Update on the LTC Morbidity Improvement Study*

By Eric Stallard

Actuaries have long recognized that improvements in LTC morbidity combined with declines in mortality rates can have profound consequences for lifetime disability and LTC/LTCI costs. The *LTC Morbidity Improvement Study* was undertaken to evaluate changes over time in morbidity/disability associated with activities of daily living (ADL) and cognitive impairment (CI), and their impact on lifetime morbidity/disability using data for aged Medicare enrollees from the 1984 and 2004 National Long-term Care Survey (NLTCS).

This article summarizes the presentation of the study made at the 2014 *ILTCI Conference* held on March 16–19, 2014 in Orlando, Fla.[1] For more than two decades, the NLTCS has served as the main actuarial resource for information on LTC morbidity/disability and mortality rates among the non-insured general population aged 65 years and older. The bottom line was that there were large declines in ADL and CI disability during 1984–2004, both separately and combined, based on the HIPAA ADL and CI triggers; moreover the declines for the CI trigger were substantially larger than for the ADL trigger. These changes are readily apparent in Figure 1 which displays the age-specific prevalence rates for 1984 and 2004 for the ADL and CI triggers separately (Fig. 1A and Fig. 1B) and combined (Fig. 1C).

Also shown at each plot is the best-fitting exponential function. These functions show that the age-specific prevalence rates were approximately exponential in form, especially the 2004 rates. The main deviations from the exponentials occurred at the highest age, 95+, where the relative rates of increase slowed down compared to the increases at younger ages.

The prevalence rates were defined as the fraction of each respective population who on any given day in 1984 or 2004 would be deemed to have met the HIPAA ADL and/or CI triggering criteria. Actuarial theory indicates that the prevalence rates are determined by the incidence and continuance rates in effect at the indicated time period but they are conceptually and numerically distinct from the incidence rates. Importantly for our study, the prevalence rates are easier than the incidence rates to estimate from survey data such as the NLTCS and can be estimated with much greater precision.

Indeed, precise estimation of changes over time in ADL and CI morbidity/disability rates was the major goal of the study. The sample sizes were 21,399

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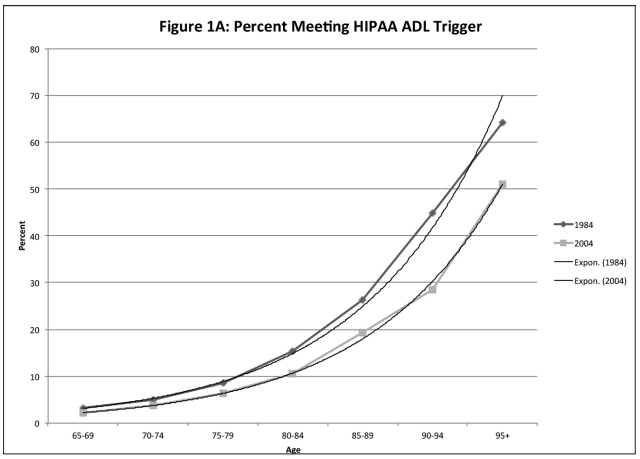
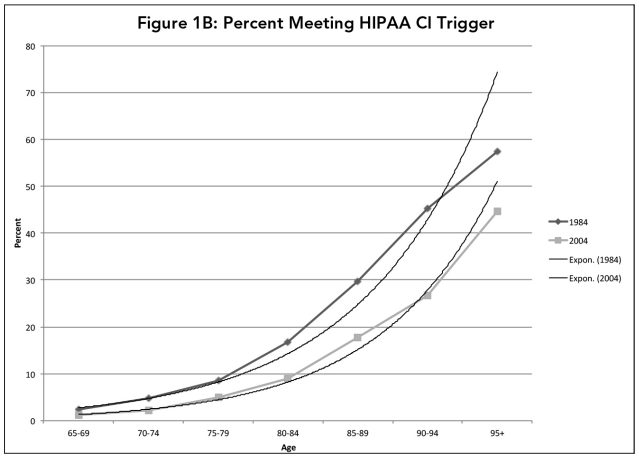
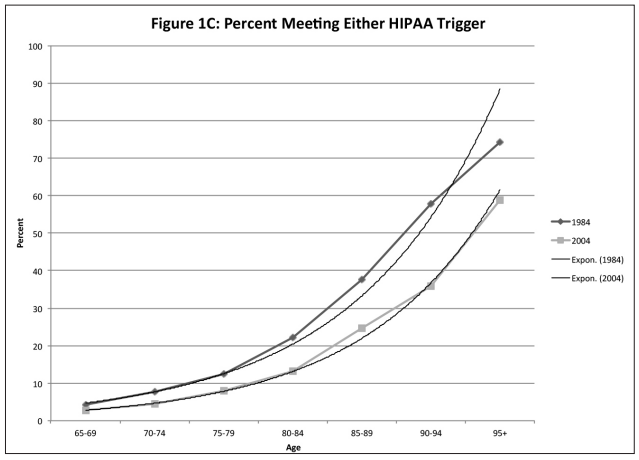
Figure 1 – Percent of Population Meeting HIPAA ADL, CI, and Combined ADL/CI Triggers, United States 1984 and 2004, Unisex, Age 65 and Above, by Age







