regarding the health choice, as well as in the ‘cold’ purely numerical problem.

Sawe 2020: Data sonification to overcome science literacy, numeracy, and visualization barriers in science communication.

* Intuitive technique for communicating scientific information by translating data I not sound (sometimes even music!)
* Can convey large data w/ many dimensions efficiently and in an engaging way.
  + Great for those with visual impairments!
* Different elements of data (types of tree) can be represented by different instruments
  + Tree height mapped to pitch
  + Tree diameter mapped to velocity (of note)
  + Tree fullness mapped to note length
  + Dead tree = silence!
* Addressing scientific/graphic literacy!
  + Multivariate data isn’t knowing stats procedures, but understanding multivariate phenomenon and heuristics
  + Sonification lets you develop these heuristics by revealing the structure of the data itself.
  + Categorical variables map to nonvarying things, like timbre
  + Continuous variables can map to frequency or tempo
  + Simplification or clear mapping of sound to data must occur occasionally, non-linear responses and uncertainty can be hard to represent through sonification.
  + The data itself can be presented quickly and easily, and works well for individuals who can choose to pace their listening as is.
* Aesthetics!
  + Abstracting the sonification can be good!
  + However, since music can drive affective states, this can be a boon and a curse.

Petrova 2018: Strengths and Gaps in Physicians’ Risk Communication: A Scenario Study of the Influence of Numeracy on Cancer Screening Communication

* Do physicians adapt to communicate to those with lower numeracy, and how does it work?
  + Mainly a survey study of physicians in UK about how they communicate w/ patients.
  + Vignette: Physician was primed to think screening was effective or not, recommended or not, and for a patient with high/low/unmentioned numeracy.
* What about physicians who have lower numeracy skills themselves?
* Screening and other information can be seen as good
  + However, false or over-diagnosis can have a real cost for individuals
  + Lower physician numeracy can lead to some of these misperceptions
    - Including worse medicare recommendations, inaccurate inferences, and inability/reluctance to communicate numerically with patients.
* Used Berlin Numeracy Test-Schwartz (BNT-S)
  + Adapted from BNT, plus 3 easy items from schwartz et al., to provide greater discriminability for low-moderately numerate.
* Physician Numeracy was only factor predicting risk communication quality, greater numeracy led to greater communication quality.
  + Greater experience and lower patient numeracy was associated w/ using visual aids.
  + Lower patient numeracy associated w/ physicians using less numbers.
* Can we increase the relative saliency of how much a person should be considering these elements when looking at risk?

Ciampa 2010: Patient Numeracy, Perceptions of Provider Communication, and Colorectal Cancer Screening Utilization

* Study on how patients use screening information, moderated by their numeracy.
  + Survey completed on 1.4k for obj numeracy and 3.2k for subj numeracy.
  + Health Information National Trends Survey (HINTS) in 2007
* Low health literacy is related to screening UNDERutilization!
  + Predicts that low numeracy individuals have different preferences for communication
* Perception of provider communication measured
  + Can we measure the what the perception directly is of individuals who used the item?
  + Is this notably different than how well you understand or improved in understanding UHC as a whole?
    - “Did this address all the health concerns that you had?”
    - “Did this involve you in decisions about your health as much as you wanted?”
      * Directly addressing how much individuals want to be involved in decision-making would be interesting to see!
* Note: Plurality of sample stated low subj numeracy
  + Most individuals reported that their healthcare providers did a good job overall
  + Low subj numeracy linked to thinking providers gave lower quality communication.
    - Did not consider the direction of this effect?
  + Low OBJECTIVE numeracy linked to thinking that their needs were met
    - Reverse of my own findings

Garcia-Retamero 2019: Numeracy and Risk Literacy: What Have We Learned so Far?

