Precise or Imprecise Probabilities?
Evidence from survey response related to late-onset dementia

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Precise or Imprecise Probabilities?

Most economic research maintains that agents hold **precise** subjective probabilities over uncertain events.

Yet economists and others have long entertained the alternative possibility (e.g., Keynes (1921), Knight (1921), Ellsberg (1961)), especially in case of **limited information**.

This has stimulated much theoretical and experimental research on **imprecise probabilities**, aka *deep uncertainty* or *ambiguity* (e.g., Walley (1991), Camerer and Weber (1992), Marinacci (2015)).

Yet **little** is **known** about the precision of probabilistic expectations people hold in **real life** when planning or making decisions with uncertain consequences.

The prevalence and nature of imprecision may vary across people and contexts: we **need empirical research** studying broad populations in substantively important contexts.

We Study *Im*precision of Dementia and LTC Probs (I)

We study imprecision of subjective probabilities for **late-onset dementia** and **long-term care (LTC) decisions** – purchasing **LTC insurance** or entering a **nursing home** – in the Health and Retirement Study (HRS).

- First empirical evidence on imprecision of survey expectations in the dementia/LTC context and on dementia risk perceptions among dementia-free older Americans.

Our elicitation procedure distinguishes between **precise (point) vs. imprecise (interval) probabilities**, while accounting for **rounding** or approximation of percent-chance reports.

- 47% of respondents hold imprecise dementia probabilities (median interval width = 20 and Q90-Q10 = 70); 27% of precise-probability respondents round their reports.
- Similar figures for unconditional LTC expectations – but lower for LCT expectations contingent on hypothetical knowledge of the future dementia state.

We Study *Im*precision of Dementia and LTC Probs (II)

Among rounding and imprecise-probability respondents, our elicitation procedure yields **two probability measures per respondent**:

(1) a 1st response, possibly rounded or approximated;

(2) a 2nd response, which we interpret as R's true point- or interval-prob.

- We analyze the mapping between the two for dementia and observe a tendency to over-report small probabilities and under-report large ones.
- For ∼30% of imprecise-probability respondents, the initial response is not included in the post-probe interval.

We investigate the **implications** of ignoring imprecise dementia probabilities for **modelling, inference on preferences, and prediction**.

- Using a framework of LTC insurance choice with uncertain dementia state, we show that ignoring imprecise probabilities can be consequential.
- We provide the first empirical evidence on the relationship between perceptions of late-onset dementia risk and LTC insurance plans.

Motivation: Why Dementia & Long-Term Care, and Some Literature

Preliminary Note: We Focus on *Late*-Onset Dementia

Alzheimer Disease and Related Dementias (ADRD) is a class of irreversible progressive brain diseases, currently incurable, affecting millions of individuals world-wide every year (Winblad et al. 2016).

2 TYPES	**EARLY-ONSET** (aka FAD or ADAD)	**LATE-ONSET** (OUR FOCUS)
onset age	30-60	over 60
genetics	mutation ("deterministic")	variant ("risk")
risk factors	(i) parent with mutation gives 50% chance of inheriting it (ii) inherited mutation gives $\sim$100% chance of onset	(i) APOE with ε4 allele gives increased risk, *but neither necessary nor sufficient for onset* (ii) other risk factors include: family history, cardiovascular health, age, gender, educ, ...
genetic testing	predictive testing tests for mutation	susceptibility testing tests for ε4, *not predictive at individual level*
prevalence	$\sim$ 5% of ADRD	remaining majority

(1) Dementia Is High-Priority in Aging Research and Policy

5-6 million Americans with ADRDs in 2018 (Alzheimer's Association, 2018) and **8-9 million Europeans** with ADRDs in 2013 (Alzheimer Europe, 2013).

In 2017, ADRD among the **top-10 causes of death in the U.S.** – 6th overall, 5th among the 65+, and 3rd among the 85+ (National Vital Statistics, 2019).

High economic burden on households and government programs due to the associated specialized care needs (Hurd et al., 2013; Winblad et al., 2016).

ADRD prevalence predicted to grow with size and proportion of the over 65 (Hudomiet et al., 2018) – and, with it, the already high demand for LTC services (National Center for Health Statistics, 2013).

Strong **link between LTC insurance purchase and** subjective probabilities of **moving to a nursing home** in the HRS (Finkelstein and McGarry, 2006).

Yet **nothing known** about people's **perceptions for dementia risk** as they age and their **relationship with economic decisions** (e.g., LTC insurance purchase, precautionary savings, retirement timing).

(2) Lack of Dementia Risk Estimates or Predictive Tools

Research on dementia **prevalence** does not provide evidence on the **risk** that currently healthy persons will develop dementia in the future.

- Few estimates of lifetime dementia risk.

Medical researchers have developed **online tools** that predict the chance that persons with specified age and health attributes will develop cardiovascular disease, breast cancer, and other illnesses.

- No tool predicting personalized risk of dementia.
  - According to Alzheimer Association's chief science officer, Maria Carillo: "*Just as there are risk predictors for whether you might have a heart attack, it will be important in the future to measure the likelihood that someone will develop Alzheimer's disease. In the future, when treatments are available, this would be helpful, especially for people in the stages before the clinical symptoms appear. For example, those people with the highest 10-year risk of getting Alzheimer's dementia would be high priority to volunteer for clinical trials evaluating Alzheimer's medications or other therapies.*" (ScienceDaily, May 22, 2018)

Imprecise Dementia and LTC Probabilities?

