Morbidity Improvement

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Session 39
March 8, 2011

Purpose

Improvement in LTC morbidity in combination with declining mortality rates can have profound consequences for lifetime disability and LTC/LTCI costs.

The LTC Morbidity Improvement Study was designed to evaluate changes over time in activities of daily living (ADL) and cognitive impairment (CI) morbidity rates, and their impact on lifetime disability.

This session describes the on-going Study and results to-date.

Final results will be available in mid-2011.

Four Specific Aims

1. Precise estimation of changes over time in ADL morbidity rates (using simulated HIPAA ADL Trigger) and the impact of those changes on lifetime disability.
2. Replicate Aim 1 for changes over time in CI morbidity rates (using simulated HIPAA CI Trigger).
3. Assess sensitivity to alternative sets of cross-sectional and longitudinal sampling weights.
4. Assess impact of alternative underwriting protocols using NLTCS variables and linked Medicare diagnostic data; adding other relevant data as necessary.

Project Organization

1. Sponsors: ILTCI Conference Board and
   SOA LTCI Section and Special Research Fund.
2. Researchers: Eric Stallard and Anatoliy Yashin.
3. Performance Period: January 2010 to mid-2011.
4. Project Oversight: SOA Project Oversight Group (POG)

   David Benz, Vince Bodnar, Jason Bushey, Mark Costello, Allen Schmitz, Barbara Scott, Steven Siegel, John Timmerberg, Ali Zaker-Shahrak.
5. Deliverables: For each Aim, report of findings.

National Long Term Care Survey (NLTCS)

1. Quality: The NLTCS is the best source of data for national disability trends among persons aged 65 years and above (Freedman et al., JAMA, 2002).

   The NHIS, in combination with the NNHS, was the only other data source rated close in quality.

2. Temporal Range: The NLTCS was fielded in 1982, 1984, 1989, 1994, 1999, and 2004, using comparable instrumentation in all years.

   Comparable instrumentation is the key requirement for assessing morbidity improvement.

NLTCS

3. Relevance: The NLTCS facilitates simulation of HIPAA ADL and CI Triggers in a peer-reviewed form accepted for use by LTCI actuaries.

   See Stallard and Yee's (2000) report on LTCI Section website.

4. Data Availability: A public use version of the NLTCS is available free of charge from Duke to users who certify that they will comply with the terms of the NLTCS Data Use Agreement.

   Users who comply with a somewhat more stringent set of terms can obtain copies of linked Medicare data from CMS.

NLTCS Summary Description

Purpose: To measure disability and use of LTC among the non-insured U.S. elderly (age 65+) at multiple points in time from 1982 to 2004.

Cumulative *n* = ~49,000.

- Each survey year *n* = ~16,000–21,000,
- with ~6,000–7,500 detailed in-person interviews each year for persons who met various screening criteria.

Disability included

- ADL and IADL limitations (3+ months)
- Cognitive impairment (CI)
- Institutionalization.

HIPAA ADL Trigger

The individual is unable to perform without "substantial assistance" (hands-on or standby) from another individual at least 2 out of 6 ADLs:

bathing,	continence,
dressing,	eating,
toileting,	transferring

for at least 90 days due to a loss of functional capacity.

NLTCS ADLs

1. Bathing
2. Continence
3. Dressing
4. Eating
5. Transferring (in/out bed)
6. Toileting
7. Inside mobility
   – *not included in the HIPAA ADL Trigger*

ADL Disability Thresholds

0. Performs ADL
1. Needs, but does not receive, help with ADL
2. Performs ADL with special equipment
3. Standby help with/without special equipment
4. Active help, with/without special equipment
5. Unable to perform ADL

Two or more ADLs at levels 3–5 are required to meet the HIPAA ADL trigger.

The traditional NLTCS triggers count the ADLs at levels 2–5.

NLTCS IADLs

1. Doing laundry
2. Doing light housework
3. Getting around outdoors
4. Going places outside of walking distances
5. Making telephone calls
6. Managing money
7. Preparing meals
8. Shopping for groceries
9. Taking medications

Unweighted Number and Percent of Persons Meeting HIPAA ADL Trigger, 1984 NLTCS, Unisex, Age 65 and Above, by Age

	Meets HIPAA ADL Trigger				
Age	No	Yes	Total	Percent	Std Error (Pct)
65-69	7,436	321	7,757	4.1%	0.2%
70-74	4,491	398	4,889	8.1%	0.4%
75-79	3,257	507	3,764	13.5%	0.6%
80-84	1,994	574	2,568	22.4%	0.8%
85-89	999	578	1,577	36.7%	1.2%
90-94	293	357	650	54.9%	2.0%
95+	53	141	194	72.7%	3.2%
Total	18,523	2,876	21,399	13.4%	0.2%

Note: HIPAA Triggers are 2+ ADL Disabilities or Severe Cognitive Impairment

Source: Authors' calculations based on the 1984 NLTCS.

Unweighted Number and Percent of Persons Meeting HIPAA ADL Trigger, 2004 NLTCS, Unisex, Age 65 and Above, by Age

	Meets HIPAA ADL Trigger				
Age	No	Yes	Total	Percent	Std Error (Pct)
65-69	4,008	104	4,112	2.5%	0.2%
70-74	2,731	140	2,871	4.9%	0.4%
75-79	2,400	164	2,564	6.4%	0.5%
80-84	2,314	284	2,598	10.9%	0.6%
85-89	1,798	448	2,246	19.9%	0.8%
90-94	442	192	634	30.3%	1.8%
95+	448	520	968	53.7%	1.6%
Total	14,141	1,852	15,993	11.6%	0.2%

Note: HIPAA Triggers are 2+ ADL Disabilities or Severe Cognitive Impairment

Source: Authors' calculations based on the 2004 NLTCS.

HIPAA CI Trigger

The individual requires "substantial supervision" to protect him/herself from threats to health and safety due to "severe cognitive impairment," defined as:

A loss or deterioration in intellectual capacity that is

(a) comparable to (and includes) Alzheimer's disease and similar forms of irreversible dementia, and

(b) measured by clinical evidence and standardized tests that reliably measure impairment in the individual's

(i) short-term or long-term memory,

(ii) orientation as to people, places, or time, and

(iii) deductive or abstract reasoning.

NLTCS Cognitive Impairment

- Short Portable Mental Status Questionnaire (SPMSQ)

  Choice of 3+, 4+, or 5+ ***errors*** *out of 10 questions;*

  or

- Caregiver report of

  Alzheimer's Disease, dementia, or other cognition problems sufficient to prevent completion of the SPMSQ with a passing score of 0–2, 0–3, or 0–4 errors.

Note the 1999 NLTCS replaced the SPMSQ with the MMSE; roughly comparable cuts are ≤22, ≤19, or ≤16 ***correct*** *out of 30 questions.*

NLTCS Substantial Supervision Criteria

Assumed to apply to respondents who met:

1. The NLTCS criteria for any ADL or IADL disability at the screener interview (which then qualified them for the detailed interview), or
2. The NLTCS criteria for IADL disability or indoor mobility impairment at the detailed interview, or
3. The HIPAA criteria for at least one ADL disability at the detailed interview.

NLTCS CI Trigger

Restricted to respondents who met:

1. The NLTCS criteria for any cognitive impairment; and
2. The NLTCS criteria for substantial supervision.

Analytic Challenges

1. The Screener component of the substantial supervision criteria is fully known for 1982 and 2004 but missing information for the other years.
2. The Institutional component of the caregiver report for non-completion of the SPMSQ is fully known for 1999 and 2004 surveys but missing information for the other years.

Unweighted Distribution of HIPAA Triggers by ADL/IADL Disability Level, 2004 NLTCS, Unisex, Age 65 and Above

ADL/IADL Disability Level*	HIPAA Trigger				
	Neither	CI only	ADL only	ADL & CI	Total
	Number of Persons				
Nondisabled	11,990	28			12,018
IADL/Inside Mobility	1,303	243			1,546
1 ADL	413	164			577
2 ADLs			144	122	266
3 ADLs			136	119	255
4 ADLs			151	163	314
5 ADLs			180	300	480
6 ADLs			101	436	537
Total	13,706	435	712	1,140	15,993

* Note: Institutional residents were treated as IADL disabled if no ADL disabilities were reported. The CI trigger was based on 3+ errors on the SPMSQ.

Source: Authors' calculations based on the 2004 NLTCS.

NLTCS Linked Medicare Data

Linkage to Medicare billing/diagnosis data for all 49,000 sampled persons in NLTCS.

Provides precise dates-of-onset of new medical conditions.

Facilitates studies of changes in medical expenditures before and after the onset of major medical conditions.

e.g., Diabetes = ICD-9 code 250.

NLTCS Survey Weights

Survey weights were employed for tabulation of responses as described in Manton et al. (2006).

Standard errors (s.e.'s) of weighted estimators of binomial proportions were based on rescaled sample weights using the procedures developed by Potthoff et al. (1992; see Appendix at end of presentation for details).

These procedures yielded overall estimated design effects of 1.13 in the 1984 NLTCS and 1.19 in the 2004 NLTCS.

Manton, K.G., Gu, X, and Lamb, V.L. Change in chronic disability from 1982 to 2004/2005 as measured by long-term changes in function and health in the U.S. elderly population. *Proceedings of the National Academy of Sciences, U.S.A.*, 103(48):18374–18379, 2006.

Potthoff, R.F., Woodbury, M.A. and Manton, K.G. "Equivalent sample size" and "equivalent degrees of freedom" refinements for inference using survey weights under superpopulation models. *Journal of the American Statistical Association*, 87(418):383–396, 1992.

Applications

1. Published trends through 2004 for traditional NLTCS ADL triggers; updated trends for HIPAA ADL triggers through 2004.
2. HIPAA CI triggers for 2004; combined results for HIPAA ADL and CI triggers.

   Need to control for changes in institutional CI reporting between 1984 and 2004.

3. Impact of alternative sample weights on HIPAA ADL and CI triggers for 2004 and on changes in HIPAA ADL triggers between 1984 and 2004.

Disability Group Estimates (%), NLTCS 1982 to 2004, Age-Standardized to 2004 U.S. Population

Disability Status \ Year	1982	1984	1989	1994	1999	2004	Relative Change (%)
Non-disabled	73.5	73.8	75.2	76.8	78.8	81.0	10.2
IADL only	5.7	6.0	4.5	4.4	3.3	2.4	-58.5
1-2 ADLs	6.8	6.9	6.6	6.1	6.3	5.6	-18.3
3-4 ADLs	2.9	3.0	3.7	3.4	3.7	3.8	29.6
5-6 ADLs	3.5	3.3	3.1	2.9	3.0	3.2	-6.9
Institution	7.5	7.0	6.9	6.3	4.9	4.0	-46.6
Per annum % declines		0.6	1.1	1.3	1.8	2.2	

Note: The traditional NLTCS ADL trigger is based on use of equipment and/or human assistance.

Source: Manton, K.G., Gu, X, and Lamb, V.L. Change in chronic disability from 1982 to 2004/2005 as measured by long-term changes in function and health in the U.S. elderly population. Proceedings of the National Academy of Sciences, U.S.A., 103(48):18374–18379, 2006.

Disability Group Estimates (%) by Age, NLTCS 1982 to 2004, Age-Standardized to 2004 U.S. Population

Disability Status \ Year	1982	1984	1989	1994	1999	2004	Relative Change (%)
			Age 65-74				
Non-disabled	85.8	86.7	88.1	88.2	89.3	91.1	6.2
IADL only	4.3	4.1	3.0	3.2	2.5	1.8	-58.7
1-2 ADLs	4.1	4.0	3.8	3.7	3.4	3.1	-25.6
3-4 ADLs	1.8	1.8	1.7	1.7	2.0	1.6	-8.4
5-6 ADLs	2.0	1.7	1.5	1.6	1.4	1.5	-22.8
Institution	2.0	1.7	1.9	1.6	1.4	0.9	-54.6
			Age 75-84				
Non-disabled	69.3	70.2	70.6	73.8	76.6	78.1	12.6
IADL only	7.0	7.5	5.8	5.2	3.6	2.5	-63.9
1-2 ADLs	8.2	8.1	8.6	7.5	8.0	6.7	-18.6
3-4 ADLs	3.4	3.5	4.5	4.1	4.2	4.5	33.5
5-6 ADLs	3.9	3.6	3.5	3.0	3.4	4.0	2.4
Institution	8.1	7.1	7.0	6.3	4.3	4.1	-48.8
			Age 85+				
Non-disabled	37.9	34.1	38.6	41.5	44.4	50.3	32.6
IADL only	7.5	9.4	6.8	7.1	5.5	4.2	-43.9
1-2 ADLs	13.3	14.6	11.9	11.6	12.9	12.1	-9.2
3-4 ADLs	6.2	6.6	8.9	7.7	9.2	10.2	64.9
5-6 ADLs	7.8	8.6	7.7	7.6	8.5	7.6	-3.4
Institution	27.2	26.6	26.1	24.6	19.5	15.6	-42.7

Note: The traditional NLTCS ADL trigger is based on use of equipment and/or human assistance.

Source: Manton, K.G., Gu, X, and Lamb, V.L. Change in chronic disability from 1982 to 2004/2005 as measured by long-term changes in function and health in the U.S. elderly population. Proceedings of the National Academy of Sciences, U.S.A., 103(48):18374–18379, 2006.

Declines in Low and High Disability Levels, NLTCS 1982-1994, 1994-2004, Age-Standardized to 2004 U.S. Population

Disablity levels	Disabled at survey years (%) 1982	1994	2004	Disability Change (%) 1982-1994	1994-2004	Annual rate of decline 1982-1994	1994-2004
Low (IADL, 1-4 ADLs)	15.5	13.9	11.8	-1.6	-2.2	0.9%	1.7%
High (5-6 ADLs, Institution)	11.0	9.2	7.2	-1.8	-2.0	1.4%	2.4%

Note: The traditional NLTCS ADL Trigger is based on use of equipment and/or human assistance.