* Overview/Aggregation of numeracy research as it relates to risk literacy for both health and financial contexts.
  + Numeracy can be both statistical numeracy (ability to calculate and use proportions/percentages) as well as risk literacy (practical ability to evaluate/understand risk to make skilled/informed decisions)
    - Should we directly measure Risk literacy on this second time?
  + Numeracy strongly related to accuracy of health related perception of risk/benefit
    - Perhaps look more at perceptions of risk and benefit research?
  + Health outcomes in patients, especially shared decision making
* Low Numeracy subjects have difficulties understanding the underlying relationships of data
  + Thus, do not benefit from interventions that clarify the structure of the data???
    - Follow this paper to get some more context
  + Also more biased by the way health-related numerical information is framed.
* Shared decision making is affected as well.
  + Low numeracy leads to less accurate decisions based on numerical information
    - E.g. willing to use screening when test shows NO benefits
  + Also more interest in paternalistic model of medical decision making
    - Where doctors are dominant and they prefer to participate, and instead delegate decision making
    - Is there some way to automatically use this as leverage???
      * Perhaps let them ‘punch in’ what they want, and then have an automatic recommendation for the types of things they desire?
* On average, the relative risk that low numeracy suffers from a constant management type disease is 40% greater than those with high numeracy!
  + After controlling for age, education, SES, BMI, and ethnicity!
* Calculations of EV/EU work fine from a prescriptive sense (they make a-priori good rational sense, and work in many circumstances)
  + However, there are holes in how descriptive (predictive) they are.
  + Numeracy leads to better choices because of normative theory, or because of ALTERNATIVE strategies that just function better regardless?
    - No, numeracy is linked to explicit EV calculation and verbalization of EV computations, as well as other mathematical elements such as transforming probability and translating percentages.
    - Also this was due to greater elaborative processing as a whole, not just strictly superior amount of EV calculations.
      * Highly numerate actually spend MORE time deliberating over choices, not just strictly making the math calculations faster.
* The highly numerate have greater emotional reactions to probability
  + Leading to higher sensitivity to probability, and less distorted probability weighting!
  + Less numerate are affected even more by incidental affect, and did in deed change their sensitivity to probability.
* “People with higher numeracy are able to extract more affective information from numbers that are relevant to their choices, and at the same time, they are less prone to incidental affect that is irrelevant to the decision-making process.”
* Low income/low numeracy individuals benefit from financial education programs to improve decision making the LEAST, and the effects are minor and quickly leave anyways
  + How and why? This is similar to the problem my intervention is trying to get at!
  + What complementary methods/alternatives work for low numeracy individuals?
* Categorical problems on improving numeracy
  + Long term work by Peters et al
    - Showed that value affirmation manipulation (trying to change perception of statistics class) lead to no change in subj numeracy over time, where in the control group, subj numeracy fell over time!
      * Objective numeracy even went up for those getting value affirmation!
  + Training the Approximate Number System/Mental number line transfers well to symbolic arithmetic tasks
    - Perhaps a quick ANS primer / mental number line training would help increase perceived value of UHC??
  + Well known that visual aids/analogies work well already, substantial benefits at minimal costs!

Rolison 2020: Understanding Health Risk Comprehension: The Role of Math Anxiety, Subjective Numeracy, and Objective Numeracy.