Given the lack of estimates of lifetime dementia risk and of predictive tools, the **prediction** task **may be difficult** for lay people.

This made us **conjecture** that many persons may hold **imprecise expectations** of their dementia risk.

> And also of LTC outcomes, to the extent that the these may depend on dementia expectations.

For this reason, we decided to elicit expectations as both precise (point) probabilities and as imprecise (interval) probabilities.

Imprecise Probabilities Across Fields

Statistics & Econometrics: Dempster (1968), Shafer (1976), Walley (1991), Kuznetsov (1991), Berger (1994), Weichselberger (2000), Manski (2000)...

Philosophy: Levi (1974, 1980), Kyburg (1961, 1983), Kyburg and Pittarelli (1992), Kyburg and Teng (2001), Bradley (2017)...

- We too view – and measure – imprecise probabilities as probability intervals, but our aim is descriptive/positive (not normative/prescriptive).
- We conceptualize imprecise probabilities as reflecting limited knowledge and interpret our findings accordingly.

Psychology/Behavioral decision science/Risk analysis: Budescu et al. (1988), Zwick and Wallsten (1989), Wallsten (1990), Wallsten et al. (1993a,b)...

- We too take a directly-ask measurement approach, but:
  - we focus on non-experts: a nationally representative sample;
  - we focus on economic behavior: choice probabilities (LTC) and probabilities over a choice-relevant state (dementia);
  - we build on the survey expectations literature in economics.

We Build on the Survey Expectations Literature

Review papers

- Manski (2004, 2018), Attanasio (2009), Hurd (2009), Delavande et al. (2011a,b), van der Klaauw (2012), Armantier et al. (2013), Delavande (2014), Schotter and Trevino (2014), Giustinelli and Manski (2018), Altig et al. (2020)..

Expectation-based treatment effects

- Arcidiacono et al. (2020), Wiswall and Zafar (2020), Giustinelli and Shapiro (2019, 2021), Hurd et al. (2021)

Choice models

- Choice probabilities with incomplete scenarios: Manski (1999), Blass et al. (2010), Delavande and Manski (2015)...
- Choice with uncertain outcomes: Delavande (2008a), Arcidiacono et al. (2012), Zafar (2013), Wiswall and Zafar (2015a), Stinebrickner and Stinebrickner (2014), Giustinelli (2016), Delavande and Zafar (2019)...

Learning and info treatments

- Delavande (2008b), Jensen (2010), Zafar (2011), Wiswall and Zafar (2015b)...

▶ Rounding, interval expectations, and decision-making/learning under ambiguity

- Interval probabilities: Manski and Molinari (2010), Giustinelli and Pavoni (2017), Bachman et al. (2020), Delavande et al. (2021a,b)...
- Rounding: Manski and Molinari (2010), Giustinelli et al. (2020)...

Measuring Precise and Imprecise Probabilities in the Health and Retirement Study (HRS)

We Elicited Percent-Chance Dementia & LTC Expectations in the Health and Retirement Study (HRS)

UMich biennial longitudinal panel study representative of 50+ U.S. population ($N \sim 20,000$).

- Scope: Physical and mental health; health insurance coverage and health care use; socio-economic status and income; ...; **expectations**.
- Units: Household survey, with specialization into family and financial Rs.
- Mixed-mode: Entry interview and interviews with physical measurements in person. Other interviews over phone (or web).
- Innovation: Short **experimental modules** on competitive basis.

Sample: Random sub-sample from 2016 HRS, **not in a nursing home** & **never diagnosed with ADRD**. In practice, 1,255 Rs split as:

1. Insurance smpl: Random half minus those with LTC insurance ($N = 578$).
2. Utilization smpl: Random half plus those with LTC insurance ($N = 677$).

We Elicited Four Expectations Per Respondent

(1) **Unconditional LTC**

- Using a scale of 0 to 100, where 0 means absolutely no chance that the event will happen and 100 means that the event is absolutely certain to happen, what is the percent chance that you will [*LTC Outcome*] sometime in the future?
  - [ ]: "purchase long-term care insurance" or "move to a nursing home."

(2) **Unconditional Dementia**

- Dementia is a general term for a decline in mental ability severe enough to interfere with daily life. Memory loss is an example. Alzheimer's is the most common type of dementia. On a scale of 0 to 100, what is the percent chance that you will develop dementia sometime in the future?

(3) **LTC If "No Dementia"** & (4) **LTC If "Dementia"**

- Suppose you learn confidentially from a medical expert that you will definitely not develop dementia in the future. On a scale of 0 to 100, what is the percent chance that you will [LTC Outcome] sometime in the future?

- Now suppose instead that the same expert determines that you will develop dementia in the future. On a scale of 0 to 100, what is the percent chance that you will [LTC Outcome] sometime in the future?

Each Expectation Was Followed by a Probing Sequence

(A) Probing sequence after a numerical point response: ▸ Survey Q

1. Exact answer *OR* rounding or approximating?
2. (**If rounding/approx.**) Try without rounding or approximating.
   If uncertain about the chances, may give a range of percent chance.