in 1984 and 15,993 in 2004; individual survey participants were differentially weighted to account for differences in the individual probabilities of selection into the NLTCS sample. The sensitivities of the estimates to alternative weighting protocols were also assessed as part of the study.

MORBIDITY IMPROVEMENT

The source data for Figs. 1A, 1B, and 1C are shown in Tables 1–3, respectively, along with age-specific measures of change, summary measures of disability and change in disability, standard errors of the summary measures, and the associated t-statistics.

The primary measures of change were the reductions in the age-standardized disability rates based on the 2004 NLTCS weighted unisex population—indicated by the row labels: 2004 ASDR. For the ADL trigger, Table 1 shows that the prevalence rate reduction was 3.26 percent, from 11.42 percent in 1984 to 8.16 percent in 2004, a relative decline of 28.5 percent, and an average annual rate of decline of 1.67 percent per year. The standard error of the change was 0.33 percent and the associated *t*-statistic was 9.85 (absolute value), which was highly statistically significant ($p << 0.001$); the *t*-statistic was in the range 8.225–16.45, indicating "high precision" of the associated estimate, but the t-statistic was not large enough to meet the more stringent cutpoint of $t > 32.90$ associated with the Longley-Cook standard for "full credibility." The separately estimated disability rates for 1984 and 2004 did meet the Longley-Cook standard.

The commonly used cutpoint of $t > 1.96$ for testing the statistical significance of an estimated change—achieved when the 95 percent-confidence interval excludes the 0-value—yields change estimates with very low precision when, as often occurs in published studies, the associated *t*-statistics are in the range 1.960–3.291, or equivalently $0.001 \leq p < 0.050$. Moreover, assessing the precision of the estimates requires the t-statistics to be reported, which is often not done.

The relative change in the 2004 ASDR provides a reasonable summarization of the relative changes in the age-specific disability rates; an alternative summarization is provided by the relative change in the 1984 ASDR which is slightly smaller: 28.3 percent vs. 28.5 percent. Thus, the ASDR changes are mildly dependent on the choice of the standard population. In contrast, the change in the overall totals without standardization avoids this mild dependency but provides a highly biased estimate of the relative change in the age-specific disability rates: 11.5 percent vs. 28.5 percent.

The corresponding calculations for the CI trigger (Table 2) showed that the prevalence rate reduction was 4.96 percent (2004 ASDR), from 11.65

percent in 1984 to 6.69 percent in 2004, a relative decline of 42.6 percent, and an average annual rate of decline of 2.74 percent per year. The standard error of the change was 0.32 percent and the associated *t*-statistic was 15.53, which was also highly statistically significant ($p << 0.001$); the *t*-statistic indicated that the associated estimate also had high precision.