* How does subj and obj numeracy, as well as math anxiety, with risk comprehension
  + Specifically in the field of medical risk/health domain.
  + Does this explain a potential ‘route’ of effect? That those who are less numerate are less able to comprehend/make sense of the theoretical risks and gains a UHC system would have?
    - Could we increase the salience of risk DIRECTLY through ‘affective’ means? If so, would that lead to shrinking the split difference?
* A combination of low objective numeracy, high math anxiety, and low subjective numeracy are all associated with poor risk comprehension.
  + However… are there independent effects, or are they all too heavily correlated to distinguish?
  + Subj and Obj numeracy are different constructs, because we can have overconfident and underconfident people w/ math skills regardless of their objective math skills.
    - Objective ability to do math skills vs self-judgements and expectations on ability to perform math
  + Math anxiety does not predict poor risk comprehension after controlling for objective numeracy!
* Is health numeracy a separate competency as compared to general numeracy?
  + More difficult to accurately answer math problems in health domain, vs financial or pure math domain
  + Perhaps due to health anxiety during the calculations?
* Obj numeracy assessing w/ 11-item Lipkus scale and 3 cognitive reflection items
  + Subj numeracy using 8-item Fagerlin et al., scale (self-reported ability to work w/ numbers and comfort/preference to work w/ numbers)
  + Math anxiety assessed w/ 13-item Adult Everyday Math Anxiety Scale (AEMAS)
  + Gen anxiety w/ 7-item GAD scale
  + Health anxiety w/ 15-item Health Anxiety Questionnaire
    - Perhaps add this as an additional measure for context??
* Risk comprehension assessed w/ battery of multiple items in health domain drawn from existing literature.
  + Absolute risk, relative risk, and lifetime risk, w/ percentages and decimals, etc.
* Math Anxiety was significant predictor of risk comprehension AFTER controlling for GAD and health anxiety!
  + All of these constructs have independent associations with risk comprehension!
  + Subj/Obj numeracy DIRECTLY related to risk comprehension
    - Math anxiety associ w/ risk when controlling for obj, but not both obj and subj numeracy.
* Math anxiety negatively affects subjective numeracy, which reduces risk-comprehension ability/tasks.
  + Could we have an sub-intervention where we DIRECTLY improve/address anxiety about numerical content? Perhaps would improve susceptibility to our main intervention.

Garcia-Retamero 2009: Communicating Treatment Risk Reduction to People With Low Numeracy Skills: A Cross-Cultural Comparison

* Overview of how to communicate with lower numeracy individuals. Survey of US and German (n ~ 1000 in each) households.
* Measured objective numeracy scores using Schwartz and Lipkus scales
  + Denominator neglect was common, but both groups of numeracy skilled based people were able to distinguish between when examining icons.
* Icon arrays worked, set up denominators worked, US had greater problems w/ risk assessment than German audiences

Galesic 2009: Using Icon Arrays to Communicate Medical Risks: Overcoming Low Numeracy

* How do Icon arrays affect risk perception for those with higher or lower numeracy?
  + Are Icon arrays better than relative risk reduction (vs absolute risk reduction) presentation?
  + 135 Students in Spain and 60 adults in Germany
  + Lipkus and Schwartz numeracy scale test
* The icon arrays were useful in all cases, especially being helpful for those with lower numeracy or those looking at relative risk reduction instead of absolute risk reduction.
  + Risk perception/Risk reduction was seen as larger and more serious when values were presented numerically.
  + When people can see numerator and denominator (icons showing affected and unaffected individuals) visual displays do NOT necessarily produce affect-laden imagery that is thought to cause overall higher perceived risk.
  + Risk was seen as higher w/ larger proportional displays of icons (even w/ same ratios)

Galeisc 2011: Do Low-Numeracy People Avoid Shared Decision Making?

* Directly relates to theory behind the ‘shared decision making’ element of our UHC invervention exercise, and seeing if there is an interaction w/ low numeracy!
* There is mixed evidence that patients care to have shared decision making
* Surveyed 2000 (1000 each german and American)
  + Shared decision making categorized as passive (dr makes choices), collaborative (both make choices), and active (I make the choices).
  + Compared this to their actual role and their preferred role in decision making.
* More numerate individuals generally were active and preferred to be more active.
  + Collaborative was also relatively common for both high and low numeracy people
  + Passive was much more common for low numeracy than others.
  + More numerate people were also more likely to have no change, compared to low numeracy w/ high desire for more passivity.
* Theory: Low-num people do not feel prepared to make important choices w/o fully understanding the information, which they leave to the professional (dr.).

Keller 2009: Effect of Risk Communication Formats on Risk Perception Depending on Numeracy