Source: Manton, K.G., Gu, X, and Lamb, V.L. Change in chronic disability from 1982 to 2004/2005 as measured by long-term changes in function and health in the U.S. elderly population. Proceedings of the National Academy of Sciences, U.S.A., 103(48):18374–18379, 2006.

Number and Percent of Persons Meeting HIPAA ADL Trigger, United States 1984, Unisex, Age 65 and Above, by Age

	Meets HIPAA ADL Trigger				
Age	No	Yes	Total	Percent	Std Error (Pct)
65-69	8,444,852	290,366	8,735,218	3.3%	0.2%
70-74	7,164,679	389,357	7,554,035	5.2%	0.3%
75-79	5,049,587	489,332	5,538,918	8.8%	0.5%
80-84	2,885,468	547,526	3,432,994	15.9%	0.8%
85-89	1,387,513	535,824	1,923,337	27.9%	1.2%
90-94	357,443	315,603	673,046	46.9%	2.3%
95+	57,874	119,490	177,364	67.4%	4.3%
Total	25,347,415	2,687,499	28,034,914	9.6%	0.2%

Note: HIPAA Triggers are 2+ ADL Impariments or Severe Cognitive Impairment

Source: Authors' calculations based on the 1984 NLTCS.

Number and Percent of Persons Meeting HIPAA ADL Trigger, United States 2004, Unisex, Age 65 and Above, by Age

	Meets HIPAA ADL Trigger				
Age	No	Yes	Total	Percent	Std Error (Pct)
65-69	8,302,057	186,582	8,488,639	2.2%	0.3%
70-74	8,404,035	333,111	8,737,147	3.8%	0.3%
75-79	7,139,472	484,462	7,623,934	6.4%	0.5%
80-84	5,389,370	639,477	6,028,847	10.6%	0.7%
85-89	2,782,747	669,256	3,452,003	19.4%	1.1%
90-94	1,058,680	423,553	1,482,233	28.6%	1.9%
95+	211,606	220,917	432,523	51.1%	4.0%
Total	33,287,967	2,957,359	36,245,325	8.2%	0.2%

Note: HIPAA Triggers are 2+ ADL Impariments or Severe Cognitive Impairment

Source: Authors' calculations based on the 2004 NLTCS.

Number and Percent of Persons Meeting HIPAA ADL Trigger, United States 1984, Males, Age 65 and Above, by Age

	Meets HIPAA ADL Trigger				
Age	No	Yes	Total	Percent	Std Error (Pct)
65-69	3,745,041	120,616	3,865,657	3.1%	0.3%
70-74	2,990,316	173,901	3,164,218	5.5%	0.5%
75-79	1,921,716	180,036	2,101,752	8.6%	0.7%
80-84	1,022,593	159,255	1,181,848	13.5%	1.2%
85-89	416,203	116,597	532,801	21.9%	2.2%
90-94	97,636	58,098	155,734	37.3%	4.7%
95+	14,034	16,617	30,651	54.2%	11.2%
Total	10,207,540	825,120	11,032,660	7.5%	0.3%

Note: HIPAA Triggers are 2+ ADL Impariments or Severe Cognitive Impairment

Source: Authors' calculations based on the 1984 NLTCS.

Number and Percent of Persons Meeting HIPAA ADL Trigger, United States 2004, Males, Age 65 and Above, by Age

	Meets HIPAA ADL Trigger				
Age	No	Yes	Total	Percent	Std Error (Pct)
65-69	3,901,966	84,560	3,986,527	2.1%	0.4%
70-74	3,772,777	144,266	3,917,043	3.7%	0.5%
75-79	3,038,784	192,068	3,230,853	5.9%	0.7%
80-84	2,163,128	206,884	2,370,013	8.7%	1.0%
85-89	1,034,299	138,381	1,172,680	11.8%	1.5%
90-94	335,161	92,981	428,141	21.7%	3.3%
95+	60,221	27,561	87,782	31.4%	8.3%
Total	14,306,337	886,702	15,193,039	5.8%	0.3%

Note: HIPAA Triggers are 2+ ADL Impariments or Severe Cognitive Impairment

Source: Authors' calculations based on the 2004 NLTCS.

Number and Percent of Persons Meeting HIPAA ADL Trigger, United States 1984, Females, Age 65 and Above, by Age

	Meets HIPAA ADL Trigger				
Age	No	Yes	Total	Percent	Std Error (Pct)
65-69	4,699,811	169,751	4,869,562	3.5%	0.3%
70-74	4,174,362	215,455	4,389,818	4.9%	0.4%
75-79	3,127,871	309,296	3,437,167	9.0%	0.6%
80-84	1,862,875	388,271	2,251,146	17.2%	1.0%
85-89	971,310	419,227	1,390,537	30.1%	1.5%
90-94	259,807	257,505	517,312	49.8%	2.7%
95+	43,840	102,873	146,713	70.1%	4.6%
Total	15,139,876	1,862,379	17,002,254	11.0%	0.3%

Note: HIPAA Triggers are 2+ ADL Impariments or Severe Cognitive Impairment

Source: Authors' calculations based on the 1984 NLTCS.

Number and Percent of Persons Meeting HIPAA ADL Trigger, United States 2004, Females, Age 65 and Above, by Age

	Meets HIPAA ADL Trigger				
Age	No	Yes	Total	Percent	Std Error (Pct)
65-69	4,400,090	102,022	4,502,112	2.3%	0.4%
70-74	4,631,258	188,845	4,820,103	3.9%	0.5%
75-79	4,100,688	292,394	4,393,081	6.7%	0.6%
80-84	3,226,241	432,593	3,658,834	11.8%	0.9%
85-89	1,748,448	530,875	2,279,323	23.3%	1.5%
90-94	723,519	330,573	1,054,092	31.4%	2.3%
95+	151,385	193,356	344,741	56.1%	4.4%
Total	18,981,630	2,070,657	21,052,287	9.8%	0.3%

Note: HIPAA Triggers are 2+ ADL Impariments or Severe Cognitive Impairment

Source: Authors' calculations based on the 2004 NLTCS.

Percent of Population Meeting HIPAA ADL Trigger, United States 1984 and 2004, Unisex, Age 65 and Above, by Age and Totalled Over Age, with Two Modes of Age Standardization

Age	1984	2004	% Change	Annual Rate of Decline; 20 yr.
65-69	3.3	2.2	-33.9	2.05%
70-74	5.2	3.8	-26.0	1.50%
75-79	8.8	6.4	-28.1	1.63%
80-84	15.9	10.6	-33.5	2.02%
85-89	27.9	19.4	-30.4	1.80%
90-94	46.9	28.6	-39.1	2.45%
95+	67.4	51.1	-24.2	1.37%
Total	9.6	8.2	-14.9	0.80%
1984 ASDR	9.6	6.6	-31.1	1.84%
2004 ASDR	11.9	8.2	-31.5	1.87%

NOTE: ASDR denotes age-standardized disability rate; the 1984 and 2004 results were separately age-standardized to the 1984 and 2004 NLTCS weighted unisex population.

Source: Authors' calculations based on the 1984 and 2004 NLTCS.

Percent of Population Meeting HIPAA ADL Trigger, United States 1984 and 2004, Males, Age 65 and Above, by Age and Totalled Over Age, with Two Modes of Age Standardization

Age	1984	2004	% Change	Annual Rate of Decline; 20 yr.
65-69	3.1	2.1	-32.0	1.91%
70-74	5.5	3.7	-33.0	1.98%
75-79	8.6	5.9	-30.6	1.81%
80-84	13.5	8.7	-35.2	2.15%
85-89	21.9	11.8	-46.1	3.04%
90-94	37.3	21.7	-41.8	2.67%
95+	54.2	31.4	-42.1	2.69%
Total	7.5	5.8	-22.0	1.23%
1984 ASDR	7.5	4.8	-35.4	2.16%
2004 ASDR	9.2	5.8	-36.7	2.26%

NOTE: ASDR denotes age-standardized disability rate; the 1984 and 2004 results were separately age-standardized to the 1984 and 2004 NLTCS weighted male population.

Source: Authors' calculations based on the 1984 and 2004 NLTCS.

Percent of Population Meeting HIPAA ADL Trigger, United States 1984 and 2004, Females, Age 65 and Above, by Age and Totalled Over Age, with Two Modes of Age Standardization

Age	1984	2004	% Change	Annual Rate of Decline; 20 yr.
65-69	3.5	2.3	-35.0	2.13%
70-74	4.9	3.9	-20.2	1.12%
75-79	9.0	6.7	-26.0	1.50%
80-84	17.2	11.8	-31.5	1.87%
85-89	30.1	23.3	-22.7	1.28%
90-94	49.8	31.4	-37.0	2.28%
95+	70.1	56.1	-20.0	1.11%
Total	11.0	9.8	-10.2	0.54%
1984 ASDR	11.0	7.9	-27.7	1.61%
2004 ASDR	13.6	9.8	-27.9	1.62%

NOTE: ASDR denotes age-standardized disability rate; the 1984 and 2004 results were separately age-standardized to the 1984 and 2004 NLTCS weighted female population.

Source: Authors' calculations based on the 1984 and 2004 NLTCS.

Disabled Life Expectancy Beyond Age *x* in Year *y* (Sullivan, 1971)

$$e_{D\,x,y} = \int_0^{\infty} {}_t p_{x,y}\ \pi_{x+t,y}\ dt$$

where

$${}_t p_{x,y} = l_{x+t,y} \big/ l_{x,y}$$

and

$\pi_{x+t,y} =$ disability prevalence at age $x+t$

Life Expectancy and HIPAA ADL Expectancy (in Years at Age 65), United States 1984 and 2004, by Sex

	Males				Females			
	1984	2004	Change	Relative Change	1984	2004	Change	Relative Change
Life Expectancy	14.46	16.67	2.21	15.3%	18.64	19.50	0.85	4.6%
ADL Expectancy	1.23	0.98	-0.25	-20.1%	2.41	1.88	-0.53	-22.0%

Source: Authors' calculations based on 1984 and 2004 NLTCS, 1984 life tables interpolated from 1980 and 1990 life tables in Bell and Miller (2005), and 2004 life tables from Social Security Online.

Observations

Large reductions in expected lifetime ADL disability days provide –

Strong evidence for the concept of morbidity compression,

Even in the face of increasing prevalence rates for major chronic diseases.

Cognitive Assessment

	NLTCS Year and Survey Component			
Information	1984		2004	
	Community Interview	**Institutional Interview**	**Community Interview**	**Institutional Interview**
SPMSQ Administered (Self-respondent Only)	Yes	Yes	Yes	Yes
Caregiver Report of CI	Yes	**No**	Yes	Yes

Distribution of HIPAA Triggers by SPMSQ Score, United States 2004, Unisex, Age 65 and Above

	HIPAA Trigger*					
SPMSQ Score	Neither	CI only	ADL only	ADL & CI	Total	s.e.(Tot. Pct.)
			Number of Persons			
Missing	24,546,440	**149,057**	302,665	1,100,733	26,098,896	
0-2 Errors	7,875,225		928,932		8,804,156	
3+ Errors	168,054	**549,190**		625,029	1,342,273	
Total	32,589,719	**698,247**	1,231,597	1,725,762	36,245,325	
			Percent Distribution			
Missing	67.7%	**0.4%**	0.8%	3.0%	72.0%	0.4%
0-2 Errors	21.7%		2.6%		24.3%	0.4%
3+ Errors	0.5%	**1.5%**		1.7%	3.7%	0.2%
Total	89.9%	**1.9%**	3.4%	4.8%	100.0%	
s.e.(Tot. Pct.)	0.3%	**0.1%**	0.2%	0.2%		

* Note: The CI trigger was based on 3+ errors on the SPMSQ.

Source: Authors' calculations based on the 2004 NLTCS.

Distribution of HIPAA Triggers by SPMSQ Score, United States 2004, Unisex, Age 65 and Above

	HIPAA Trigger*					
SPMSQ Score	Neither	CI only	ADL only	ADL & CI	Total	s.e.(Tot. Pct.)
			Number of Persons			
Missing	24,546,440	**149,057**	302,665	1,100,733	26,098,896	
0-2 Errors	7,875,225		928,932		8,804,156	
3 Errors	97,931	**238,033**		163,201	499,165	
4 Errors	32,611	**100,542**		106,274	239,427	
5+ Errors	37,512	**210,615**		355,554	603,681	
Total	32,589,719	**698,247**	1,231,597	1,725,762	36,245,325	
			Percent Distribution			
Missing	67.7%	**0.4%**	0.8%	3.0%	72.0%	0.4%
0-2 Errors	21.7%		2.6%		24.3%	0.4%
3 Errors	0.3%	**0.7%**		0.5%	1.4%	0.1%
4 Errors	0.1%	**0.3%**		0.3%	0.7%	0.1%
5+ Errors	0.1%	**0.6%**		1.0%	1.7%	0.1%
Total	89.9%	**1.9%**	3.4%	4.8%	100.0%	
s.e.(Tot. Pct.)	0.3%	**0.1%**	0.2%	0.2%		

* Note: The CI trigger was based on 3+ errors on the SPMSQ.

Source: Authors' calculations based on the 2004 NLTCS.

Distribution of HIPAA Triggers by SPMSQ Score, United States 2004, Unisex, Age 65 and Above, Institutional Residents

	HIPAA Trigger*					
SPMSQ Score	Neither	CI only	ADL only	ADL & CI	Total	s.e.(Tot. Pct.)
			Number of Persons			
Missing	15,475	**38,827**	78,730	722,943	855,976	
0-2 Errors	97,553		200,166		297,719	
3+ Errors		**80,939**		223,430	304,370	
Total	113,029	**119,767**	278,896	946,373	1,458,065	
			Percent Distribution			
Missing	1.1%	**2.7%**	5.4%	49.6%	58.7%	2.1%
0-2 Errors	6.7%		13.7%		20.4%	1.7%
3+ Errors		**5.6%**		15.3%	20.9%	1.7%
Total	7.8%	**8.2%**	19.1%	64.9%	100.0%	
s.e.(Tot. Pct.)	1.1%	**1.2%**	1.7%	2.1%		

* Note: The CI trigger was based on 3+ errors on the SPMSQ.