(B) Probing sequence after a Don't Know response: ▸ Survey Q

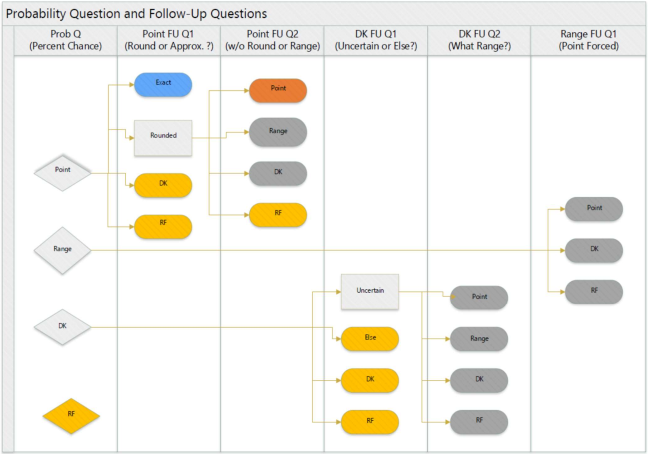
1. Uncertain about the chances *OR* something else?
2. (**If uncertain**) May give a range of percent chance.

(C) Probing sequence after a numerical interval response: ▸ Survey Q

1. "Forced" point.

Patterns of Imprecision of Subjective Probabilities: With a Focus on Dementia Expectations

We Classify Respondents into Probabilistic Response Types



CLASSIFICATION of PROBABILITIES:

1) **EX:** initial point-probability response is exact (unrounded).
2) **PR:** initial point-probability response is rounded, post-probe response is precise.
3) **IM:** initial point-probability response is rounded, post-probe response is an interval (or initial response is a spontaneous interval).
4) **Other**

Empirical Distribution of Probabilistic Response Types and Interval Width for Dementia (I)

Distribution of Probabilistic Response Types

	All respondents	
% EX	**34.82**	
% PR	**14.34**	
% IM	**46.45**	
% Other	**4.38**	
N	1,255	

Distribution of Interval Width among Imprecise (IM) Respondents

	Respondents who gave an initial point response		**Respondents who gave an initial interval response**
1st decile	**10**		**10**
Median	**20**		**20**
9th decile	**80**		**80**
N	442		78

Notes:

1) Precise (EX + PR) vs. imprecise (IM): **49.16%** vs. **46.45%**.
2) Spontaneous interval probabilities: **6.5%**.

Empirical Distribution of Probabilistic Response Types and Interval Width for Dementia (II)

Distribution of Probabilistic Response Types

	All respondents	Respondents who gave **an initial point response of 0**	Respondents who gave **an initial point response of 50**	Respondents who gave **an initial response other than 0 or 50**
% EX	**34.82**	**73.30**	**27.90**	27.08
% PR	**14.34**	**8.25**	**23.61**	13.24
% IM	**46.45**	**15.53**	**47.64**	53.92
% Other	**4.38**	2.91	0.86	5.76
N	1,255	206	233	816

Distribution of Interval Width among Imprecise (IM) Respondents

	Respondents who gave an initial point response	Respondents who gave **an initial point response of 0**	Respondents who gave **an initial point response of 50**	Respondents who gave **an initial response other than 0 or 50**	**Respondents who gave an initial interval response**
1st decile	**10**	**10**	**10**	10	**10**
Median	**20**	**20**	**20**	20	**20**
9th decile	**80**	**80**	**70**	80	**80**
N	442	29	107	306	78

Notes:

1) Precise (EX + PR) vs. imprecise (IM): **49.16%** vs. **46.45%**.
2) Spontaneous interval probabilities: **6.5%**.
3) No evidence of greater rounding or imprecision underneath 0 and 50 percent responses.

Heterogeneity Across Observed Respondent Attributes

Age: **Older respondents more likely to report rounded/approximated probabilities and to hold interval probabilities.**

Educ: **More educated respondents are less likely to report rounded/approximated probabilities, but more likely to hold imprecise probabilities.**

Race: Black respondents are less likely to report rounded/approximated probabilities and to hold imprecise probabilities.

Gender: No statistically significant association between probabilistic response type and gender.

Cognition: **No significant association** between probabilistic response type and measured cognitive ability (TICS score count).

> **But respondents in the top tercile of the cognition score distribution tend to give wider intervals** ($\sim$7 percent points on average).

Beyond Dementia: Imprecision of LTC Probabilities

Figures for **unconditional LTC** probabilities are **similar** to those for dementia (both EX-PR-IM classification and IM Rs' interval width).

- Insurance: 53% precise vs. 42% imprecise
- Utilization: 50% precise vs. 46% imprecise
  - Recall Dementia: 49% precise vs. 47% imprecise
  - Across all questions: over 60% imprecise

But **(hypothetical) knowledge** of the dementia state **reduces imprecision**.

- Insurance if No Dementia: 72% precise vs. 25% imprecise
- Insurance if Dementia: 78% precise vs. 17% imprecise
- Utilization if No Dememtia: 67% precise vs. 27% imprecise
- Utilization if Dementia: 69% precise vs. 25% imprecise
  - EX-PR-IM: Mainly by decreasing % IM; % PR also down slightly.
  - IM intervals: By reducing large intervals ⇒ lower mean and dispersion, but not median or mode.
  - Corner dementia probs: Conditioning reduces IM for these, too.