* How various levels of numeracy influence interpretation of risk communication formats.
  + N = 266, surveyed on risk perception for prenatal screening and colon cancer, in a medium sized swiss city. Women specifically.
* Compared formats (ratio, pictogram, paling perspective scale)
  + Paling perspective scale might be useful to paint a picture of which risks or which common elements for each type of treatment might be worth considering
  + Which specific things could be rarer, but are addressed in the higher spending categories?
* Pictogram was a blank sheet w/ persons colored in to represent relative level of risk (low or high) and the paling perspective scale had 1:1000 as low and 1:100 as high risk.
* Pictogram resulted in lower risk ratings compared to paling perspective scale and the ratio w/ numerator (which were functionally similar)
  + Lower numerate did not distinguish b/w high and low risk levels for down syndrome when given either of the 3 formats for either DS or CC.
  + High numerate did not distinguish b/w high and low risk when given ratio format, but did when given pictogram or paling perspective scale for DS
    - Only paling perspective scale worked for colon cancer.
* Perhaps providing a relative risk anchor would be useful?
  + Chance of winning lottery, struck by lightning, dying from 300 MI of driving, etc.
  + Raw relative risk is somewhat irrelevant, it’s more of… can a person get a hold of what the relative risks are and what they should prioritize in UHC… and if they get that, does that lead to a greater understanding and support for UHC, as it’s seen as good value for money?

Persson 2021: A preregistered replication of motivated numeracy

* Does motivated numeracy still exist and exhibit a strong effect?
  + Two numeracy based exercises, one w/ rash cream, and one w/ gun ban on crime (apolitical and highly political)
* Historical finding is that subjects better at interpreting data when ‘correct’ interpretation was congruent w/ their political ideology, and this effect is even greater for highly numerate.
  + Numeracy seems pretty highly correlated w/ political affiliation… which may be an explanatory third factor in the results for our original UHC study
* Replication mostly successful, a positive effect of numeracy in which more numerate subjects were better able to give correct answer, in both political and apolitical scenarios.
  + When looking at effect of political orientation, numeracy does not seem to moderate the effect (no interaction).
* Seems like there is no effect of motivated numeracy, and that generally higher numeracy skill leads to more accurate interpretation of information.

Hess 2010: How do people perceive graphical risk communication? The role of subjective numeracy

* How is a graphical risk ladder (similar to paling perspective scale) perceived and how this relates to subjective numeracy.
  + Risk is either portrayed on it’s own (array of pictograms) or related to OTHER risks to put it in context (which I love!)
  + Uses eye tracking data to determine what parts and how long people look at relative elements.
  + N = 47, follow up from an earlier study
  + Measured Numeracy with Subjective Numeracy Scale (Fagerlin and Zikumnd-Fischer 2007)
* Why is it harder for low numeracy to understand graphics?
  + Perhaps graph reading is harder b/c it’s part of numeracy itself
  + Alt: high numeracy people integrate more information when making a choices than low numeracy, and thus understand and get more info from the graph.
* Mean subj numeracy was average (4.4 from 1-6).
  + Large negative correlation b/w subj numeracy and time spent looking at the PPS as well as total number of ‘gaze events’. Interpretation is that participants w/ lower subj numeracy need more time and more gazes to extract info from the graph.
  + Total number of areas not correlated w/ subjective numeracy. Except when considered as proportion of total gazes, wherein higher subj numeracy meant looking at more things faster in a shorter period of time (more efficient).
* People didn’t look @ the third reference risk as much as the first or second, thus when looking at PPS, people didn’t use the full potential for risk that the graph offered them
  + Only that data that is similar to the target and spatially closest
  + Logarithmic scale may be too hard to grasp, perhaps a linear scale would work better if the risks in the ladder do not vary too much in probability.
* Subjects with lower subj numeracy seem to have trouble getting info from the PPS. Thus, need to customize graphics to simplify the process for lower numeracy individuals.

Schapiro 2019: Improving Communication in Breast Cancer Treatment Consultation: Use of a Computer Test of Health Numeracy

* Communicating statistics/probability is hard, especially for cancer, this project uses a computer assessment of numeracy.
  + Pilot study of Computer Adapted Test of Numeracy Understanding in Medicine Instrument (CAT-NUMi) before cancer treatment consultation for women w/ stage 0-3 breast cancer.
  + Physician then got the report w/ the numeracy and advice on how to communicate to someone w/ that health numeracy level. Study tried to see if there was an impact or change in information clarity/satisfaction w/ the addition of this screening tool.
  + N = 50 patients in several hospitals, one in Chicago and one in Wisconsin
* Screening w/ the tool may be helpful to optimize communication in the cancer treatment consultation.
* Can perhaps communicate numeric information for individuals that need it, and otherwise numerical for those that don’t.
  + This is ‘tailoring’ the health intervention to the patient themselves.
  + The CAT-NUMi tool itself is adaptive, giving harder or easier questions based on how well the person performed on the previous elements.
  + Perhaps use a larger post consultation process, such as more items that have lack of clarity, concerns, explained results, compassionate, etc.?
  + Lead to 33% of Physicians changing their information/communication approach