Source: Authors' calculations based on the 2004 NLTCS.

Distribution of HIPAA Triggers by SPMSQ Score, United States 2004, Unisex, Age 65 and Above, Institutional Residents

	HIPAA Trigger*					
SPMSQ Score	Neither	CI only	ADL only	ADL & CI	Total	s.e.(Tot. Pct.)
			Number of Persons			
Missing	15,475	**38,827**	78,730	722,943	855,976	
0-2 Errors	97,553		200,166		297,719	
3 Errors		**28,601**		39,453	68,054	
4 Errors		**7,137**		26,117	33,253	
5+ Errors		**45,202**		157,861	203,063	
Total	113,029	**119,767**	278,896	946,373	1,458,065	
			Percent Distribution			
Missing	1.1%	**2.7%**	5.4%	49.6%	58.7%	2.1%
0-2 Errors	6.7%		13.7%		20.4%	1.7%
3 Errors		**2.0%**		2.7%	4.7%	0.9%
4 Errors		**0.5%**		1.8%	2.3%	0.6%
5+ Errors		**3.1%**		10.8%	13.9%	1.5%
Total	7.8%	**8.2%**	19.1%	64.9%	100.0%	
s.e.(Tot. Pct.)	1.1%	**1.2%**	1.7%	2.1%		

* Note: The CI trigger was based on 3+ errors on the SPMSQ.

Source: Authors' calculations based on the 2004 NLTCS.

Distribution of HIPAA Triggers by ADL/IADL Disability Level, United States 2004, Unisex, Age 65 and Above

ADL/IADL Disability Level**	HIPAA Trigger*					
	Neither	CI only	ADL only	ADL & CI	Total	s.e.(Tot. Pct.)
			Number of Persons			
Nondisabled	29,675,587	**64,014**			29,739,601	
IADL/Inside Mobility	2,215,298	**382,542**			2,597,840	
1 ADL	698,834	**251,692**			950,526	
2 ADLs			268,546	202,027	470,573	
3 ADLs			231,219	192,294	423,514	
4 ADLs			261,289	257,720	519,009	
5 ADLs			294,215	440,844	735,060	
6 ADLs			176,327	632,877	809,204	
Total	32,589,719	**698,247**	1,231,597	1,725,762	36,245,325	
			Percent Distribution			
Nondisabled	81.9%	**0.2%**			82.1%	0.3%
IADL/Inside Mobility	6.1%	**1.1%**			7.2%	0.2%
1 ADL	1.9%	**0.7%**			2.6%	0.1%
2 ADLs			0.7%	0.6%	1.3%	0.1%
3 ADLs			0.6%	0.5%	1.2%	0.1%
4 ADLs			0.7%	0.7%	1.4%	0.1%
5 ADLs			0.8%	1.2%	2.0%	0.1%
6 ADLs			0.5%	1.7%	2.2%	0.1%
Total	89.9%	**1.9%**	3.4%	4.8%	100.0%	
s.e.(Tot. Pct.)	0.3%	**0.1%**	0.2%	0.2%		

* Note: The CI trigger was based on 3+ errors on the SPMSQ.

** Note: Institutional residents were treated as IADL disabled if no ADL disabilities were reported.

Source: Authors' calculations based on the 2004 NLTCS.

Distribution of HIPAA Triggers by ADL/IADL Disability Level, United States 2004, Unisex, Age 65 and Above, Institutional Residents

ADL/IADL Disability Level**	HIPAA Trigger* Neither	CI only	ADL only	ADL & CI	Total	s.e.(Tot. Pct.)
			Number of Persons			
Nondisabled						
IADL/Inside Mobility	32,560	**40,695**			73,255	
1 ADL	80,468	**79,072**			159,540	
2 ADLs			36,101	77,891	113,992	
3 ADLs			54,686	107,306	161,992	
4 ADLs			73,779	132,009	205,787	
5 ADLs			74,079	248,208	322,287	
6 ADLs			40,252	380,960	421,211	
Total	113,029	**119,767**	278,896	946,373	1,458,065	
			Percent Distribution			
Nondisabled						
IADL/Inside Mobility	2.2%	**2.8%**			5.0%	0.9%
1 ADL	5.5%	**5.4%**			10.9%	1.3%
2 ADLs			2.5%	5.3%	7.8%	1.2%
3 ADLs			3.8%	7.4%	11.1%	1.3%
4 ADLs			5.1%	9.1%	14.1%	1.5%
5 ADLs			5.1%	17.0%	22.1%	1.8%
6 ADLs			2.8%	26.1%	28.9%	1.9%
Total	7.8%	**8.2%**	19.1%	64.9%	100.0%	
s.e.(Tot. Pct.)	1.1%	**1.2%**	1.7%	2.1%		

* Note: The CI trigger was based on 3+ errors on the SPMSQ.

** Note: Institutional residents were treated as IADL disabled if no ADL disabilities were reported.

Source: Authors' calculations based on the 2004 NLTCS.

Distribution of HIPAA Triggers by ADL/IADL Disability Level, United States 2004, Unisex, Age 65 and Above, Institutional Residents with SPMSQ Results

ADL/IADL Disability Level**	HIPAA Trigger* Neither	CI only	ADL only	ADL & CI	Total	s.e.(Tot. Pct.)
			Number of Persons			
Nondisabled						
IADL/Inside Mobility	32,142	**31,728**			63,869	
1 ADL	65,411	**49,212**			114,623	
2 ADLs			33,039	37,321	70,361	
3 ADLs			40,336	37,831	78,167	
4 ADLs			58,599	39,169	97,767	
5 ADLs			48,695	62,267	110,962	
6 ADLs			19,497	46,842	66,340	
Total	97,553	**80,939**	200,166	223,430	602,089	
			Percent Distribution			
Nondisabled						
IADL/Inside Mobility	5.3%	**5.3%**			10.6%	2.1%
1 ADL	10.9%	**8.2%**			19.0%	2.6%
2 ADLs			5.5%	6.2%	11.7%	2.1%
3 ADLs			6.7%	6.3%	13.0%	2.2%
4 ADLs			9.7%	6.5%	16.2%	2.5%
5 ADLs			8.1%	10.3%	18.4%	2.6%
6 ADLs			3.2%	7.8%	11.0%	2.1%
Total	16.2%	**13.4%**	33.2%	37.1%	100.0%	
s.e.(Tot. Pct.)	2.5%	**2.3%**	3.1%	3.2%		

* Note: The CI trigger was based on 3+ errors on the SPMSQ.

** Note: Institutional residents were treated as IADL disabled if no ADL disabilities were reported.

Source: Authors' calculations based on the 2004 NLTCS.

Distribution of HIPAA Triggers by ADL/IADL Disability Level, United States 2004, Unisex, Age 65 and Above, Institutional Residents without SPMSQ Results

ADL/IADL Disability Level**	HIPAA Trigger* Neither	CI only	ADL only	ADL & CI	Total	s.e.(Tot. Pct.)
			Number of Persons			
Nondisabled						
IADL/Inside Mobility	419	**8,967**			9,386	
1 ADL	15,057	**29,860**			44,917	
2 ADLs			3,061	40,570	43,631	
3 ADLs			14,350	69,475	83,824	
4 ADLs			15,180	92,840	108,020	
5 ADLs			25,384	185,941	211,325	
6 ADLs			20,754	334,118	354,872	
Total	15,475	**38,827**	78,730	722,943	855,976	
			Percent Distribution			
Nondisabled						
IADL/Inside Mobility	0.0%	**1.0%**			1.1%	0.6%
1 ADL	1.8%	**3.5%**			5.2%	1.3%
2 ADLs			0.4%	4.7%	5.1%	1.2%
3 ADLs			1.7%	8.1%	9.8%	1.7%
4 ADLs			1.8%	10.8%	12.6%	1.9%
5 ADLs			3.0%	21.7%	24.7%	2.4%
6 ADLs			2.4%	39.0%	41.5%	2.8%
Total	1.8%	**4.5%**	9.2%	84.5%	100.0%	
s.e.(Tot. Pct.)	0.7%	**1.2%**	1.6%	2.0%		

* Note: The CI trigger was based on 3+ errors on the SPMSQ.

** Note: Institutional residents were treated as IADL disabled if no ADL disabilities were reported.

Source: Authors' calculations based on the 2004 NLTCS.

Number and Percent of Persons Meeting HIPAA CI Trigger, United States 2004, Unisex, Age 65 and Above, by Age

	Meets HIPAA CI Trigger				
Age	No	Yes	Total	Percent	Std Error (Pct)
65-69	8,384,960	103,679	8,488,639	1.2%	0.2%
70-74	8,539,577	197,570	8,737,147	2.3%	0.3%
75-79	7,247,763	376,171	7,623,934	4.9%	0.4%
80-84	5,482,051	546,796	6,028,847	9.1%	0.6%
85-89	2,840,985	611,018	3,452,003	17.7%	1.1%
90-94	1,086,664	395,569	1,482,233	26.7%	1.9%
95+	239,316	193,207	432,523	44.7%	3.9%
Total	33,821,316	2,424,010	36,245,325	6.7%	0.2%

Note: HIPAA Triggers are 2+ ADL Impariments or Severe Cognitive Impairment

Source: Authors' calculations based on the 2004 NLTCS.

Number and Percent of Persons Meeting HIPAA ADL Trigger, United States 2004, Unisex, Age 65 and Above, by Age

	Meets HIPAA ADL Trigger				
Age	No	Yes	Total	Percent	Std Error (Pct)
65-69	8,302,057	186,582	8,488,639	2.2%	0.3%
70-74	8,404,035	333,111	8,737,147	3.8%	0.3%
75-79	7,139,472	484,462	7,623,934	6.4%	0.5%
80-84	5,389,370	639,477	6,028,847	10.6%	0.7%
85-89	2,782,747	669,256	3,452,003	19.4%	1.1%
90-94	1,058,680	423,553	1,482,233	28.6%	1.9%
95+	211,606	220,917	432,523	51.1%	4.0%
Total	33,287,967	2,957,359	36,245,325	8.2%	0.2%

Note: HIPAA Triggers are 2+ ADL Impariments or Severe Cognitive Impairment

Source: Authors' calculations based on the 2004 NLTCS.

Number and Percent of Persons Meeting Either HIPAA Trigger, United States 2004, Unisex, Age 65 and Above, by Age

	Meets Either HIPAA Trigger				
Age	No	Yes	Total	Percent	Std Error (Pct)
65-69	8,249,343	239,296	8,488,639	2.8%	0.3%
70-74	8,353,574	383,573	8,737,147	4.4%	0.4%
75-79	7,023,298	600,636	7,623,934	7.9%	0.5%
80-84	5,230,199	798,648	6,028,847	13.2%	0.7%
85-89	2,602,925	849,078	3,452,003	24.6%	1.2%
90-94	951,734	530,500	1,482,233	35.8%	2.0%
95+	178,647	253,875	432,523	58.7%	3.9%
Total	32,589,719	3,655,606	36,245,325	10.1%	0.2%

Note: HIPAA Triggers are 2+ ADL Impariments or Severe Cognitive Impairment

Source: Authors' calculations based on the 2004 NLTCS.

Components of Life Expectancy at Age 65, United States 2004, Any HIPAA Disability, by Sex

Item & Sex	HIPAA Trigger*				Total Life Expectancy
	Nondisabled	CI Only	ADL Only	ADL & CI	
Years					
Males	15.41	**0.28**	0.47	0.51	16.67
Females	17.21	**0.41**	0.74	1.14	19.50
Percent					
Males	92.47%	**1.65%**	2.80%	3.08%	100.0%
Females	88.26%	**2.09%**	3.78%	5.87%	100.0%
s.e.(Pct.)					
Males	0.34%	**0.17%**	0.22%	0.23%	
Females	0.41%	**0.21%**	0.26%	0.29%	

*Note: The CI trigger was based on 3+ errors on the SPMSQ.

Source: Authors' calculations based on the 2004 NLTCS.