Detailed stats: EX-PR-IM, IM Intervals

Relationship Between Initial and Post-Probe Subjective Dementia Probabilities

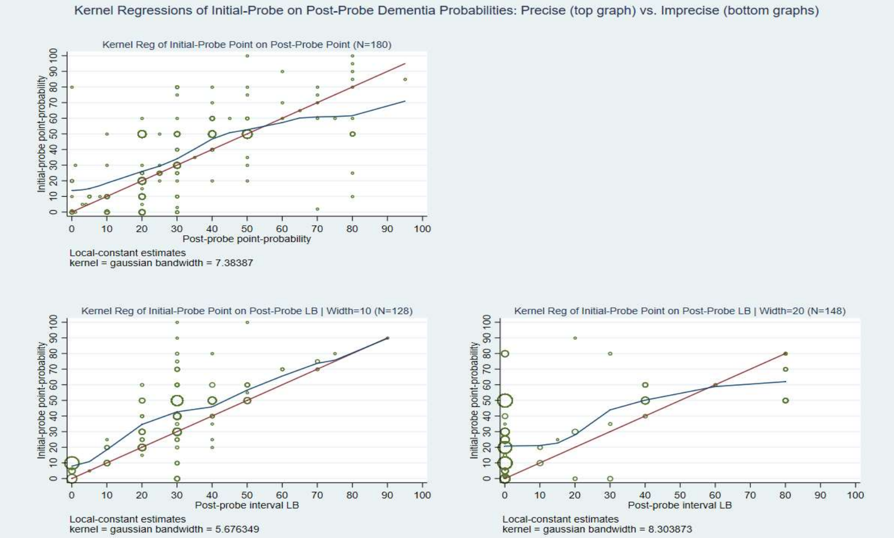
Initial vs. Post-Probe Point-Probabilities among *PR Rs*: Within-Respondent Comparison

Post-Probe Point: / Initial Point:	0, 50, or 100	25 or 75	multiple of 10	multiple of 5	multiple of 1	total N
0, 50, or 100	**12.78**	0.56	27.22	0.00	0.56	74
25 or 75	0.56	**2.22**	3.89	0.00	0.00	12
multiple of 10	5.00	1.67	**35.00**	1.67	1.11	80
multiple of 5	0.56	0.00	2.22	**1.67**	1.11	10
multiple of 1	0.56	0.00	1.67	0.00	**0.00**	4
total N	35	8	126	6	5	180
% granularity transitions:						
finer	**36.12**					
same	**51.67**					
coarser	12.21					
% initial = post-probe	**32.22**					

Point-Prob vs. Interval-Prob among *IM Rs*: Within-Respondent Comparison

	Any width	Width in: (0, 10]	(10, 20]	(20, 100]
Respondents who give first a point and then an interval				
(i) point is *midpoint* of the interval	10.86	5.84	22.93	2.70
(ii) point is *inside* the interval, but not the midpoint	58.14	54.74	45.86	74.32
(iii) point is *outside* the interval, *within* a *5 points* distance	**4.30**	4.38	5.09	3.38
(iv) point is *outside* the interval, *within* a *6-to-10 points* distance	**11.54**	18.98	6.37	10.14
(v) point is *outside* the interval, a distance *greater than 10 points*	**15.16**	16.06	19.75	9.46
N	442	137	157	148
Respondents who give first an interval and then a point				
(i) point is *midpoint* of the interval	**16.67**	18.53	43.75	2.86
(ii) point is *inside* the interval, but not the midpoint	**74.36**	70.37	56.25	85.71
(iii) point is *outside* the interval, *within* a *5 points* distance	1.28	3.70	0	0
(iv) point is *outside* the interval, *within* a *6-to-10 points* distance	6.41	3.70	0	11.43
(v) point is *outside* the interval, a distance *greater than 10 points*	1.28	3.70	0	0
N	78	27	16	35

Relationship Between Initial and Post-Probe Probs: Kernel Regressions (CExp)



Magnitudes of Subjective Probabilities of Developing Dementia

Dementia Risk Perceptions by Prob Response Type

	***Initial = Post* Probe**	*Initial*		***Post*-Probe**		
Response distribution:	Point-Prob. among EX Rs	Point-Prob. among PR Rs	Point-Prob. among IM Rs	Point-Prob. among PR Rs	LB among IM Rs	UB among IM Rs
% 0	34.55	9.44	5.49	4.44	50	0
% 50	14.87	30.56	19.04	15	4.73	9.91
% 100	1.60	1.11	0.51	0	0	16.22
% Other val	48.98	58.89	54.21	80.56	45.27	73.42
% Interval	NA	NA	13.89	NA	NA	NA
% DK	NA	NA	6.86	NA	0	0.45
N	437	180	583	180	444	444
1st decile	0	1	5	10	0	20
Median	**15**	40	30	**30**	**0**	**40**
Mean	**25.46**	37.21	34.77	**33.65**	**15.56**	**45.84**
9th decile	70	70	70	70	40	100
N	437	180	462	180	444	442

Comparison with Realizations-Based Estimates

Seshadri and Wolf (2007)

Study: Framingham Hearth Study, Original cohort (dementia-free at 55).

ADRD estimates [95% CI]: **14.3**% [12.0, 16.2]% to **24.3**% [20.7, 27.8]%

Chene et al. (2015)

Study: FHS, Original & Offspring cohorts (dementia-free at 65 &/or 45).

ADRD estimates [95% CI]: **13.8**% [12.2, 15.3]% to **24.6**% [22.7, 26.5]%

Fishman (2017)

Study: Aging, Demographics and Memory Study (ADAMS), HRS subset (1920 & 1940 cohorts).

ADRD estimates (SE): **24.4**% (7.2%) to **37**% (3.8%)

Bottom line: The range of realizations-based estimates is broadly similar to the range of precise and imprecise prob responses that we elicited in the HRS.