Risk Communication Subheading

Zikmund-Fisher 2011: Cool but Counterproductive: Interactive, Web-Based Risk Communications Can Backfire

* Compare and contrast ‘classic’ paper activities vs interactive risk graphing available on web-based tools (hopefully improving engagement)
* N~3.3k, demographically diverse, presented 3 types of risk information on 2 treatments with a chance of causing 1 of 2 side effects
  + A treatment is strongly better (better on both dimensions)
  + A treatment is somewhat better (better on one dimension)
  + A treatment is a trade-off (better on one dimension and worse on other)
* Also varied whether information was a static pictograph (icon array) or was actively manipulated using flash-based animations (fill in the blank pictographs).
  + Hypothesis that the interactive graphic will help subjects choose the ‘better option’ when available, and complete the survey more often.

Participants read short vignette imagining them being diagnosed with Thyroid cancer and having to choose one of two types of therapy, with one of 2 side effects. The risk was presented either w/ static images or an interactive task

* Would the interactive task increase respondent ability to recognize which was better?
  + In the static task, pictographs were very simple but clear
  + In the interactive task, participants used their mouse to indicate what they believed was the appropriate risk level, then they were given feedback on it’s accuracy.
    - However, participants COULD move forward in the study even if the graphs were not set correctly, or the second graph was NOT set.

Measures included subjective numeracy, total time spent on the static graph or interactive graph pages, and whether or not the survey was quit midway (to see if people were annoyed with it), as well as education level.

Results

* Participants in the interactive task were significantly less likely to complete the survey (65% vs 80%), specifically due to the interactive graphics task itself!
  + The interactive task also took significantly more time.
* Subjects made poorer treatment choices in all 3 risk-level conditions, if assigned to using interactive graphics!
  + Correctly graphing all levels did improve relative correct choice making in the ‘strong dominance’ condition only (but was still worse than the static array)!
* Interactive tasks also lead to weaker gist knowledge recall and understanding (which treatment had higher risk than the other?)

Conclusions/Why?

* Could be because there wasn’t particularly high motivation (asking healthy people about medical issues that were hypothetical), but even for those that did the task well, there was NO significant improvement?!? Thus motivation seems unlikely to be the difference-maker.
* Could be that the novelty of the task lead participants to think overly about what they were doing, and not engage in meaningful critical thinking/processing about risks.
* Teach-back form of methodology was used here, compared to ‘exploratory task’ provided by others, was a significant difference in paradigm.

Zikmund-Fisher 2012: Animated Graphics for Comparing Two Risks: A Cautionary Tale

* More work on whether or not animated graphics are superior to static risk images
  + Compared to the previous, which was an interactive task!
* N~4.2k, demographically diverse collected on the internet.
* Two hypothetical thyroid cancer treatments but w/ varied side effects.
  + Participants were randomly assigned to get risk in 1 of 10 different pictographic formats.
    - Control condition was static grouped icons w/ static icon display
    - Treatment condition were 8 different flash-based animated versions that had different combinations of:
      * Building the risk 1 icon at a time
      * Having scattered risks settle into a group
      * Having scattered risks shuffle themselves (automatically or w/ user control)
* Assessed participant ability to choose better treatment (choice accuracy) and gist knowledge of side effects (knowledge accuracy), as well as evaluation ratings for the graphics themselves!

In general, we are looking at another way of communicating risk information, where individuals either experience an out-come or not, how do we communicate this? We can see that the icon array is a way of adapting towards this.

* Scattered icons spreading is meant to convey this sense of random aggregation
* Animation has been shown to work well on those that had good mathematics skills
  + While hurting those with poorer math skills
* Also, additional complexity in the visual stimulus can make it more difficult to attend to particular cues or important aspects.