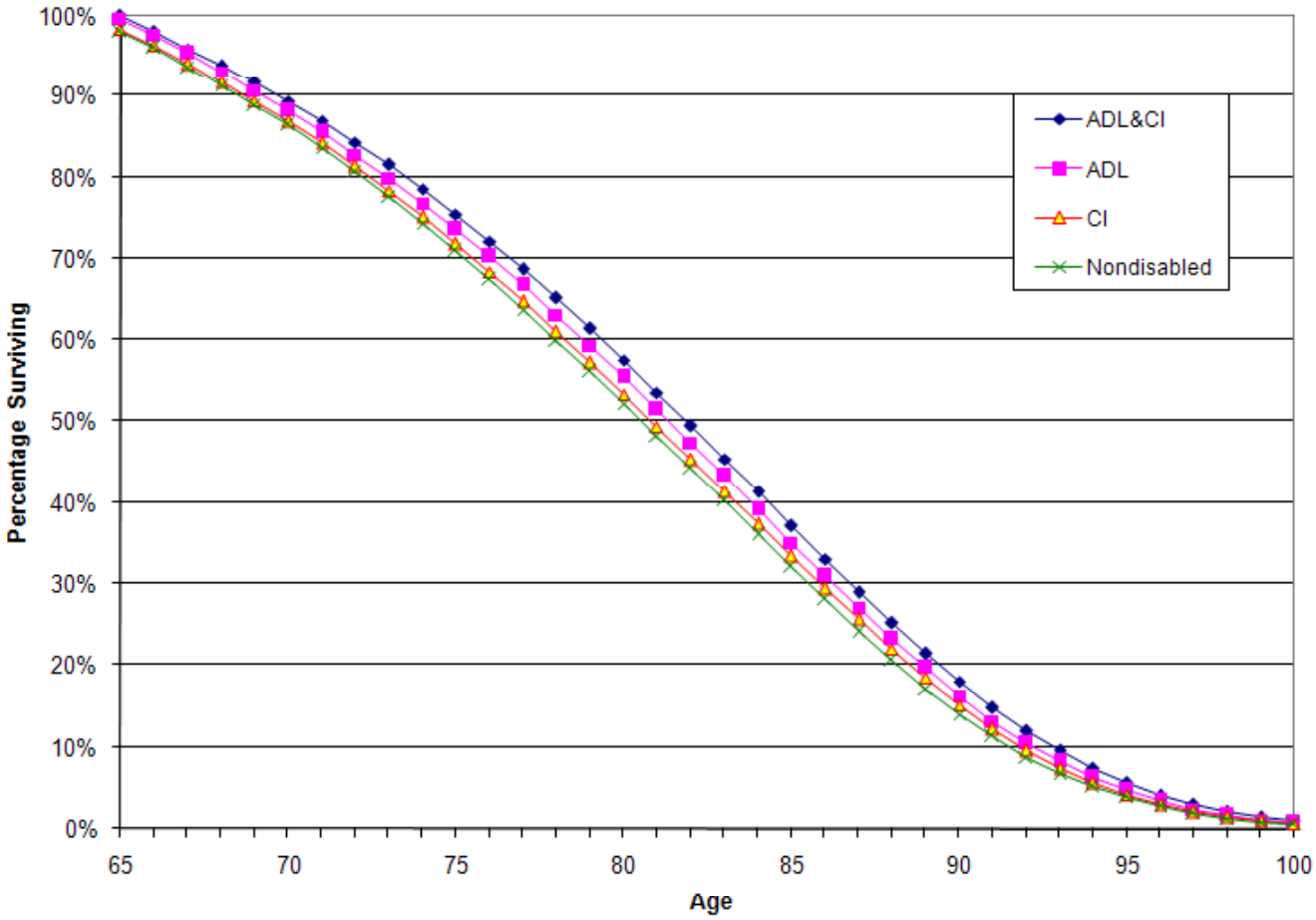
Mean and Standard Deviation of Current Age by HIPAA Disability Status -- Age 65 and Above, United States 2004, by Sex

Item & Sex	HIPAA Trigger*				Total Population
	Nondisabled	ADL Only	CI Only	ADL & CI	
Mean Age					
Males	75.2	79.5	82.5	81.7	75.7
Females	76.3	82.1	84.1	86.0	77.3
Standard Deviation					
Males	6.7	7.7	7.4	7.8	6.9
Females	7.1	8.6	7.9	7.3	7.7

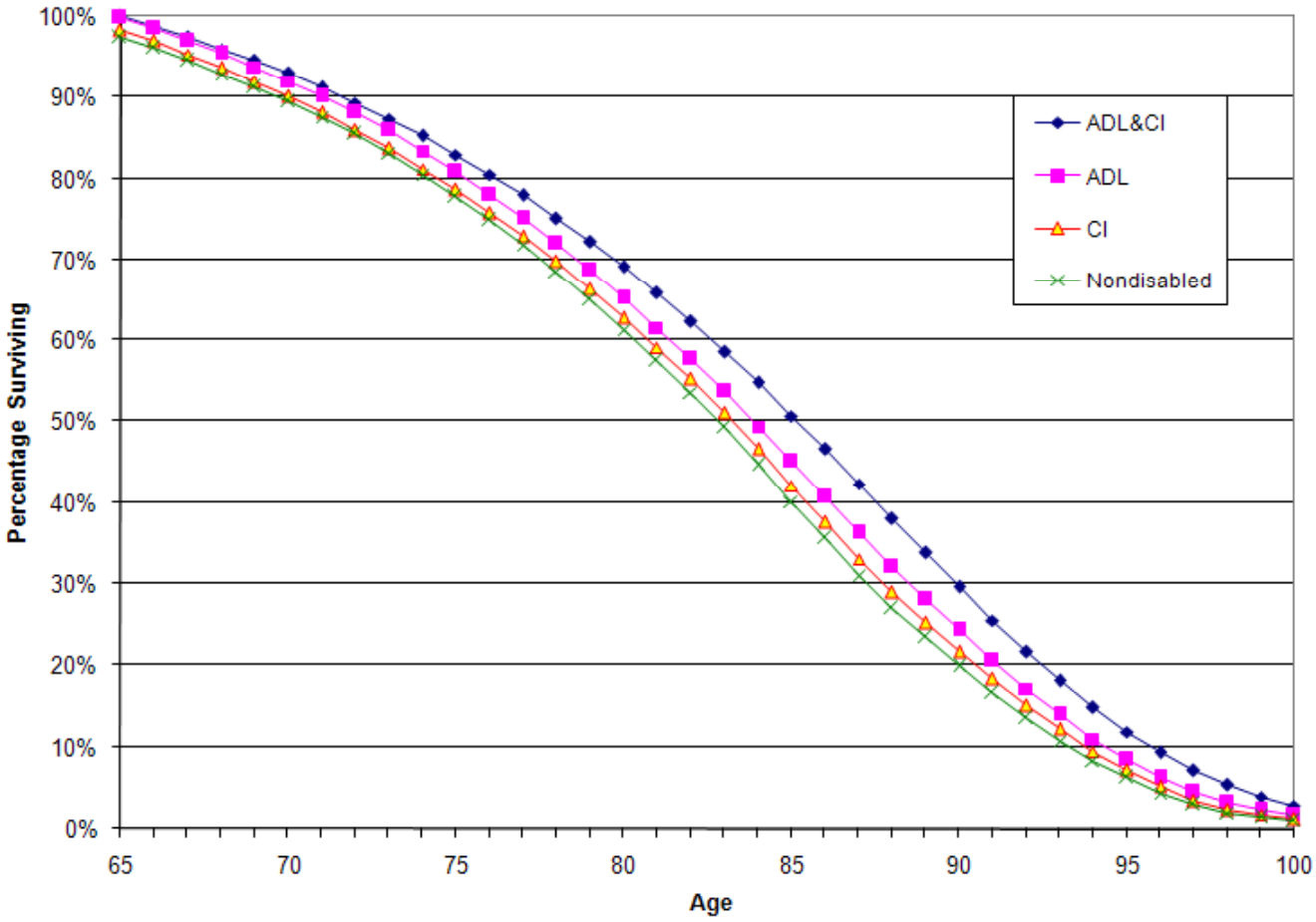
*Note: The CI trigger was based on 3+ errors on the SPMSQ.

Source: Authors' calculations based on the 2004 NLTCS.

Joint Relative Survival at Ages 65+, Meets Any HIPAA Trigger, United States 2004, Males



Joint Relative Survival at Ages 65+, Meets Any HIPAA Trigger, United States 2004, Females

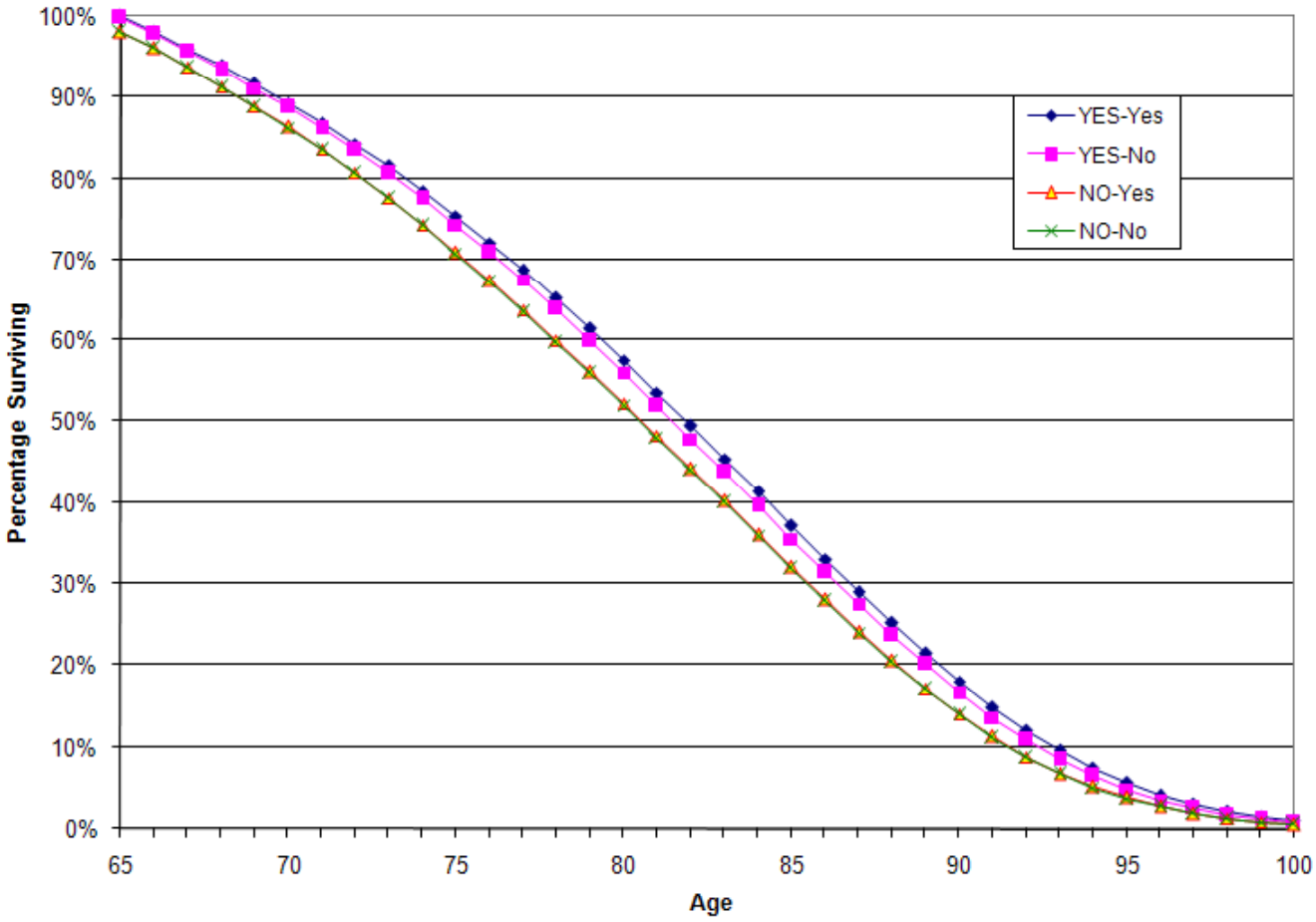


Components of Life Expectancy at Age 65, United States 2004, HIPAA Disability and Institutionalization, by Sex

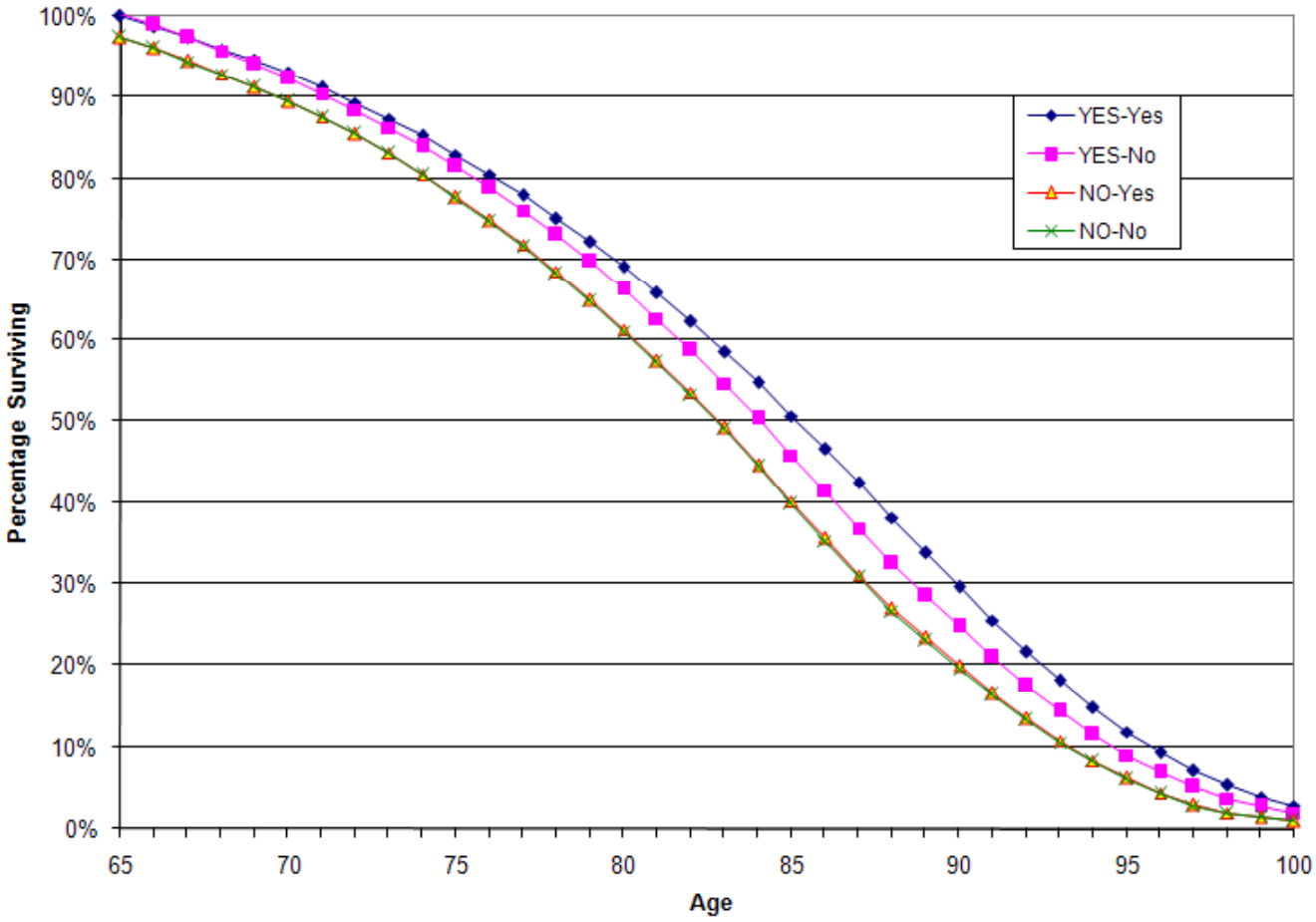
	Meets Either HIPAA Trigger				
	NO Institutionalized		YES Institutionalized		
Item & Sex	No	Yes	No	Yes	Total Life Expectancy
Years					
Males	15.36	0.05	0.89	0.36	16.67
Females	17.14	0.06	1.37	0.92	19.50
Percent					
Males	92.19%	0.28%	5.35%	2.19%	100.0%
Females	87.93%	0.33%	7.02%	4.72%	100.0%
s.e.(Pct.)					
Males	0.35%	0.07%	0.30%	0.19%	
Females	0.42%	0.09%	0.35%	0.26%	

Source: Authors' calculations based on the 2004 NLTCS.