- Recall: In our smpl, EX mean **25.46**% (median **15**%);
  PR mean **33.65**% (median **30**%);
  IM mean in [**15.56, 45.84**]% (median in [**0, 40**]%).

Implications for Decision Making: Illustration of LTC Insurance Demand with Precise or Imprecise Probabilities

LTC Insurance Demand with Precise Dementia Prob (I)

Decision variable $d = 1\{\text{purchase LTC insurance}\}$.

Uncertain future state $s = 1\{\text{develop dementia}\}$. (Assume: not affected by d.)

Subjective probability of state $P_s = P(s = 1) =$ prob of developing dementia.

State-dependent utility $U(w, s)$, where $w =$ initial wealth.

Given a choice, utility is higher in the dementia-free state: $U(w, 0) > U(w, 1)$.

In the dementia state, being insured is preferred over not being insured.

More observables $x_p =$ price of LTC insurance, $x_c =$ cost of LTC without insurance, where $x_c > x_p$.

- Bayesian benchmark (known/precise P_s): max-SEU decision maker chooses

$$d^* = \begin{cases} 1 & \text{if} \quad P_s U(w - x_p, 1) + (1 - P_s) U(w - x_p, 0) \geq P_s U(w - x_c, 1) + (1 - P_s) U(w, 0) \\ 0 & \text{otherwise.} \end{cases}$$

LTC Insurance Demand with Precise Dementia Prob (II)

Equivalently, $d^* = 1$ if

$$P_s \geq P^* = \frac{U(w,0) - U(w - x_p, 0)}{[U(w - x_p, 1) - U(w - x_c, 1)] + [U(w,0) - U(w - x_p, 0)]}.$$

Given observation of (d, w, x_p, x_c), this inequality delivers **revealed-preference restrictions** on $U(\cdot,\cdot)$ (partially identified).

- CARA case: Under CARA utility with parameter r, $d^* = 1$ if

$$P_s \geq P^* = \frac{exp(rx_p) - 1}{f[exp(rx_c) - exp(rx_p)] + [exp(rx_p) - 1]},$$

where f is the marginal utility of wealth in the dementia state relative to that in the dementia-free state (normalized to 1).

  - Given a joint distribution of (f, r), can derive population choice probabilities. So given data on (d, x_p, x_c, P_s), can **estimate the joint distribution of $(\mathbf{f}, \mathbf{r})$**.

- Note: Correct use of the inequality $P_s \geq P^*$ (low-structure case) and unbiased inference on (f, r) (high-structure case) requires **accurate measurement of $\mathbf{P_s}$**.

  - Recall: In our sample, 27% of precise-prob Rs give a rounded dementia prob.

Introducing Imprecise Dementia Probability

- *Imprecise* (interval) probability of state $P_s \in [P_L, P_H]$.
  - Recall: In our sample, 47% of Rs have imprecise dementia probability.

- Decision criteria under ambiguity:

(i) *maximin* (MM) The decision maker evaluates each action by the worst SEU that it might yield and chooses an action with the least-bad worst SEU. The worst feasible SEUs for $d \in \{0, 1\}$ occur when $P_s = P_H$. The maximin choice is

$$d^* = 1 \quad \text{if} \quad P_H \geq P^*.$$

(ii) *minimax-regret* (MMR) The decision maker evaluates each action by the worst reduction in EU that it might yield vs. the highest EU achievable. The MMR choice is

$$d^* = 1 \quad \text{if} \quad P_M \geq P^*,$$

where P_M is the midpoint of $[P_L, P_H]$.

  - In these cases, given random-sample data on $(d, w, x_p, x_c, P_L, P_H)$, one can **estimate the joint distribution of** $(\mathbf{f}, \mathbf{r})$.

- Note: Using the initial probability response conflates **model misspecification** and **covariate measurement error**.

Implications for Prediction of LTC Insurance Demand

(1) Given a fixed configuration of state-dependent utilities and threshold P^*, Bayesian, MM, and MMR decision makers would make **different decisions**.

- MM *VS.* Bayesian: When $P_s < P^* \leq P_H$, a MM decision maker would purchase insurance whereas a Bayesian would not.
- MMR *VS.* Bayesian: When $P_s < P^* \leq P_M$, a MMR decision maker would purchase insurance whereas a Bayesian would not.
- MM *VS.* MMR: When $P_M < P^* \leq P_H$, a MM decision maker would purchase insurance whereas a MMR DM would not.

(2) Taking the **initial response** given by IM respondents as a **summary statistics of their interval** is **not a good assumption** in general.

- In our sample, ~30% of IM Rs give an initial point-response that is not contained in the post-probe interval, and for only slightly over 10% the initial point coincides with the midpoint of the interval.
- Many IM Rs give an initial point-response that is higher than the interval's UB, P_H. Whenever the decision threshold P^* lies between P_H and the initial point, using the latter as a summary statistic for the interval would lead to predict, incorrectly, that the agent will purchase LTC insurance.