Design

* Study design was very similar to previous study, with similar risk information on focal beam therapy and crossed beam therapy for thyroid cancer being selected.
  + Same risks of causing fatigue.
  + Different risks of causing mouth and throat problems.
* Randomly assigned to 1 of 10 conditions
  + The two static conditions.
    - Static grouped
    - Static scattered
  + The eight animated conditions
    - Scatter/settles
    - Grouped/built
    - Scatter/built
    - Scatter/built/settles
    - Scatter/autoshuffles
    - Scatter/autoshuffles/settles
    - Scatter/user shuffles
    - Scatter/user shuffles/settles
* Built meant icons were added in one at a time, sequentially
* Scattered meant that the icons filled in either randomly or in a group
* Shuffled meant that they were forced to either press a button that shuffled the layout a few times, or were shuffled at random a few times automatically.
* Settles means that any group that starts scattered, eventually is allowed to ‘settle’ into a final grouping indicating relative risk magnitude.

Measures included SNS, evaluation of each graphic, and need for cognition scale (due to concerns about survey duration)

Results

* Treatment choice accuracy for low numeracy was 75%, and there were no differences across the 10 graphics presented.
  + Bigger differences for highly numerate, but most of the groups were less likely than the control group to choose accurately (other than built/grouped)
* Gist knowledge accuracy was pretty good and similar amongst both low and high numeracy groups.
  + Static info had the highest or next/highest level of knowledge
  + V2, and V9 were significantly lower for both high and low numerates
  + V5 and V10 were lower for high numerates and V7 lower for low numerates.
* In general, graph evaluation rating was higher for high numerates than low numerates.
  + Static/grouped and Grouped/built were reported as having the highest evaluation ratings.
  + V3 and V6 were also fine, and lower by a nonsignificant amount.
  + All other conditions were significantly lower than the baseline condition.

Really should measure graph literacy (if we’re adding graph

Zikmund-Fisher 2014a: Numeracy and Literacy Independently Predict Patient’s Ability to Identify Out-of-Range Test Results

* What skills predict how patients can interpret and understand laboratory results that they have direct access to?
  + They don’t necessarily have context or information regarding ‘how bad is bad’ or even ‘what is bad’
* Specifically, can adults identify blood test values outside reference ranges when presented in a format similar to electronic health record implementations.
* N=1.8k, adult participants b/w 40-70 years old, half with diabetes.
* Asked to imagine that they had T2 diabetes, shown lab results for hemoglobin A1C that was slightly randomized to be either slightly or moderately outside of the reference range
  + Other test results were randomized to be within or outside of the reference ranges.
* Assessed if patients could realize that A1C was out of reference, if they had glycemic control, or if they should call their doctor.

This is considered good and of value because greater amounts of medical technology are being integrated into healthcare. Patients both expand and are more able to see their own test results, hopefully letting them plan, prepare, and have questions set-out regarding any results that are in or out of range. Also, significant improvement in self-management of health conditions!

* However, there is limited health literacy, so how can people actually make use of this data?
  + Affects contextual information (what a test is, what values are normal/concerning, etc.) necessary for health
* Also, lower numeracy skills in most patients.
  + Linked to difficulty interpreting test outcome data
  + Cannot get a feeling of ‘goodness’ or ‘badness’ from the data.

Design

* Participants asked to imagine that they had T2 diabetes with good control, specifically A1C of 6.8, trying to keep that number BELOW 7 (was provided context up front!)
  + Then asked to imagine they were viewing the results of blood tests
    - Tests either showed elevated A1C (7.1 or 8.4) so either slightly or moderately out of range.
  + Also either multiple results were out of range, or all other results were in range (multiple deviations vs single deviation).
    - The numbers were either elevated OR reduced (this could be directionally confusing!) consistent w/ temporary viral infection.
* Test results remained visible, and the subjects were asked questions about test understanding!
* Asked about blood glucose control, mark which results were abnormal and how worried they should be, and what they would do (immediate dr visit, schedule visit, talk about it in 3 months).
  + Also measured perceived usefulness of the scales.
* Measured various individuals differences
  + Subjective Numeracy w/ SNS
  + Limited Health Literacy (Chew et al., 2008)