Joint Relative Survival at Ages 65+, Meets Either HIPAA Trigger (YES/NO) and Institutionalization (Yes/No), United States 2004, Males



Joint Relative Survival at Ages 65+, Meets Either HIPAA Trigger (YES/NO) and Institutionalization (Yes/No), United States 2004, Females



Components of Life Expectancy (in Years) at Ages 65 and Above, United States 2004, HIPAA Disability and Institutionalization, by Sex and Age

	Meets Either HIPAA Trigger						
	NO		YES				
	Institutionalized		Institutionalized				
Sex & Age	No	Yes	No	Yes	Total Life Expectancy	Any Yes	Any Yes (%)
Males							
65	15.36	0.05	0.89	0.36	16.67	1.30	7.8%
70	11.96	0.05	0.88	0.38	13.27	1.31	9.9%
75	8.93	0.05	0.86	0.40	10.24	1.31	12.8%
80	6.36	0.04	0.80	0.41	7.62	1.26	16.5%
85	4.22	0.04	0.77	0.41	5.45	1.23	22.5%
90	2.59	0.05	0.70	0.45	3.80	1.21	31.8%
95	1.62	0.03	0.51	0.52	2.68	1.06	39.6%
Females							
65	17.14	0.06	1.37	0.92	19.50	2.35	12.1%
70	13.36	0.07	1.31	0.98	15.72	2.36	15.0%
75	9.89	0.07	1.30	1.04	12.29	2.41	19.6%
80	6.80	0.06	1.24	1.11	9.22	2.41	26.2%
85	4.22	0.07	1.17	1.16	6.62	2.40	36.2%
90	2.45	0.05	1.04	1.06	4.60	2.15	46.7%
95	1.14	0.02	1.07	0.99	3.21	2.07	64.4%

Source: Authors' calculations based on the 2004 NLTCS.

Observations

The HIPAA CI Trigger was a significant component of LTC disability identified by the combined HIPAA Triggers in the 2004 NLTCS.

Analytic Challenge: The 1984 NLTCS Institutional Interviews did not ask about Alzheimer's disease, dementia, or other cognition problems preventing use of the SPMSQ.

Need to assess potential bias using the 2004 NLTCS data for which such information was provided.

Observations

The results presented above indicate that 93.7% of institutionalized persons who were not given the SPMSQ met the HIPAA ADL trigger in 2004.

Only 1.8% met neither HIPAA trigger.

The remaining 4.5% met the HIPAA CI trigger but not the ADL trigger.

This group represented 2.7% of all institutionalized persons and 1.1% of all persons who met either HIPAA trigger.

Ongoing work is using the above results to model the corresponding information in the 1984 NLTCS, allowing changes over time in CI and combined ADL/CI morbidity rates to be quantified.

Table 7. Selected Comparisons of Actual and Expected Health Outcomes for Noninstitutionalized Persons with Self-Reported BMI Obesity, Obesity/Overweight, and Diabetes in the NLTCS; Reweighted to U.S. 2004 Unisex Noninstitutionalized Population, Age 65 and Above

	Self-Reported Medical Condition							
Outcome	Actual (A)	Expected (E)	A/E Ratio	s.e.(A/E)	A − E	Percent of Total[1]	s.e.(Pct. of Total)	Effective N
	Obesity (BMI ≥ 30) at Age 50							
Diabetes	1,393,590	527,724	**2.64**	0.27	865,866	16.41%	2.22%	2,399
HIPAA Disability	381,210	164,023	**2.32**	0.46	217,187	12.03%	3.63%	2,399
Death	141,157	121,630	**1.16**	0.37	19,527	1.65%	3.63%	2,399
	Obesity (BMI ≥ 30) One Year Prior							
Diabetes	2,119,959	972,825	**2.18**	0.21	1,147,134	20.69%	2.87%	2,557
HIPAA Disability	425,541	322,883	**1.32**	0.27	102,657	5.00%	3.92%	2,557
Death	166,985	247,448	**0.67**	0.21	-80,463	-6.21%	4.25%	2,557
	Current Obesity (BMI ≥ 30)							
Diabetes	2,165,735	937,273	**2.31**	0.22	1,228,462	21.51%	2.75%	2,607
HIPAA Disability	437,541	307,014	**1.43**	0.28	130,527	6.15%	3.78%	2,607
Death	135,350	237,222	**0.57**	0.20	-101,872	-7.71%	3.84%	2,607

Note 1: The referenced total is the sum of the indicated outcomes for persons with and without the indicated self-reported medical

Source: Authors' calculations based on the 2004 NLTCS.

Table 8. Actual and Expected Numbers Meeting the HIPAA Disability Trigger for Noninstitutionalized Persons with Self-Reported BMI Obesity at Age 50 and/or Self-Reported Current Diabetes in the NLTCS; Reweighted to U.S. 2004 Unisex Noninstitutionalized Population, Age 65 and Above

Self-Reported Medical Condition(s)	Actual (A)	Expected (E)	A/E Ratio	s.e.(A/E)	A − E	Percent of Total[1]	s.e.(Pct. of Total)	Effective N
	Reference Population: Persons without Self-Reported Current Diabetes							
Diabetes	471,898	220,000	**2.14**	0.43	251,899	13.96%	4.32%	2,399
	Reference Population: Persons without Self-Reported Obesity at Age 50							
Obesity at Age 50	381,210	164,023	**2.32**	0.46	217,187	12.03%	3.63%	2,399
	Reference Population: Persons with Neither Self-Reported BMI Obesity at Age 50 nor Self-Reported Current Diabetes							
Diabetes w/o Obesity	302,855	155,393	**1.95**	0.47	147,462			
Obesity w/o Diabetes	212,167	99,025	**2.14**	0.53	113,142			
Obesity & Diabetes	169,043	45,920	**3.68**	1.11	123,123			
Obesity and/or Diabetes	684,065	300,339	**2.28**	0.34	383,727	21.26%	5.07%	2,399

Note 1: The referenced total is the weighted total number of noninstitutionalized persons meeting the HIPAA disability trigger in the NLTCS with known status for both medical conditions.

Source: Authors' calculations based on the 2004 NLTCS.

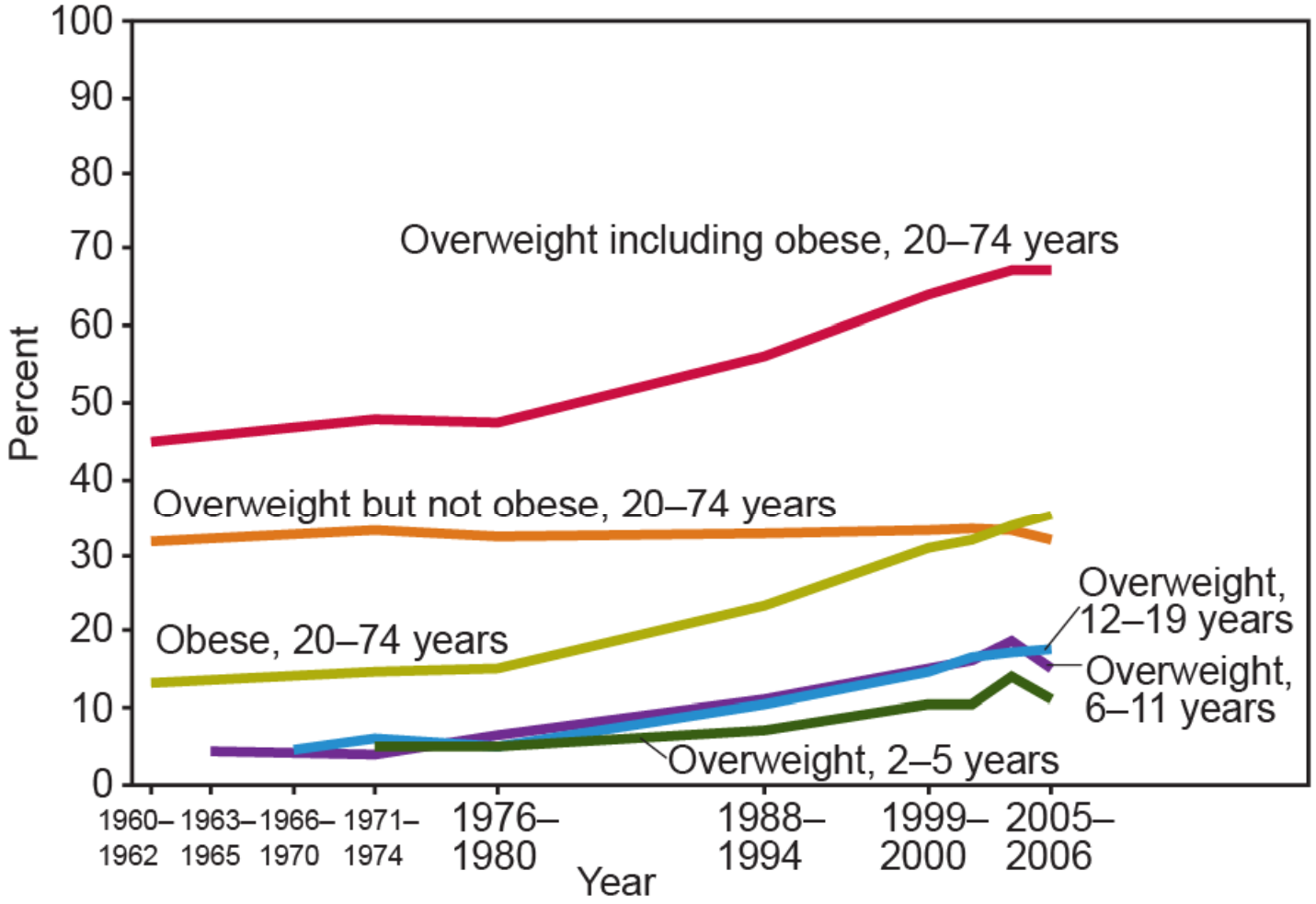
Observations

- Current obesity was associated with large increases in diabetes, non-significant increases in disability, and substantial decreases in mortality among elderly persons.
- Obesity at age 50 was associated with large increases in diabetes and disability, and non-significant increases in mortality among elderly persons.
- Diabetes was associated with large increases in disability (and mortality; not shown) among elderly persons.
- Obesity at age 50 and diabetes were both associated with large increases in disability among elderly persons.

Observations

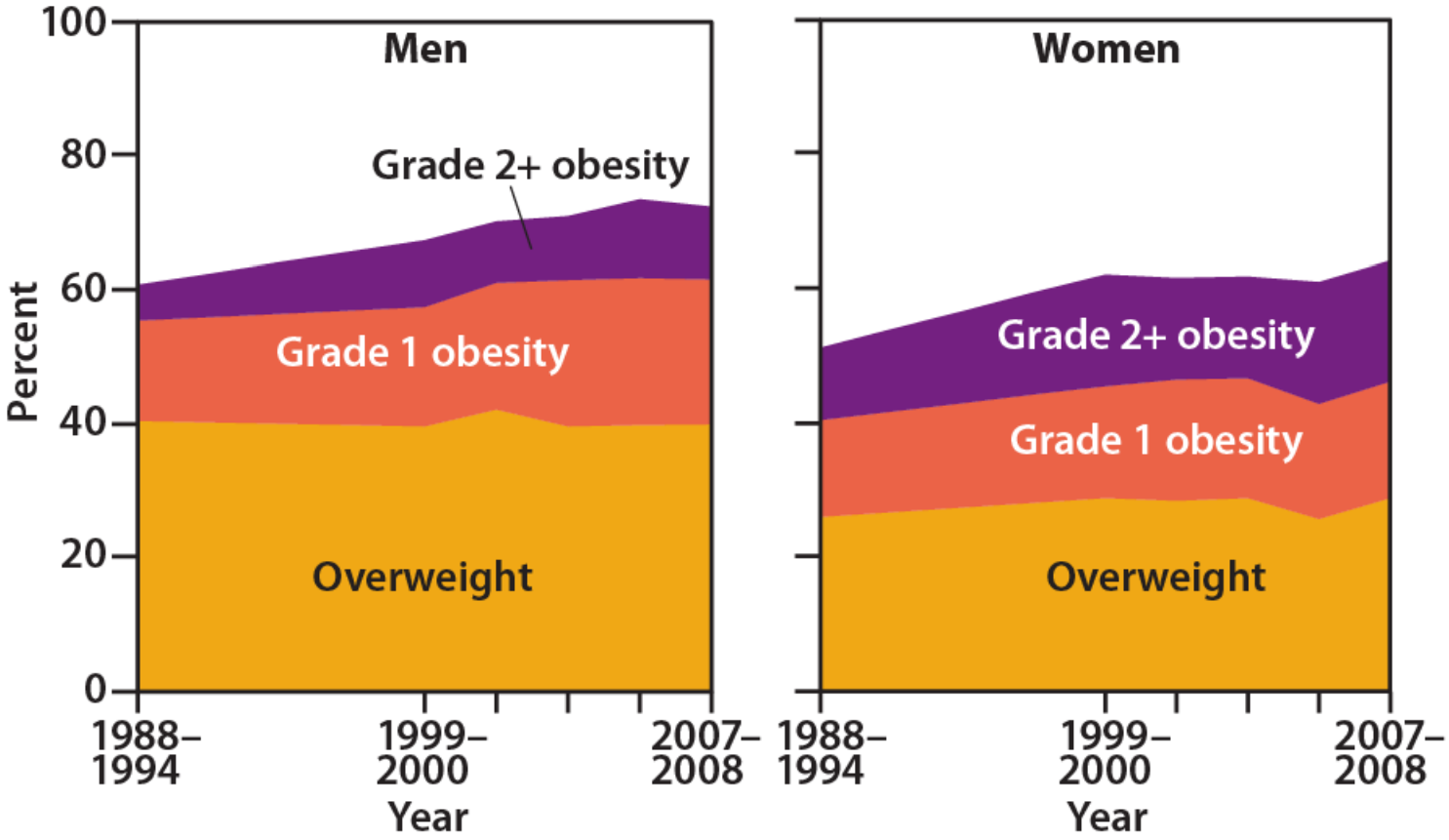
- The 3.68 A/E ratio for the joint conditions was consistent with either an additive or multiplicative interaction model, implying A/E ratios of 3.09 and 4.17, respectively;
- The 3.68 value was close to mid-way (3.63) between these alternatives but the standard errors were too large to make definite conclusions about the form of the interaction.