The corresponding calculations for the combined ADL and CI triggers (Table 3) showed that the prevalence rate reduction was 5.94 percent (2004 ASDR), from 16.03 percent in 1984 to 10.09 percent in 2004, a relative decline of 37.1 percent, and an average annual rate of decline of 2.29 percent per year. The standard error of the change was 0.37 percent and the associated t-statistic was 16.27, which was also highly statistically significant ($p << 0.001$); the *t*-statistic indicated that the associated estimate also had high precision.

SENSITIVITY ANALYSIS

The sensitivities of the estimates to three alternative weighting protocols are shown in Figure 2. The first (Duke/PNAS Weights; Fig. 2A) was the protocol used in generating Figure 1 and Tables 1–3; this protocol was developed at Duke University by Kenneth Manton, the principal investigator of the NLTCS. The second (Unadjusted Cox Weights; Fig. 2B) was generated using an alternative set of weights developed at Battelle, Inc., by Brenda Cox and colleagues. The third (Adjusted Cox Weights; Fig. 2C) reflects our reconciliation of differences between the first and second protocols. The plots show that the use of the Cox weights primarily impacted the 2004 disability rates, modestly reducing the rate of morbidity improvement.

The differences between the three weighting protocols are shown in Table 4. The annual rate of decline of 2.29 percent under the Duke/PNAS weights declined to 2.01 percent under the adjusted Cox weights and 1.88 percent under the unadjusted Cox weights. The associated *t*-statistic of 16.27 under the Duke/PNAS weights declined to 14.54 under the adjusted Cox weights and 13.71 under the unadjusted Cox weights. All three weighting protocols indicated that the rates of decline were highly statistically significant and the rate estimates had high statistical precision.

The *t*-statistics in the rightmost two columns indicated that the adjusted Cox estimate was just outside the 95 percent-confidence interval for the Duke/PNAS ($t = 1.97$ vs. the 1.96 cutpoint) whereas the unadjusted Cox estimate was substantially further away ($t = 2.88$). Thus, the sensitivity analysis answered the question of whether the estimated

Table 1

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

	1984	2004	Change	% Change	Annual Rate of Decline; 20 yr.
65-69	3.27	2.20	-1.07	-32.8	1.97%
70-74	5.04	3.81	-1.22	-24.3	1.38%
75-79	8.55	6.35	-2.20	-25.7	1.47%
80-84	15.27	10.61	-4.66	-30.5	1.80%
85-89	26.22	19.39	-6.83	-26.1	1.50%
90-94	44.92	28.58	-16.34	-36.4	2.24%
95+	64.18	51.08	-13.10	-20.4	1.13%
Total	9.22	8.16	-1.06	-11.5	0.61%
1984 ASDR	9.22	6.61	-2.61	-28.3	1.65%
2004 ASDR	11.42	8.16	-3.26	-28.5	1.67%
		Standard Error			
Total	0.20	0.23	0.30		
1984 ASDR	0.20	0.19	0.28		
2004 ASDR	0.24	0.23	0.33		
		t-statistic			
Total	46.31	36.20	-3.52		
1984 ASDR	46.31	33.94	0.00		
2004 ASDR	47.13	36.20	-9.85		

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

Source: Author's calculations based on the 1984 and 2004 NLTCS; see Table 1.8 in the Final Report.

Table 2

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

	1984	2004	Change	% Change	Annual Rate of Decline; 20 yr.
65-69	2.31	1.22	-1.09	-47.1	3.13%
70-74	4.78	2.26	-2.52	-52.7	3.67%
75-79	8.60	4.93	-3.67	-42.6	2.74%
80-84	16.77	9.07	-7.70	-45.9	3.03%
85-89	29.70	17.70	-12.00	-40.4	2.55%
90-94	45.16	26.69	-18.48	-40.9	2.60%
95+	57.48	44.67	-12.81	-22.3	1.25%
Total	9.24	6.69	-2.56	-27.7	1.61%
1984 ASDR	9.24	5.21	-4.03	-43.6	2.82%
2004 ASDR	11.65	6.69	-4.96	-42.6	2.74%
		Standard Error			
Total	0.20	0.21	0.28		
1984 ASDR	0.20	0.17	0.26		
2004 ASDR	0.25	0.21	0.32		
		t-statistic			
Total	46.75	32.62	-8.98		
1984 ASDR	46.75	30.79	-15.49		
2004 ASDR	47.52	32.62	-15.53		

NOTE: ASDR denotes age-standardized disability rate; the 1984 ASDR and 2004 ASDR results were age-standardized, respectively, to the 1984 and 2004 NLTCS weighted unisex population. The CI trigger used 3+ errors on the Short Portable Mental Status Questionnaire (SPMSQ).