Results

* Health literacy and numeracy were moderately correlated.
  + However, 10% had lower numeracy and higher literacy, 6% had higher numeracy and lower literacy.
* Roughly 50% of participants correctly identified that A1C was out of range (although diabetics were more likely, 56% vs 45%).
  + Also more likely in the multiple deviations condition (55% vs 47%)
  + The amount it was out of range DID NOT have an effect!
    - Except for those with ACTUAL diabetes!
* The combined effect of lower literacy AND lower numeracy more than halves probability of identifying out of range values (77% to 38% for diabetics and 65% to 30%)
* Perceptions of control were lower for the more out of range A1C value (8 vs 7.1)
  + Even more-so for patients w/ diabetes (lower control!)
* Most participants would call dr. in all conditions (69%)
  + In the single deviation condition, calling was significantly lower for 7.1 A1C vs 8.2
  + Having multiple non-normal test results significantly increased odds of calling when A1C was 7, but somehow lower when A1C was 8?
* For diabetics, high health literacy (correctly?) reduced likelihood of calling dr. in the 7.1 condition, but not in 8.4 condition, and instead higher numeracy predicted calling intention in the 8.4 condition!
* Usefulness was highly correlated w/ literacy and numeracy, but overall was not perceived as super high in general (not found to be super useful!)

Conclusion

* People are bad at determining if their results are good or bad, and by how much.
  + Thus, the additional access for people to verify themselves has some issues.
* Since there is inability to determine how bad something is w/o health and numeracy skills, this is something to address.
* Lower-numerates have trouble recognizing that a jump in A1C from slightly to moderately out of range was worth immediate response.
  + Important distinction b/w patients knowing test numbers, versus grasping the personal meeting of that data
* Depending on the context, additional numerical information can be counterproductive!

Zikmund-Fisher 2014b: Blocks, Ovals, or People? Icon Type Affects Risk Perceptions and Recall of Pictographs

* Pictographs are a useful way of communicating risk statistics especially for the less numerate and less graph literate.
* Which icon types are best at improving recognition and recall?
* N=1.5k, 35-75 demographically diverse recruited online.
* Used cardiovascular risk calculator after putting in their own actual health data.
  + Received risk estimate using 1 of 6 iconographies
    - Rectangular blocks
    - Filled ovals
    - Smile/frown faces
    - Head/shoulder outline
    - “Restroom Icons”
    - Actual photographs of people of varied races (matching gender)
* Measured perceived risk magnitude, approximate recall, and opinions of the arrays.
  + Recall was significantly higher w/ anthropomorphic icons than other types, restroom icons rated as most preferred.
    - RR icons best for high graph literate/numerates
    - No better than other types for low graph literate/numerates.

Historically, iconography was seen as a valuable method of communicating risk, especially for the less numerate. The iconography itself was varied by category:

* Symbols: Filled ovals and rectangular blocks
* Indexes: Smile/Frown face
* Icons: Head/shoulders, RR Icons, actual photographs.

Asked patients to both grade how big/small the risk *feels* as well as the likelihood of them getting cardiovascular issues moving forward.

Results

* Generally, 75% of participants accurately recalled the 10-year cardiovascular risk
  + 20% overestimated, 5% underestimated.
* Anthropomorphic icons had higher degrees of accuracy, than all others
* Risk perceptions were similar and correlated with actual likelihood of getting it.
  + Thus, subjects felt roughly as strongly about it as they were likely to get CVD issues.
  + However… for those who are very graph literate/numerate, icon type was significant on correlation b/w perceived and actual risk.
    - RR icons, photos, and ovals, had higher correlation b/w actual and perceived risk, which was significant!