Overweight and obesity

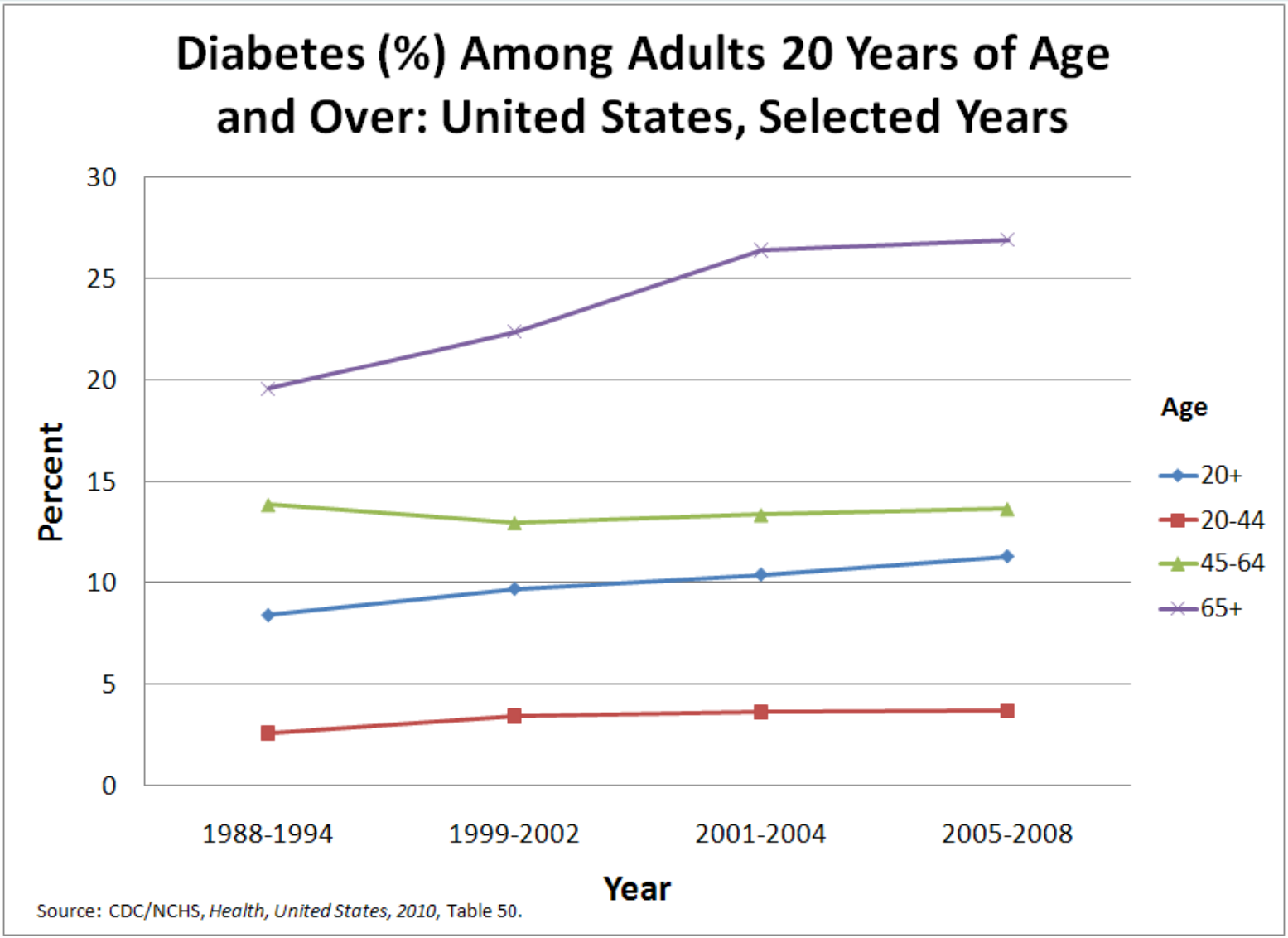


SOURCE: CDC/NCHS, *Health, United States, 2009*, Figure 7. Data from the National Health Examination Survey and the National Health and Nutrition Examination Survey.

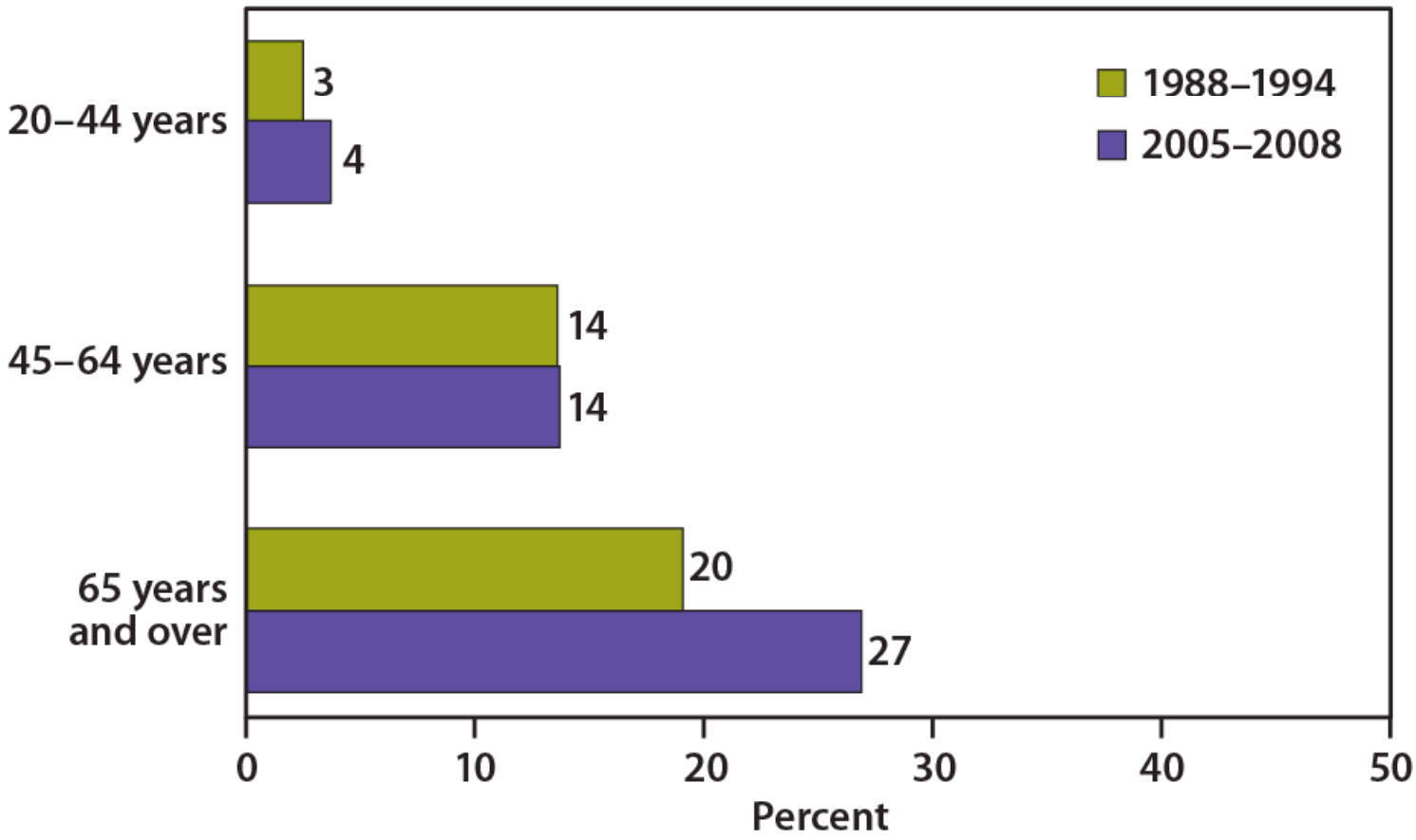
Overweight and obesity among adults 20 years of age and over



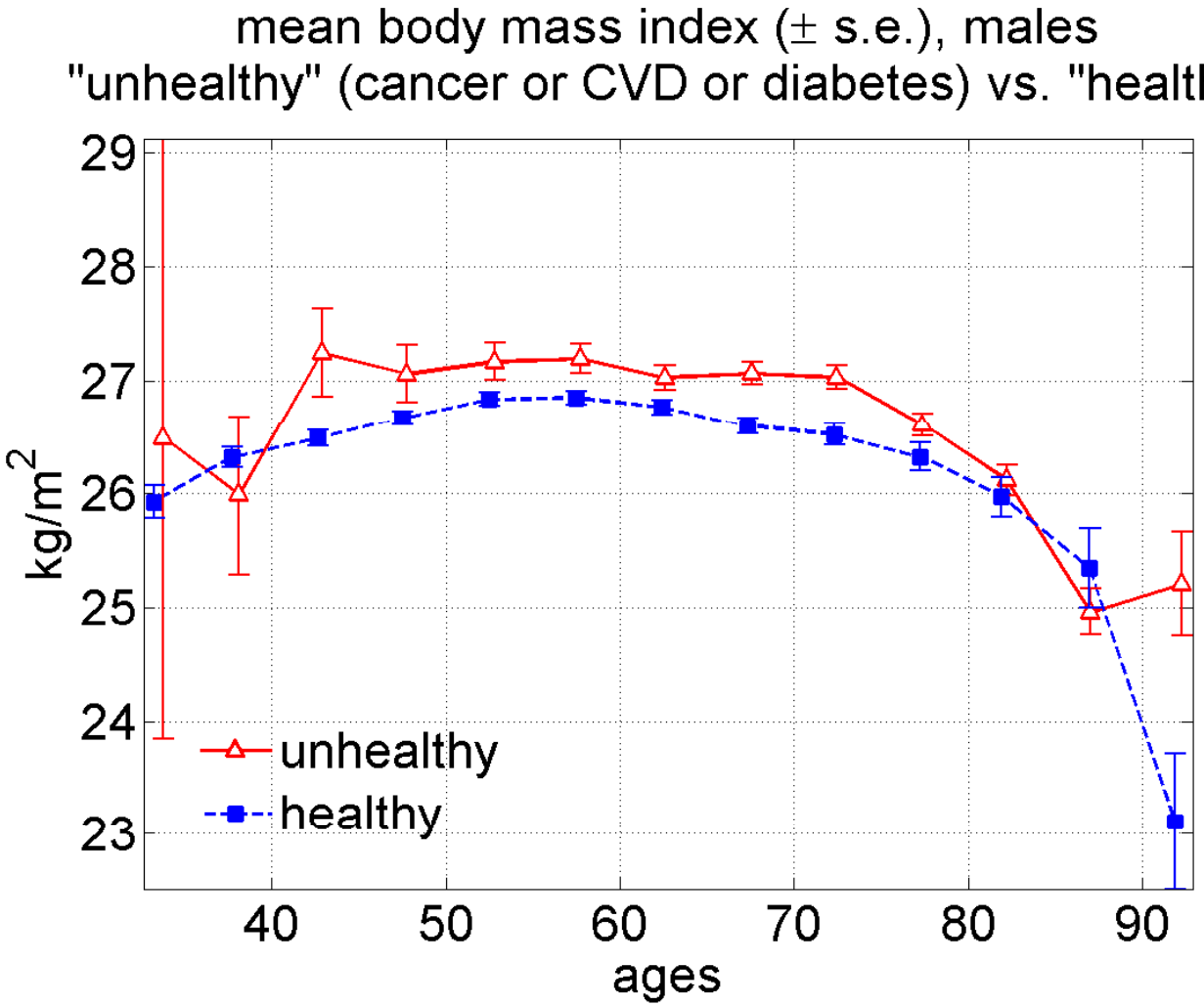
NOTES: Overweight is body mass index (BMI) greater than or equal to 25, but less than 30; grade 1 obesity is BMI greater than or equal to 30 but less than 35; grade 2+ obesity is BMI 35 or greater.
SOURCE: CDC/NCHS, *Health, United States, 2010*, Figure 14. Data from the National Health and Nutrition Examination Survey.


Diabetes (%) Among Adults 20 Years of Age and Over: United States, Selected Years
30
25
20
15
10
5
0
Percent
1988-1994
1999-2002
2001-2004
2005-2008
Year
Age
20+
20-44
45-64
65+
Source: CDC/NCHS, Health, United States, 2010, Table 50.