Source: Author's calculations based on the 1984 and 2004 NLTCS; see Table 2.16 in the Final Report.

Table 3

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

	1984	2004	Change	% Change	Annual Rate of Decline; 20 yr.
65-69	4.30	2.82	-1.48	-34.4	2.09%
70-74	7.70	4.39	-3.31	-43.0	2.77%
75-79	12.47	7.88	-4.59	-36.8	2.27%
80-84	22.29	13.25	-9.04	-40.6	2.57%
85-89	37.66	24.60	-13.06	-34.7	2.11%
90-94	57.86	35.79	-22.07	-38.1	2.37%
95+	74.15	58.70	-15.45	-20.8	1.16%
Total	13.05	10.09	-2.96	-22.7	1.28%
1984 ASDR	13.05	8.16	-4.89	-37.5	2.32%
2004 ASDR	16.03	10.09	-5.94	-37.1	2.29%
		Standard Error			
Total	0.23	0.25	0.33		
1984 ASDR	0.23	0.21	0.31		
2004 ASDR	0.27	0.25	0.37		
		t-statistic			
Total	57.26	41.15	-8.85		
1984 ASDR	57.26	38.31	-15.68		
2004 ASDR	59.14	41.15	-16.27		

NOTE: ASDR denotes age-standardized disability rate; the 1984 ASDR and 2004 ASDR results were age-standardized, respectively, to the 1984 and 2004 NLTCS weighted unisex population. The HIPAA triggers are based on 2+ ADL Impariments or 3+ errors on the SPMSQ.

Source: Author's calculations based on the 1984 and 2004 NLTCS; see Table 2.21 in the Final Report.

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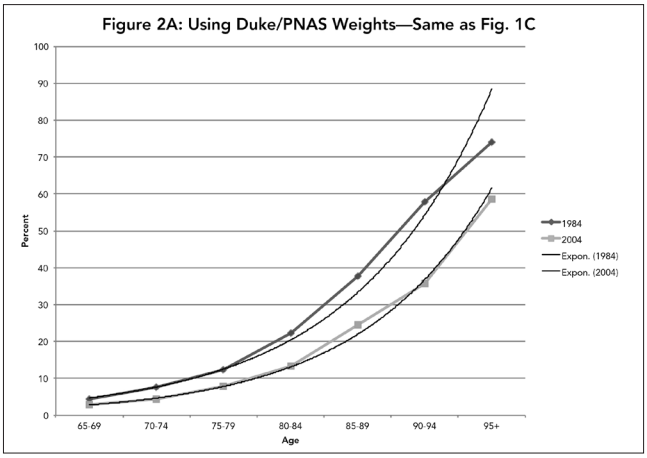
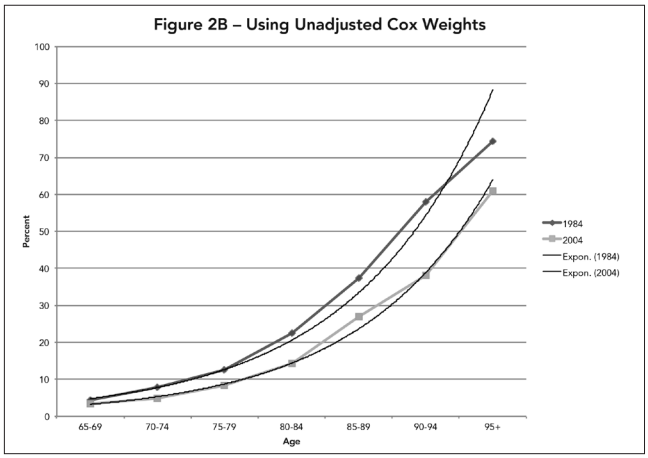
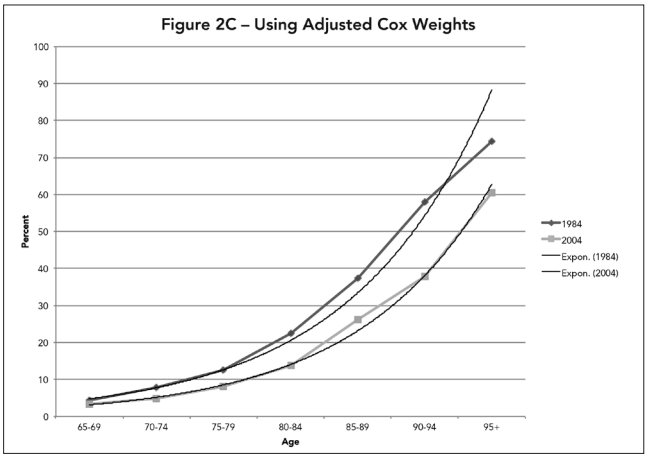
Figure 2 – Alternative Estimates of the Percent of Population Meeting the HIPAA Combined ADL/CI Triggers, United States 1984 and 2004, Unisex, Age 65 and Above, by Age