Linear Prediction of LTC Insurance Prob by Dementia Prob

(measured as percent chance: ▸ Uncond LTC Probs, ▸ LTC Probs if No Dem, ▸ LTC Probs if Dem)

Sample (based on post-probe info):	ALL Rs (1)	EX or PR Dementia Prob (2)	IM Dementia Prob (3)	EX or PR Dementia Prob (4)		IM Dementia Prob (5)			
IM assumption:						(5A) *maximin*		(5B) *minimax regret*	
Data type:	Initial responses			Post-probe responses					
Outcome / Predictors	Probability of LTC Insurance			Probability of LTC Insurance		Probability of LTC Insurance		Probability of LTC Insurance	
				LB	UB	LB	UB	LB	UB
Dementia Prob	0.08 (0.05)	0.15 (0.06)	-0.02 (0.08)	0.09 (0.06)	0.11 (0.07)	0.12 (0.07)	0.19 (0.08)	0.08 (0.08)	0.12 (0.10)
Intercept	20.46 (2.00)	18.94 (2.47)	23.56 (3.42)	16.84 (2.29)	26.24 (2.81)	9.95 (3.13)	21.33 (3.76)	12.92 (2.83)	26.21 (3.46)
N of obs.	510	286	224	290		226			

Conclusion

Imprecise probabilities have been recognized in economic theory and elsewhere for a long time, but almost nothing was known about it empirically.

- We have documented that it is prevalent in contexts that matter.
- We have described findings for dementia expectations, not elicited before.

The standard elicitation format "hides" imprecision, as respondents are willing to answer in the format in which they are asked.

- We have shown how initial response (in the standard format) and post-probe response relate to each other.
- We have begun to investigate the implications of ignoring imprecision (and rounding) of dementia probabilities for modelling and prediction of LTC insurance demand.

Next: More on the relationship between dementia and LTC choice probabilities (both structural modelling and interval-data regressions), exploiting multiple probability measures (state-contingent LTC probabilities in addition to unconditional LTC and dementia probabilities).

Thank You!

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Probing Sequence after a Numerical Point Response (Back)

Probing sequence after a numerical point response

1. When people are asked to give a numerical response, like percent chance, sometimes they give exact answers and sometimes they give rounded or approximate numbers. When you said [X] percent just now, did you mean this as an exact answer or were you rounding or approximating?
   - *Possible answers:* Exact answer; Rounding/approximating.

2. **(If rounding/approx.)** Now please try without rounding or approximating your answer. What is the percent chance that [EVENT] sometime in the future? If you are uncertain about the chances, you may give a range. For example, you may say something like "less than 20 percent," "between 30 and 40 percent" or "greater than 80 percent."
   - *Possible answers:* A percent chance in 0-100; a closed or open from below/above range.

Probing Sequence after Other Responses (▸ Back)

Probing sequence after a Don't Know response

1. When people are asked to give the percent chance that something will happen in the future, sometimes they give exact answers and sometimes they feel uncertain about the chances. When you said you don't know just now, did you mean you feel uncertain about the chances or something else?
   - *Possible answers:* Uncertain about the chances; Something else.

2. (**If uncertain**) If you are uncertain about the chances, you may give a range instead. For example, you may say something like "less than 20 percent," "between 30 and 40 percent" or "greater than 80 percent." If you could give a range, what range would you give to the percent chance that [EVENT] sometime in the future?
   - *Possible answers:* A percent chance in 0-100; a closed or open from below/above range.

Probing sequence after a numerical interval response

1. If you had to answer with a single value to the previous question, what point would you give?
   - *Possible answers:* A percent chance in 0-100.

"Pre-Post:" Relationship between Initial and Post-Probe Dementia Probabilities (Back)

Empirical Expectations of Initial Point (y) Given Post-Probe Point or Interval (x)

Panel A. "Round/Approx." sub-sample with precise probabilities (x = post-probe point)

x	0	10	20	30	40	50	60	70	80	90	100
E(y|x)	16.38	11	24.57	35.79	52	52.22	73.33	57.4	62.08	-	-
[CI]	[0, 69.6]	[0, 41.8]	[0, 61.9]	[0, 78.1]	[28.6, 75.5]	[23.4, 81.1]	[43.4, 100]	[0, 100]	[6.57, 100]		
N	8	11	46	29	20	27	3	5	12	0	0

Panel B. "Round/Approx." sub-sample with imprecise probabilities (x = interval LB)

x	0	10	20	30	40	50	60	70	80	90	100
Sub-sample with interval width = 10 (1st decile)											
E(y|x)	7	15.83	29.74	43.33	46.43	59.44	70	72.5	-	90	-
[CI]	[0, 15.3]	[2.8, 28.9]	[5, 54.5]	[5.7, 81]	[17.8, 75.1]	[28.3, 90.6]		[65.6, 79.4]			
N	10	6	19	63	14	9	2	2	0	1	0
Subsample with interval width = 20 (median)											
E(y|x)	20.77	15	40	38.33	52.5	-	60	-	62	-	-
[CI]	[0, 56.2]	[1.1, 28.9]	[0,100]	[0,100]	[38.6, 66.4]				[36.2, 87.8]		
N	120	2	3	3	8	0	1	0	10	0	0

Dementia Risk Perceptions by R's Attributes (B)

Age: Mean dementia expectations vary non-monotonically with age, among both precise- and imprecise-probability respondents (Rs).

Educ: Among *precise-probability* Rs, the less educated have lower dementia probability. Respondents with at least some college have statistically higher dementia probability.

Race: Among *precise-probability* Rs, non-whites have lower dementia prob. Among *imprecise-probability* Rs, blacks tend to give higher UB probability and other-race Rs to report higher LB and lower UB.

Gender: No statistically significant differences across genders.