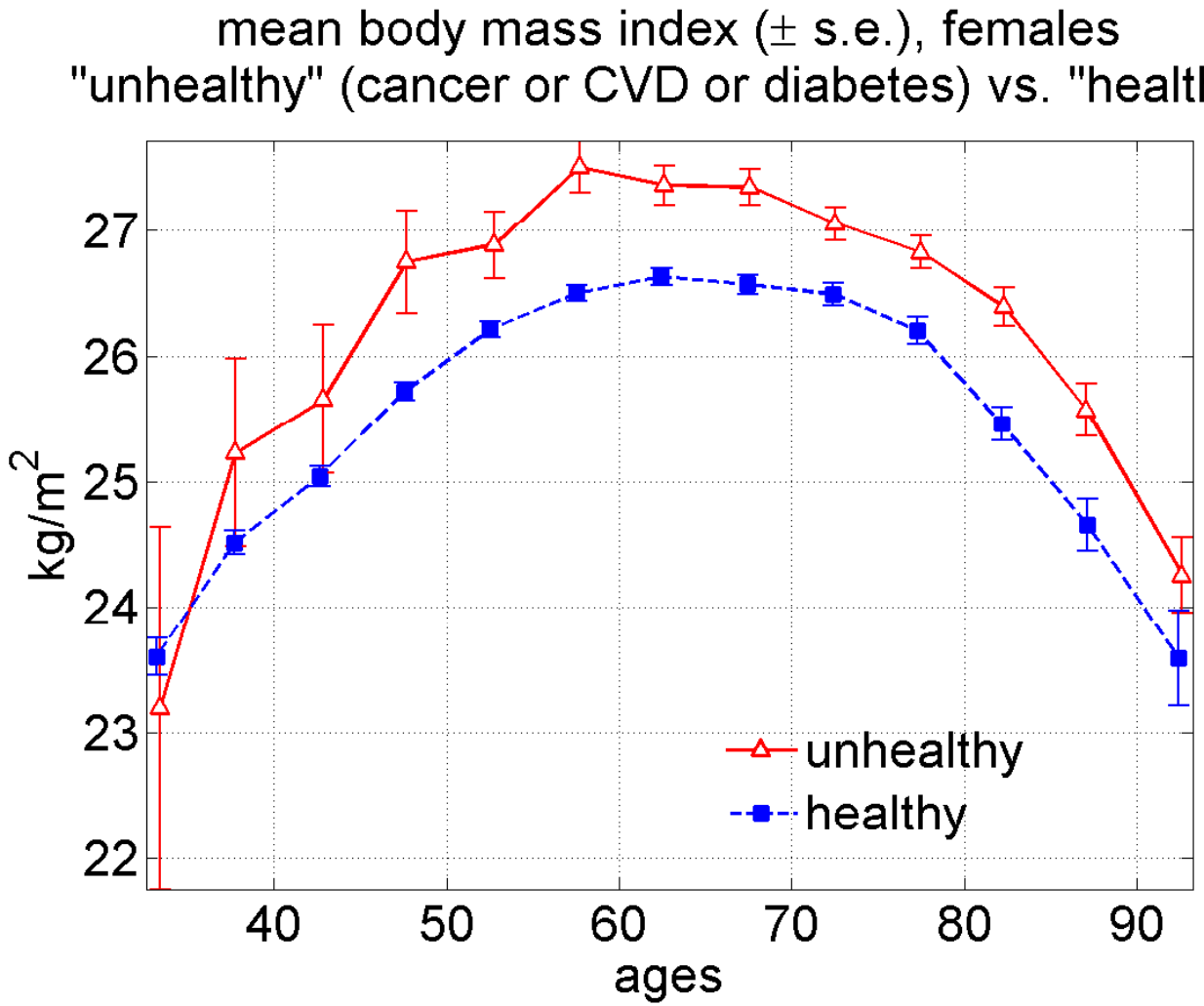
Diabetes prevalence



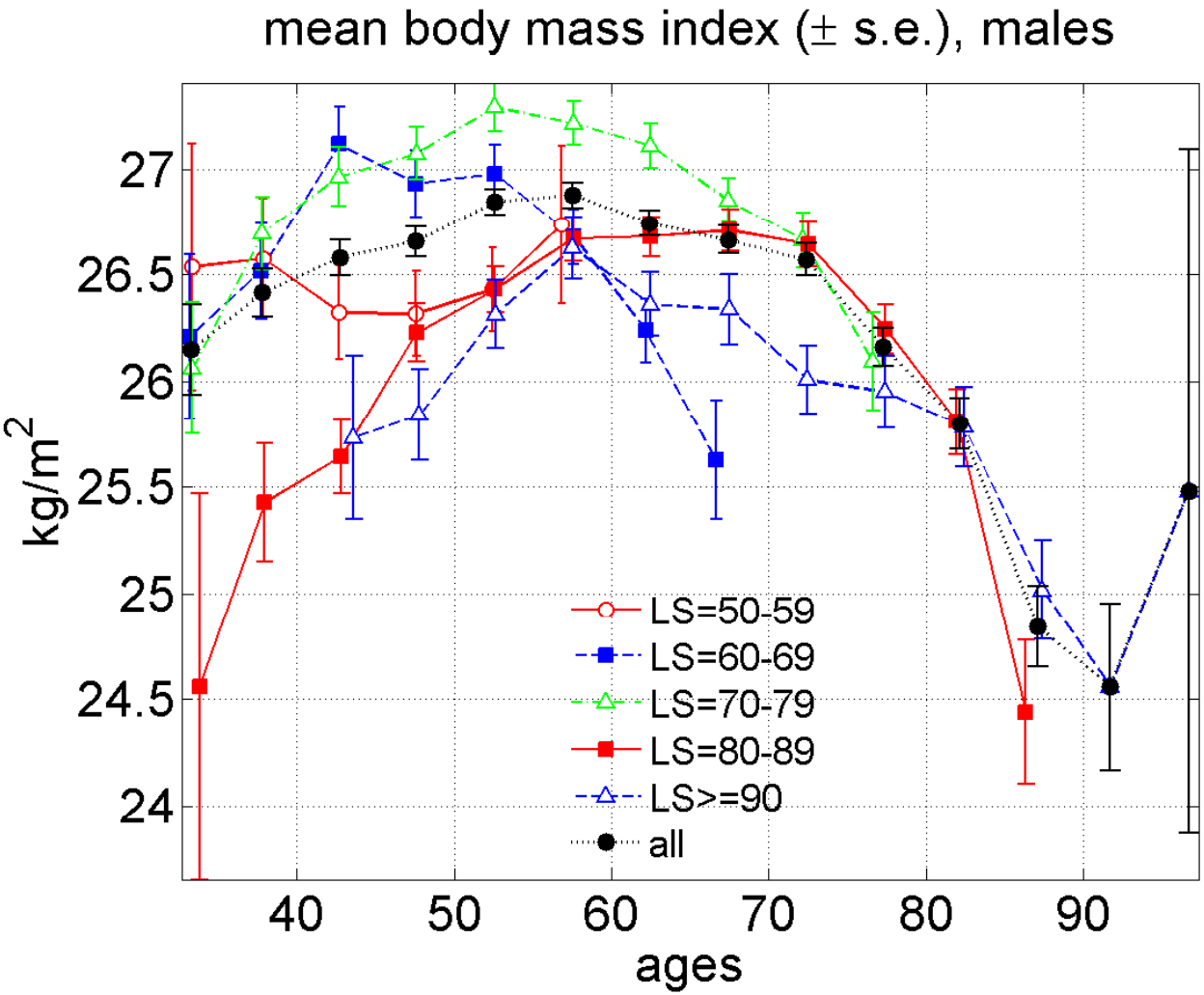
SOURCE: CDC/NCHS, *Health, United States, 2010*, Figure 5. Data from the National Health and Nutrition Examination Survey.



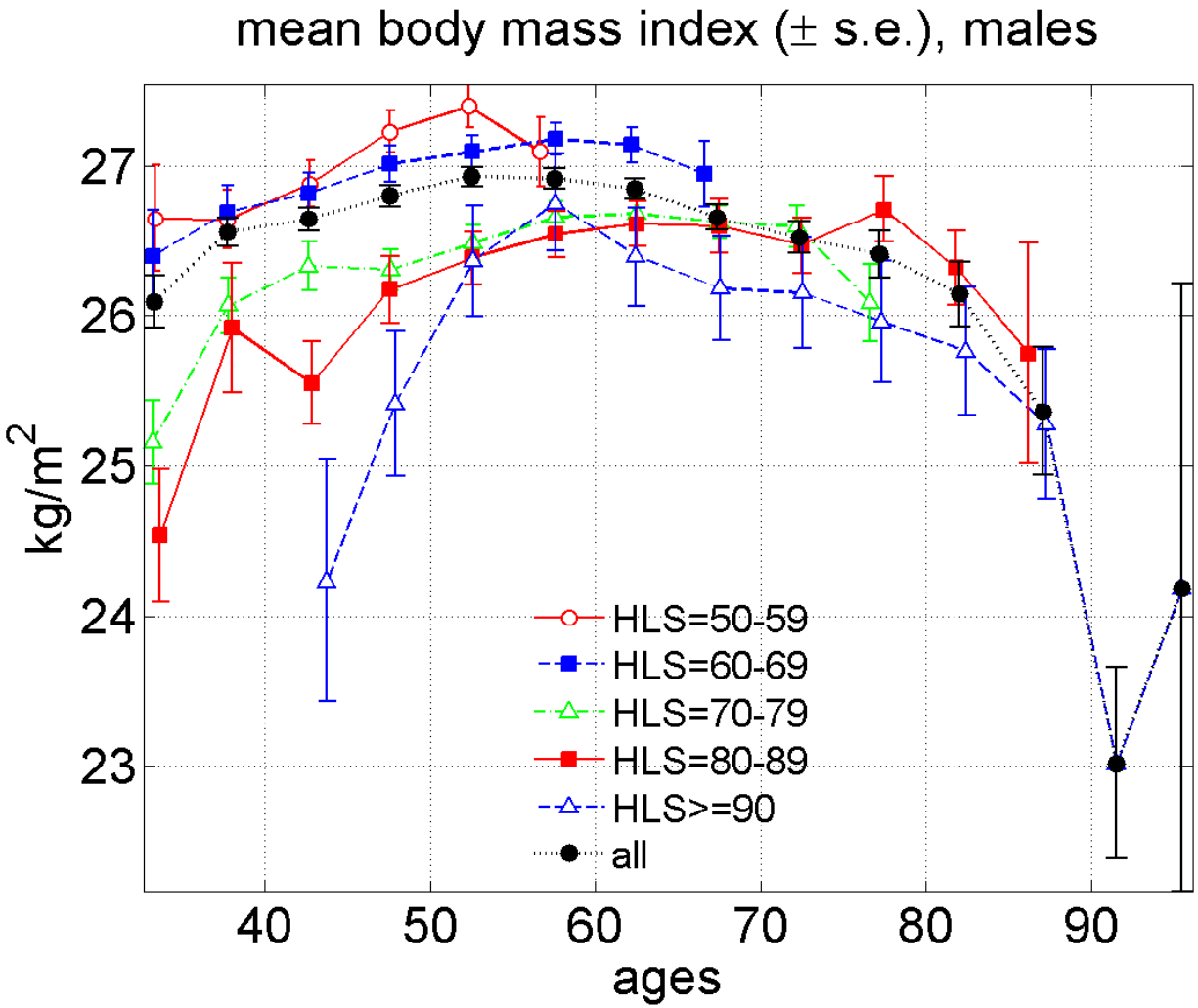
Source: Yashin et al., 2011. Patterns of Aging Related Changes on the Way to 100: An Approach to Studying Aging, Mortality, and Longevity from Longitudinal Data. Presented at the SOA Living to 100 and Beyond Symposium, Orlando, January 6, 2011.



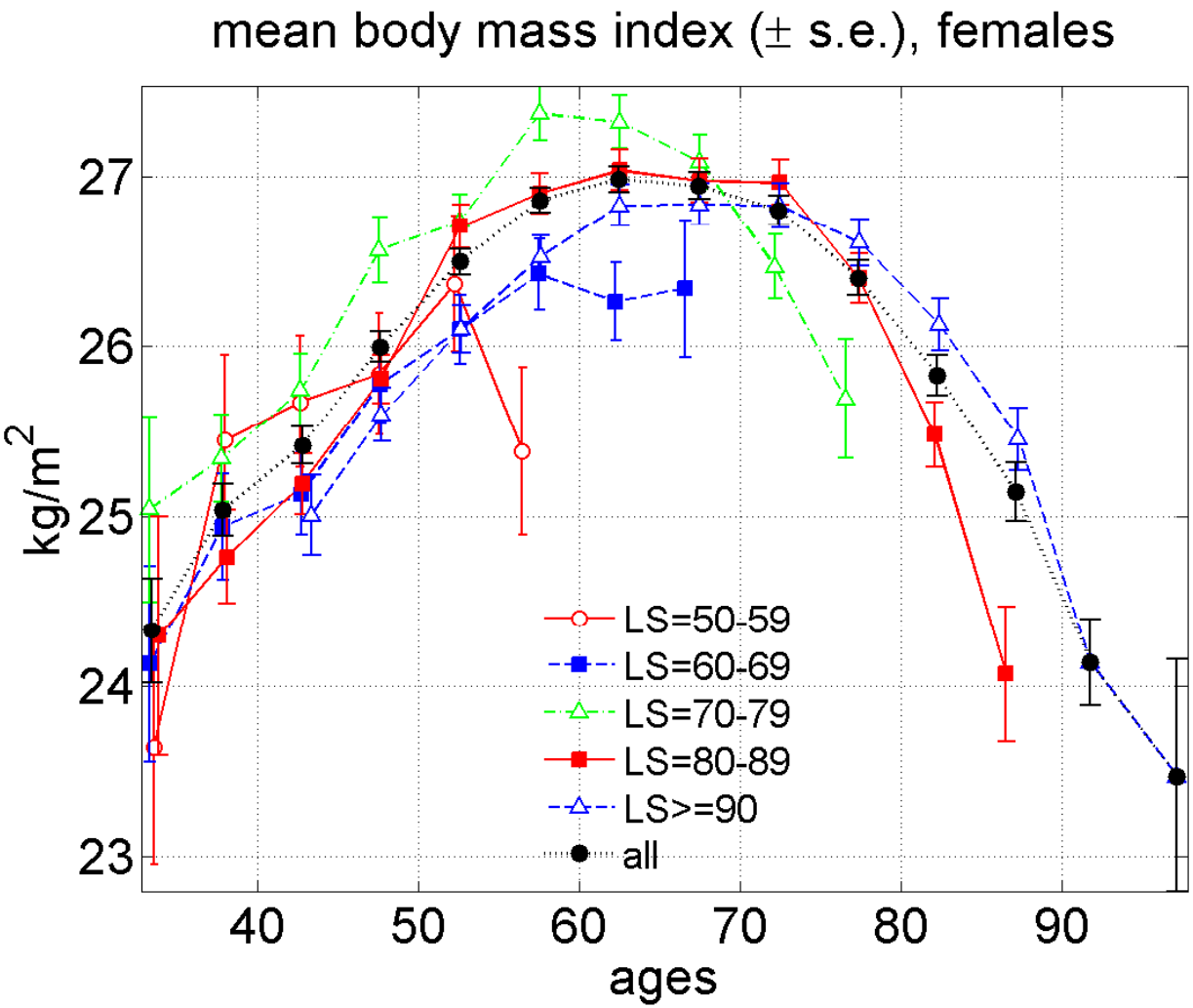
Source: Yashin et al., 2011. Patterns of Aging Related Changes on the Way to 100: An Approach to Studying Aging, Mortality, and Longevity from Longitudinal Data. Presented at the SOA Living to 100 and Beyond Symposium, Orlando, January 6, 2011.