large declines in ADL and CI disability during 1984–2004 were robust with respect to reasonable alternative survey weighting protocols: they were. The sensitivity analysis also showed that the adjusted Cox protocol produced estimates near to or within the 95 percent-confidence intervals for the corresponding Duke/PNAS estimates, indicating that our reconciliation of the differences between the Duke/PNAS and the Cox protocols was successful.

COMPRESSION OF MORBIDITY

Morbidity improvement is a necessary but not sufficient condition for the reduction in lifetime morbidity—termed the compression of morbidity by James Fries in his classic 1980 article "Aging, natural death, and the compression of morbidity" in the *New England Journal of Medicine*—under current conditions of continual mortality improvement. The main concern is that increasing numbers of persons will survive to advanced ages where the prevalence of morbidity is much higher and the potential exists for increased lifetime risk of such morbidity.

We use the term survival increment to represent the increased lifetime disability that would occur, solely due to reductions in mortality under the assumption that age-specific morbidity rates remained constant. Similarly, we use the term morbidity decrement to represent the reduction in lifetime disability that would occur, solely due to reductions in morbidity under the assumption that the age-specific mortality rates remained constant. If we set the morbidity rates for the survival increment to their 1984 values and the mortality rates for the morbidity decrements to their 2004 values, then it can be shown that the net change in lifetime morbidity between 1984 and 2004 is equal to the survival increment minus the morbidity decrement, which may be positive, negative, or zero, depending on the relative sizes of the survival increment and the morbidity decrement. Thus we have the following condition:

For the compression of morbidity to occur, the morbidity decrement must exceed the survival increment.

Table 5 displays the expected lifetime years of disability, their changes, and the component survival increments and morbidity decrements, for the combined HIPAA ADL and CI triggers under the three alternative weighting protocols shown in Figure 2. In each case the morbidity decrements far exceed the corresponding survival increments. The *t*-statistics for the morbidity decrements were 16.25, 13.67, and 14.48, respectively, indicating that the estimated morbidity decrements were statistically highly significant and had high precision. The *t*-statistics for the net changes were 11.53, 8.83, and 9.68, respectively, also indicating that the estimated net changes were statistically highly significant and had high precision.

Thus, the evidence supporting the morbidity compression hypothesis was very strong, based on the assumption that the term "morbidity" could be operationalized using the HIPAA ADL and CI triggering criteria. Moreover, the effect size was large and the alternative estimates had high statistical precision—the relative reduction in expected lifetime years of disability was in the range of 22–28 percent, or 24–28 percent with the unadjusted Cox estimate eliminated.