Table

Dementia Risk Perceptions: Comparison of Means Across R's Attributes (Back)

Sub-sample:	Precise (EX+PR)		Imprecise (IM)			
Outcome:	Point		Interval LB		Interval UB	
Estimate:	Coef.	Mean	Coef.	Mean	Coef.	Mean
Age						
59- (reference)	27.57	27.57	14.55	14.55	43.22	43.22
	(1.97)		(2.07)		(2.91)	
60-64	3.94	31.51	5.95	20.50	1.60	44.82
	(3.18)		(3.09)		(4.35)	
65-69	6.99	34.56	5.85	20.40	6.20	49.42
	(3.52)		(3.15)		(4.43)	
70-74	-0.07	27.50	-1.18	13.37	-1.26	41.96
	(3.38)		(3.58)		(5.03)	
75-79	-3.98	23.59	1.53	16.08	6.56	49.78
	(3.74)		(3.26)		(4.57)	
80-84	0.62	28.19	-3.62	10.93	0.06	43.28
	(4.69)		(4.23)		(5.94)	
85+	-7.95	19.92	1.50	16.05	8.10	51.32
	(5.50)		(5.21)		(7.32)	
Gender						
male (reference)	27.60	27.60	16.59	16.59	45.27	45.27
	(1.72)		(1.64)		(2.28)	
female	1.48	29.08	0.07	16.66	1.00	46.27
	(2.21)		(2.08)		(2.90)	
Race						
white (reference)	30.64	30.64	17.08	17.08	45.19	45.19
	(1.27)		(1.15)		(1.60)	
black	-8.54	22.10	-4.21	12.21	9.94	55.13
	(2.71)		(2.92)		(5.12)	
other	-5.06	25.58	1.81	18.89	-0.93	44.26
	(3.87)		(3.67)		(4.06)	
Education						
no diploma	19.39	19.39	15.49	15.49	47.05	47.05
(reference)	(2.67)		(2.66)		(3.72)	
high school	11.87	31.26	-0.48	15.01	-4.43	42.62
	(3.04)		(2.99)		(4.20)	
some college	13.78	33.17	7.98	23.47	4.62	51.67
	(4.60)		(4.36)		(6.11)	
bachelor	9.41	28.80	7.17	22.66	5.85	52.90
	(3.89)		(3.74)		(5.25)	
graduate	3.97	23.36	-2.91	12.58	-0.49	46.56
	(4.54)		(4.08)		(5.72)	
N	591		431		431	

Empirical Distribution of Probabilistic Response Types to the LTC Questions (Back)

	All respondents	Respondents who gave an initial point response of 0	Respondents who gave an initial point response of 50	Respondents who gave an initial response other than 0 or 50	**All respondents**	Respondents who gave an initial point response of 0	Respondents who gave an initial point response of 50	Respondents who gave an initial response other than 0 or 50
	Unconditional LTC *Insurance*				***Unconditional*** LTC *Utilization*			
% EX	38.41	70.42	15.96	15.57	34.12	73.53	7.63	14.94
% PR	14.88	9.17	26.60	15.98	15.95	10.08	21.37	18.18
% IM	42.21	16.25	55.32	62.70	45.79	13.03	69.47	61.04
% Other	4.50	4.17	2.13	5.74	4.14	3.36	1.53	5.84
N	578	240	94	244	677	238	131	308
	Conditional LTC *Insurance* Given ***No Dementia***				*Conditional* LTC *Utilization* Given ***No Dementia***			
% EX	60.73	90.09	51.11	39.53	55.24	88.09	48.94	36.46
% PR	11.07	5.17	22.22	13.95	11.82	5.11	31.91	13.42
% IM	24.57	3.88	24.44	40.53	27.18	4.68	19.15	41.52
% Other	3.63	0.86	2.22	5.98	5.76	2.13	0	8.61
N	578	232	45	301	677	235	47	395
	Conditional LTC *Insurance* Given ***Dementia***				*Conditional* LTC *Utilization* Given ***Dementia***			
% EX	67.30	92.66	66.67	54.25	58.64	93.84	45.33	49.56
% PR	10.38	4.52	10	13.49	10.78	2.74	20	11.84
% IM	17.47	1.69	20	25.22	25.11	2.05	33.33	31.14
% Other	4.84	1.13	3.33	7.04	5.47	1.37	1.33	7.46
N	578	177	60	341	677	146	75	456

Width of Intervals among IM Rs (Back)

	Respondents who gave an initial point response	Respondents who gave an initial point response of 0	Respondents who gave an initial point response of 50	Respondents who gave an initial response other than 0 or 50	Respondents who gave an initial interval response
Unconditional LTC *Insurance*					
1st decile	10	10	10	10	20
Median	20	20	20	20	25
9th decile	80	95	80	70	60
N	231	38	49	144	4
Conditional LTC *Insurance* Given ***No Dementia***					
1st decile	10	10	10	10	10
Median	20	20	20	20	20
9th decile	80	20	50	80	60
N	62	7	9	46	62
Conditional LTC *Insurance* Given ***Dementia***					
1st decile	10	10	5	10	10
Median	20	20	5	20	10
9th decile	70	80	50	80	50
N	51	3	10	38	35
Unconditional LTC *Utilization*					
1st decile	10	10	10	10	5
Median	20	20	20	20	10
9th decile	70	50	50	80	100
N	278	30	80	168	4
Conditional LTC *Utilization* Given ***No Dementia***					
1st decile	10	10	10	10	9
Median	20	20	10	20	20
9th decile	40	100	50	30	50
N	78	8	9	61	84
Conditional LTC *Utilization* Given ***Dementia***					
1st decile	10	20	10	10	10
Median	20	20	30	20	20
9th decile	60	90	60	55	80
N	97	3	21	73	52