Discussion

* RR icons seemed to be the best combo of ease and impact.
  + However… this pattern was not nearly as clear for those with less numerate or less graphically literate people.
* Less numerate people process icon arrays differently from more numerate people
  + Numerate people tend to count icons vs nonnumerates who don’t
  + RR icons had the most white space, thus making them the most distinct and easy to count

Zikmund-Fisher 2017: Graphics help patients distinguish between urgent and non-urgent deviations in laboratory test results

* Most EHR’s present lab results in a table format, which is common for clinicians, but more difficult for patients to understand.
  + Does presenting results using visual displays (number lines) improve understanding?
* N=1.6k, demographically diverse recruited from the internet
* Asked to hypothesize viewing test results
  + First viewed near-normal results, then extreme values
  + Viewed either in table format w/ standard range provided, or one of three number line formats
    - Simple 2-color format
    - Format w/ diagnostic categories such as ‘borderline high’ indicated by colored blocks
    - Gradient format that used gradients to smoothly represent increasing risk as values deviate from standard ranges.
* Measured subjective sense of urgency, behavioral intentions, and perceptions of the display format itself.
* Visual displays reduced perceived urgency and desire to contact for near-normal results (good), but did not affect perceptions of extreme values (also good!)
  + Health literacy, numeracy, and graphical literacy, the gradient line displays had the greatest sensitivity to changes in test results.
* In general, visual displays increased the ‘meaningfulness’ of test results by clearly defining possible values, leveraging color cues and evaluative labels

Generally, patients value the increased access to information, but may not have the tools to accurately interpret the information to make good choices for themselves. Patients need to both react correctly to high risk, and not over-react to unnecessarily low risk. Both of these is a matter of perception! Alternative formats could help patients understand more information, including number line graphs and other formats.

Design

* Participants asked to imagine that they had recently visited doctor to discuss medications and then undergone blood tests thereafter, viewing these results in online EHR portal
* Three specific test results: Platelet count, ALT, and serum creatine.
  + They vary in size of established standard ranges relative to test values, and level of patient risk associated w/ varying degrees of deviation from standard ranges.
* Initially reported as slightly outside the range, then significantly outside the range.
* Which of 4 formats were used to display the test results?
  + Table condition – standard format w/ standard range and appropriate units
  + Simple Line – displays that were colored solid gray except for a green ranged labeled “standard range”.
  + Block line – number lines that had areas outside the standard range divided into solid-color blocks using stoplight red-yellow-green, very low = red, borderline high = yellow, etc.
    - The color choice provides additional reference points to increase evaluability and support increased gist processing to facilitate meaning derivation
  + Gradient line – number lines similar to block line, but transitions were graphically smoothed using color gradients to more accurately represent the continuous nature of underlying value to risk relationship.
    - Category labels were replaced w/ 2 small arrows labeled low and high, compromising b/w simplicity and volume of information.
* Measures
  + Perceived test urgency/how urgent is the results
  + Behavioral intentions
  + Display format preferences, including trust and understanding!
  + Subjective numeracy scale
  + Chew et al., 2008 screening for health literacy
  + Galesic and Garcia-Retamero’s graphical literacy scale

Results

* Participants perceived urgency was high for very out of range
* Near normal value perception varied substantially across formats, especially for ALT and serum creatinine tests.
  + Near normal in a table display was most urgent
  + Near normal in gradient line perceived as least urgent
* Both the gradient line and simple line displays resulted in greater sensitivity to change for all three tests.
* Behavioral intentions had no significant differences, other than near normal ALT and serum creatinine results in table format were NOT willing to wait (which is a bad thing!)
* Mean preferences for tables were substantially lower than for the number line displays.

Conclusion

* Even using simple number line graphics can decrease unnecessary urgency and improve sensitivity to variations in test values.
* The most powerful cue is the concrete placement of test results in a visual space of possible values
  + Patients literally see whether their values are high, low, or in the middle, and construct cognitive and emotional responses accordingly.
  + This facilitates correct responses, either action (when clinically urgent) or inaction (when values are being appropriately handled).
* Differences in perception were most apparent for ALT and serum creatinine tests, where values can be out of standard range, but still not have clinical consequences, and people can often/easily overreact.
* The addition of meaning-rich cues and reference standards (colors and “how does this compare to X” process that people naturally use to derive meaning from data)