DISCUSSION

Our analysis raises several critical questions: Will morbidity compression continue indefinitely? Will it reach a stable lower limit? Or will it reverse direction and become a morbidity expansion? How will these changes interact with mortality?

In a 2011 article in the *Journal of Aging Research*, Fries and colleagues observed that the morbidity compression seen over the past 30 years was achieved without a coherent health-promotion strategy in place. Fries argued that continued morbidity compression was not inevitable, but it could be made to continue into the foreseeable future using a four-part health-promotion strategy consisting of 1. Primordial prevention (risk factor elimination), 2. Primary prevention (risk factor reduction), 3. Secondary prevention (disease specific), and 4.Tertiary prevention (morbidity treatment/reduction).

If such a strategy were implemented in whole or in part, one would also expect further reductions in mortality beyond those that would have occurred in their absence, which would further increase the size of the survival increments to be overcome by the concurrent morbidity decrements. Thus, it is the dynamic interplay between survival increments and morbidity decrements that will determine the course of morbidity compression over the foreseeable future. The extent to which these dynamics are shared by the subpopulation of LTC insureds will be of critical importance to LTCI actuaries. Establishing their existence in the general population and measuring their effects with precision are but the first steps in effectively dealing with them. Much more needs to be done. ■

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Table 4

Annual Rate of Decline in the Percent of Population Meeting Either HIPAA Trigger, United States 1984 and 2004, Unisex, Age 65+, by Age and Totaled Over Age, with Two Modes of Age Standardization – Tabulated Using Three Alternative Weighting Protocols

	Annual Rate of Decline (%)			Ratio of Cox to Duke/PNAS		*t*-statistic	
Age	Duke/PNAS Weight	Unadjusted Cox Weight	Adjusted Cox Weight	Unadjusted	Adjusted	Unadjusted	Adjusted
65-69	2.09	1.29	1.29	0.618	0.618		
70-74	2.77	2.26	2.39	0.817	0.862		
75-79	2.27	1.97	2.16	0.870	0.952		
80-84	2.57	2.19	2.37	0.851	0.922		
85-89	2.11	1.64	1.79	0.776	0.850		
90-94	2.37	2.06	2.10	0.868	0.886		
95+	1.16	1.00	1.04	0.859	0.891		
Total	1.28	1.05	1.18	0.819	0.919	1.60	0.72
1984 ASDR	2.32	1.89	2.02	0.814	0.869	2.92	2.06
2004 ASDR	2.29	1.88	2.01	0.823	0.879	2.88	1.97
		Standard Error					
Total	0.14	0.14	0.14	0.972	0.978		
1984 ASDR	0.15	0.14	0.15	0.975	0.981		
2004 ASDR	0.14	0.14	0.14	0.977	0.983		
		t-statistic					
Total	8.85	7.46	8.32	0.843	0.940		
1984 ASDR	15.68	13.09	13.88	0.835	0.886		
2004 ASDR	16.27	13.71	14.54	0.843	0.894		

NOTE: ASDR denotes age-standardized disability rate; the 1984 ASDR and 2004 ASDR results were age-standardized, respectively, to the 1984 and 2004 NLTCS weighted unisex population. The HIPAA triggers are based on 2+ ADL Impairments or 3+ errors on the SPMSQ.

Source: Author's calculations based on the 1984 and 2004 NLTCS; see Table 3.10 in Final Report.

Table 5

Alternative Estimates of Change in Unisex HIPAA ADL/CI Expectancy (in Years at Age 65), United States 1984 and 2004

	Year				
Weighting Protocol	1984	2004	Survival Increment	Morbidity Decrement	Net Change
Duke/PNAS Weight	2.50	1.81	**0.35**	**1.05**	**-0.70**
Unadjusted Cox Weight	2.52	1.97	**0.36**	**0.90**	**-0.55**
Adjusted Cox Weight	2.52	1.92	**0.36**	**0.95**	**-0.59**
Life Expectancy	16.64	18.11	1.48	–	1.48

Source: Author's calculations based on the 1984 and 2004 NLTCS; see Tables 2.27, 3.11, 3.12 in Final Report.

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