Uncond LTC Probabilities by Response Type (Back)

	***Initial* = *Post* Probe**	*Initial*		**Post Probe**		
Response distrib.	Point-Prob. in *EX* Group	Point-Prob. in PR Group	Point-Prob. in IM Group	Point-Prob. in PR Group	LB in IM Group	UB in IM Group
			Unconditional LTC *Insurance*			
0	76.13	25.58	15.98	13.95	51.08	0
50	6.76	29.07	21.31	12.79	5.19	4.76
100	6.76	1.16	2.05	3.49	0	17.32
Other value	10.35	44.19	58.61	69.77	43.73	77.92
Interval	NA	NA	2.05	NA	NA	NA
DK	NA	NA	0.82	NA	0	0
N	222	86	244	86	231*	231*
1st decile	0	0	0	0	0	20
Median	**0**	15	20	**25**	**0**	**30**
Mean	**13.74**	29.13	29.24	**31.98**	**15.91**	**44.11**
9th decile	60	70	60	70	50	100
N	222	86	237*	86	231*	231*
			Unconditional LTC *Utilization*			
0	75.76	22.22	10	9.26	47.50	0
50	4.33	25.93	29.35	16.67	3.57	7.17
100	10.82	2.78	1.29	0	0.36	14.70
Other value	9.09	49.07	56.13	74.07	48.57	78.13
Interval	NA	NA	1.29	NA	NA	NA
DK	NA	NA	1.94	NA	0	0
N	231	108	310	108	280*	279*
1st decile	0	0	0	0	0	20
Median	**0**	40	40	**30**	**10**	**40**
Mean	**15.88**	35.42	35.85	**33.26**	**19.45**	**45.80**
9th decile	100	80	75	70	55	100
N	231	108	300*	108	280*	279*

LTC Probabilities If No Dem by Response Type (Back)

Response distrib.	***Initial* = *Post* Probe** Point-Prob. in EX Group	*Initial* Point-Prob. in PR Group	*Initial* Point-Prob. in IM Group	***Post* Probe** Point-Prob. in PR Group	***Post* Probe** LB in IM Group	***Post* Probe** UB in IM Group
		Conditional LTC *Insurance* Given *No Dementia*				
0	59.54	18.75	6.34	21.88	51.61	0
50	6.55	15.63	7.75	10.94	3.23	6.45
100	3.70	3.13	0.71	1.56	0	14.52
Other value	30.21	62.48	33.79	65.62	45.16	79.03
Interval	NA	NA	46.48	NA	NA	NA
DK	NA	NA	4.93	NA	0	0
N	351	64	142	64	62*	62*
1st decile	0	0	0	0	0	20
Median	**0**	20	25	**20**	**0**	**35**
Mean	**15.83**	29	30.07	**26.52**	**14.35**	**41.45**
9th decile	50	70	70	70	30	100
N	351	64	69*	64	62*	62*
		Conditional LTC *Utilization* Given *No Dementia*				
0	55.35	15	5.98	7.50	46.15	0
50	6.15	18.75	4.89	12.50	1.28	3.85
100	4.28	2.50	0.54	1.25	0	8.97
Other value	34.22	63.75	35.82	78.75	52.57	87.18
Interval	NA	NA	48.36	NA	NA	NA
DK	NA	NA	4.35	NA	0	0
N	374	80	184	80	78*	78*
1st decile	0	0	0	3	0	15
Median	**0**	30	20	**25**	**5**	**30**
Mean	**16.22**	33.50	28.28	**31.18**	**16.77**	**37.58**
9th decile	50	80	70	65	50	80
N	374	80	87*	80	78*	78*

LTC Probabilities If Dem by Response Type (Back)

	***Initial = Post* Probe**	*Initial*		**Post Probe**		
Response distrib.	Point-Prob. in EX Group	Point-Prob. in PR Group	Point-Prob. in IM Group	Point-Prob. in PR Group	LB in IM Group	UB in IM Group
	Conditional LTC *Insurance* Given *Dementia*					
0	42.16	13.33	2.97	13.33	27.45	7.84
50	10.28	10	11.88	13.33	9.80	1.96
100	10.54	3.33	0	6.67	0	29.41
Other value	37.02	73.34	41.58	66.67	62.75	60.79
Interval	NA	NA	36.63	NA	NA	NA
DK	NA	NA	6.93	NA	0	0
N	389	60	101	60	51*	51*
1st decile	0	0	10	0	0	20
Median	**20**	25	50	**40**	**30**	**60**
Mean	**36.85**	35.15	45.40	**38.07**	**33.73**	**61.86**
9th decile	100	80	80	80	80	100
N	389	60	57*	60	51*	51*
	Conditional LTC *Utilization* Given *Dementia*					
0	34.51	5.48	1.76	5.48	35.05	0
50	8.56	20.55	14.71	13.70	4.12	4.12
100	15.37	6.85	2.35	5.48	0	22.68
Other value	41.56	67.12	44.13	75.34	60.83	73.20
Interval	NA	NA	32.93	NA	NA	NA
DK	NA	NA	4.12	NA	0	0
N	397	73	170	73	97*	97*
1st decile	0	10	10	7	0	20
Median	**35**	50	50	**40**	**30**	**50**
Mean	**42.11**	45.67	51.55	**44.10**	**32.53**	**58.38**
9th decile	100	90	85	80	80	100
N	397	73	107*	73	97*	97*