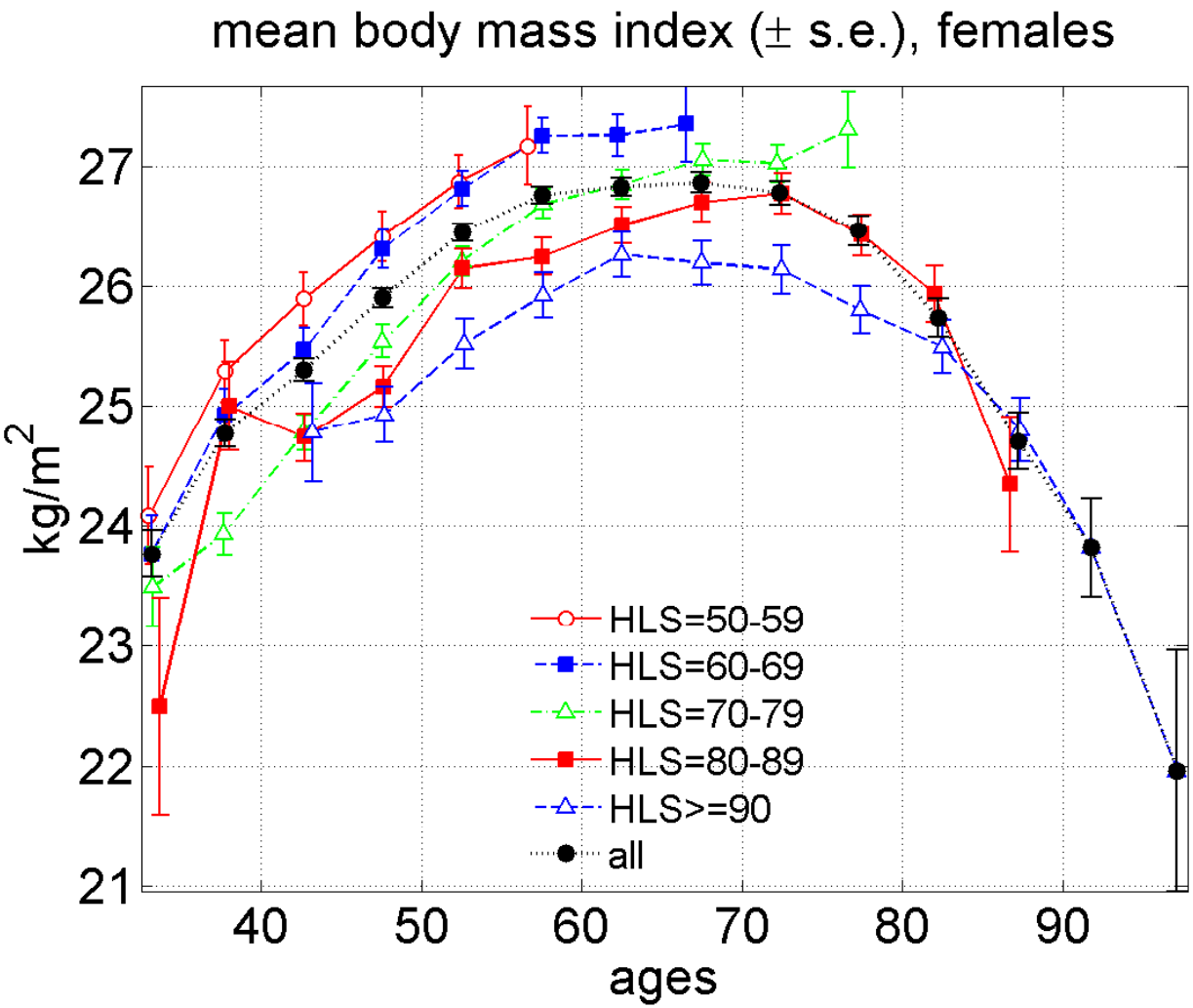
Source: Yashin et al., 2011. Patterns of Aging Related Changes on the Way to 100: An Approach to Studying Aging, Mortality, and Longevity from Longitudinal Data. Presented at the SOA Living to 100 and Beyond Symposium, Orlando, January 6, 2011.



Source: Yashin et al., 2011. Patterns of Aging Related Changes on the Way to 100: An Approach to Studying Aging, Mortality, and Longevity from Longitudinal Data. Presented at the SOA Living to 100 and Beyond Symposium, Orlando, January 6, 2011.



Source: Yashin et al., 2011. Patterns of Aging Related Changes on the Way to 100: An Approach to Studying Aging, Mortality, and Longevity from Longitudinal Data. Presented at the SOA Living to 100 and Beyond Symposium, Orlando, January 6, 2011.



Source: Yashin et al., 2011. Patterns of Aging Related Changes on the Way to 100: An Approach to Studying Aging, Mortality, and Longevity from Longitudinal Data. Presented at the SOA Living to 100 and Beyond Symposium, Orlando, January 6, 2011.

Observations

Temporal Trends (CDC/NCHS)

- Obesity at ages 20-74 years increased from 15% to 35% between 1976-80 and 2005-06.
- Diabetes at ages 65+ increased from 20% to 27% between 1988-94 and 2005-08.

Age Trends (Framingham Heart Study)

- BMI increased over age with peak values near age 60.
- Healthy persons had lower BMI than unhealthy persons at ages 35+; the differentials were greater for females.
- Short-lived persons exhibited early & large declines in BMI, not part of the healthy life span. Low BMI was associated with unhealthy life in short-lived persons.

Observations

NLTCS Findings

- High BMI at age 50 was associated with increased risk of disability among elderly persons.
- High current BMI was not associated with increased risk of disability among elderly persons.

Potential Impact on Underwriting (Aim 4)

- Is the excess near-term mortality associated with high BMI at age 50 sufficient to compensate LTCI carriers for the increased risk of disability 25-30 years later?
- How about for cigarette smoking?

Thank You!

Acknowledgements

This research was funded in part by the National Institute on Aging through Grants R01AG028259, R01AG030612, R01AG032319, and R01AG030198-01A2.

Funding for the NLTCS was provided by the National Institute on Aging, most recently through Grant U01-AG07198.

Appendix: Survey Weights

Survey Weights

Basic definitions:

r_i = probability that person *i* is one of *n* persons selected for a survey in a population (*P*) of size *N*;

$W_i = 1 / r_i$, the inverse of the probability that person *i* is one of *n* persons selected for the survey;

W_i is the "survey weight" for person *i* and r_i is the probability of selection;

e.g., the 1984 and 2004 NLTCS averages of r_i were:

$E_{1984}(r_i) = 21{,}399 / 28{,}034{,}914 = 0.000763298$

$E_{2004}(r_i) = 15{,}993 / 36{,}245{,}325 = 0.000441243$

Survey Weights

Supplementary definitions:

p_i = probability that a randomly selected person in the population is, in fact, person *i*.

= 1/*N*, by convention; which obviously satisfies

$$\sum_{i \in P} p_i = 1.$$

$s \in S$ denotes one of many possible distinct samples.

p_s = probability that a randomly chosen sample is, in fact, *s*; the probabilities must satisfy the condition

$$\sum_{s \in S} p_s = 1.$$

Survey Weights

Now, connect the definitions:

The probability that person *i* is a member of *s* is the sum of p_s over all samples containing person *i.*

Hence,

$$r_i = \sum_{s:\, i \in s} p_s$$

and

$$W_i = 1 / \sum_{s:\, i \in s} p_s$$

Survey Weights

Then, solve for the sum of the survey weights in s:

$$\sum_{i \in s} W_i = \sum_{i \in s} 1 / \sum_{s':\, i \in s'} p_{s'}$$

$$= \sum_{i \in s} \left(1 / \sum_{s':\, i \in s'} p_{s'} \right) \times \left(p_s / p_s \right)$$

$$= \sum_{i \in s} p_{s|i} / p_s, \qquad (p_{s|i} = \text{ cond. prob. of } s \text{ given } i)$$

$$= \sum_{i \in s} p_{i|s} / p_i \qquad (p_{i|s} = \text{ cond. prob. of } i \text{ given } s)$$

$$= N,$$

which is the size of the surveyed population, P.

Survey Weights

(1) Define the unweighted average of the variate X_i associated with person i in the population P, as:

$$\bar{X} = \sum_{i \in P} X_i \, / \, N.$$

(2) Define the survey-weighted average of the variate X_i associated with person i in sample s, as:

$$\bar{X}_s = \sum_{i \in s} W_i \times X_i \, / \sum_{i \in s} W_i$$

$$= \sum_{i \in s} p_{i|s} \times X_i .$$

Survey Weights

The expected value of $\bar{X}_s$ is $\bar{X}$, as seen below:

$$
\begin{aligned}
\mathrm{E}(\bar{X}_s) &= \sum_{s \in S} p_s \times \sum_{i \in s} p_{i|s} \times X_i \\
&= \sum_{i \in P} p_i \times \sum_{s:\, i \in s} p_{s|i} \times X_i \\
&= \sum_{i \in P} p_i \times X_i \\
&= \sum_{i \in P} X_i \,/\, N \\
&= \bar{X},
\end{aligned}
$$

proving that $\bar{X}_s$ is an unbiased estimator of $\bar{X}$.

Survey Weights

Multiplication of the survey weights by an arbitrary constant, c_s, leaves $\bar{X}_s$ unaltered:

$$\begin{aligned}\bar{X}_s &= \sum_{i \in s} W_i \times X_i / \sum_{i \in s} W_i \\ &= \sum_{i \in s} c_s \times W_i \times X_i / \sum_{i \in s} c_s \times W_i \\ &= \sum_{i \in s} w_{is} \times X_i / \sum_{i \in s} w_{is}.\end{aligned}$$

Standard assumptions:

$c_s = 1$, for which: $\sum_{i \in s} w_{is} = N$

$c_s = n / N$, for which: $\sum_{i \in s} w_{is} = n$.

Survey Weights

Potthoff et al.'s (1992) alternative assumption:

$$c_s = \sum_{i \in s} W_i \; / \sum_{i \in s} W_i^2$$
$$= N / \sum_{i \in s} W_i^2 .$$

Potthoff's re-weighting formula:

$$w_{is} = W_i \times c_s$$
$$= W_i \times \sum_{i' \in s} W_{i'} / \sum_{i' \in s} W_{i'}^2 .$$

Potthoff, R.F., Woodbury, M.A. and Manton, K.G. "Equivalent sample size" and "equivalent degrees of freedom" refinements for inference using survey weights under superpopulation models. *Journal of the American Statistical Association*, 87(418):383–396, 1992.

Survey Weights

Define the "equivalent" or "effective" sample size:

$$\hat{n}_s = \sum_{i \in s} w_{is} = \sum_{i \in s} w_{is}^2 \qquad \text{(since } w_{is} = W_i \times c_s \text{)}$$

$$= n \times \bar{w}_s \qquad \text{(using } \bar{w}_s = \sum_{i \in s} w_{is} / n \text{)}$$

$$= n \times \bar{w}_s^2 + \sum_{i \in s} (w_{is} - \bar{w}_s)^2$$

$$= n \times \left(1 - \sum_{i \in s} (w_{is} - \bar{w}_s)^2 / \sum_{i \in s} w_{is}^2 \right)$$

$$\leq n,$$

with equality only when the survey weights, W_i *or* w_{is}, are equal for all i in sample s.

Survey Weights

Potthoff demonstrated the superiority of $\hat{n}_s$ over n as the "sample size" parameter for a statistically homogeneous population with independent observations.

For example, for an unbiased survey-weighted estimator of a binomial proportion, assuming X_i is 0–1,

$$\hat{q}_s = \sum_{i \in s} w_{is} \times X_i \,/\, \hat{n}_s \ ,$$

an unbiased estimator of the variance is given by:

$$\widehat{\mathrm{var}}(\hat{q}_s) = \hat{q}_s \times (1 - \hat{q}_s) \,/\, (\hat{n}_s - 1).$$

Survey Weights

The ratio $n / \hat{n}_s$ is called the "design effect."

It approximates the relative increase in the variance attributable to differentials in the sampling probabilities, r_i.

The use of n in variance formulas for survey-weighted estimators yields downwardly biased standard errors.

The use of N in such formulas has no justification.