Mortality Table Development 2014 VBT Primary Tables

American Academy of Actuaries and Society of Actuaries
Joint Project Oversight Group

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2014 Valuation Basic Table (VBT) Development

2014 VBT Status to-date

- **Status to date**
  - Developed aggregate select and ultimate experience tables
  - NS/SM/Unismoker, M/F, ANB, ALB
  - Underwriting Criteria Scoring Tool revised (to be exposed at a later date)
- **Remaining to be finalized**
  - Relative risk (RR) tables
  - Composite Smoking table   Target completion: Spring 2015
  - Written report

Underlying experience

- SOA's Individual Life Experience Committee (ILEC) experience data from 2002-2009
- Significant increase in experience from 2008 VBT and 2001 VBT by:
  - Exposure, especially at older issue ages and for female risks
  - Number of claims
  - Number of contributing companies
  - Amount of preferred experience
  - Amount of business that had been blood tested (i.e., smoker/non-smoker distinct rates)
  - Amount of business issued with a non-tobacco versus non-smoker classification

Underlying experience, cont'd

- The 2014 VBT primary tables are based on 2002-2009 industry experience, which has a large volume of data - a significant increase in exposure and number of claims over the studies underlying both the 2008 and 2001 VBT table development.

Study/Table	Exposure		Actual deaths	Companies
	By Amount	By Number	Number Claims	Number
2002-2009 / 2014 VBT	$30.7 trillion	266 million	2.5 million	51
2002-2004/ 2008 VBT	$6.9 trillion	75 million	0.7 million	35
1990-1995 / 2001 VBT	$5.7 trillion	175 million	~ 1.25 million	21
Increase from 2008 VBT	345%	255%	257%	46%
Increase from 2001 VBT	439%	52%	100%	143%

Underlying experience, cont'd

- Overall, mortality improved from 2008 VBT

Study Period	Male	Female	Aggregate	Exposure (Trillion)	# Death Claims
2002-2004 (underlying 2008 VBT)	101.1%	100.5%	100.9%	$ 7.4	699,890
2002-2009 (underlying 2014 VBT)	94.2%	94.7%	94.3%	30.7	2,549,490
2002-2009 experience for common companies to 2002-2004 study	92.3%	94.3%	92.8%	19.2	1,940,403
2002 – 2009 100k+	88.3%	89.2%	88.5%	26.9	162,095
2002 – 2009 250k+	84.1%	85.4%	84.4%	20.6	46,570

Expected basis is 2008 VBT RR 100 Table

Source: Society of Actuaries, Individual Life Experience Reports 2002 through 2009 Preliminary

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Underlying experience, cont'd

In addition to gender, life insurance mortality experience varies by many factors including face amount, smoker status, and issue age.

A/E* Ratio –NS versus SM

Smoker Status	A/E Ratio by Amount
Non-smoker	92.3%
Smoker	97.5%
Unknown Status	99.8%
Aggregate	94.3%

A/E* Ratio – By Amount

Face Amount Band ($)	A/E Ratio by Amount
50,000 – 99,999	105.6%
250,000 – 499,999	88.6%
1,000,000 – 2,499,999	81.9%
5,000,000 – 9,999,999	74.1%
Aggregate	94.3%

A/E* Ratio – By Issue Age

Issue Age	A/E Ratio by Amount
40 – 49	100.1%
60 – 69	95.1%
80-89**	61.6%

* Expected basis = 2008 VBT Primary Tables, ANB
** 80-90 for common companies drops to 55%

Source: Society of Actuaries, Individual Life Experience Reports 2003 through 2009 Preliminary

Underlying experience, cont'd

- Variation in experience by contributing company

  - By amount, the actual to expected ratios ranged from 36% to 1,164% for NS risks and from 41% to 194% for SM risks

  - By policy count, the actual to expected ratios ranged from 49% to 863% for NS risks and from 75% to 184% for SM risks

Underlying experience, cont'd

Actual to Expected (A/E) comparison, cont'd

A/E Ratios for contributing companies – non-smoker risks
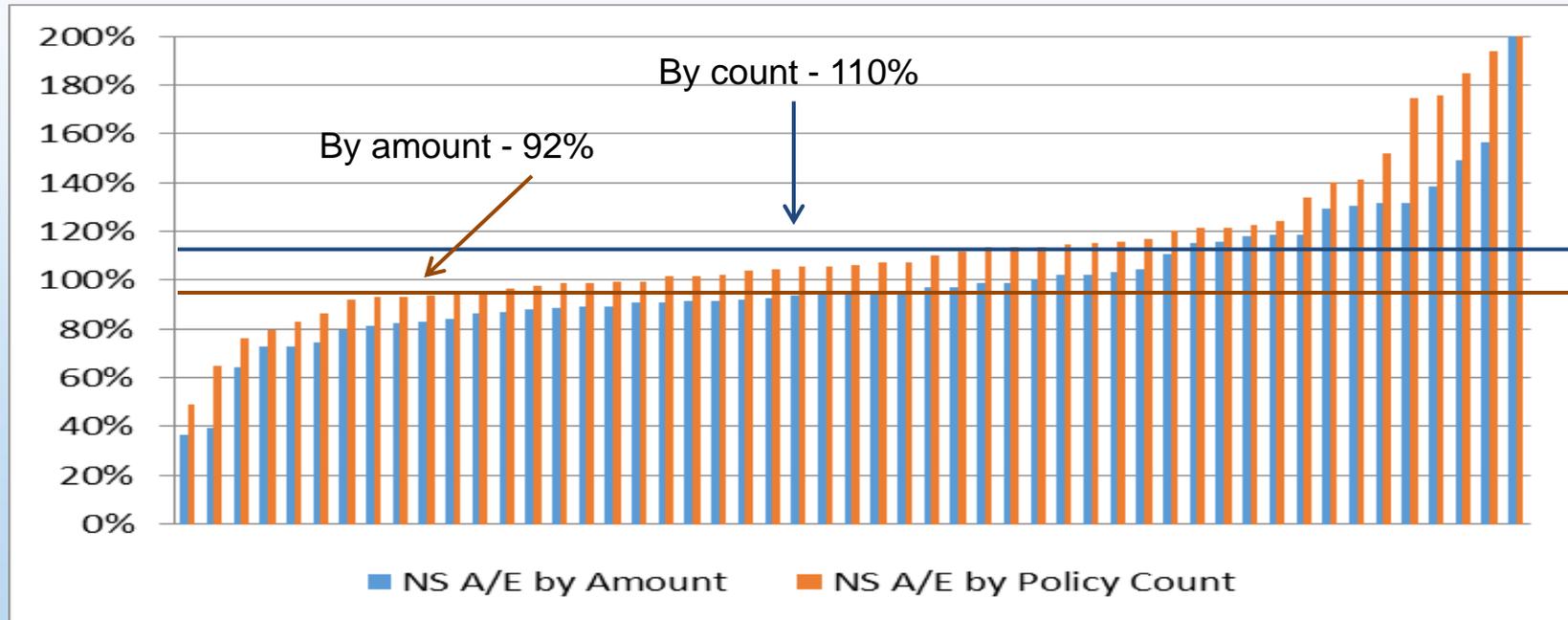
Expected basis = 2008 VBT RR 100 Table

Underlying experience, cont'd

Actual to Expected (A/E) comparison, cont'd

A/E Ratios for contributing companies –Smoker risks
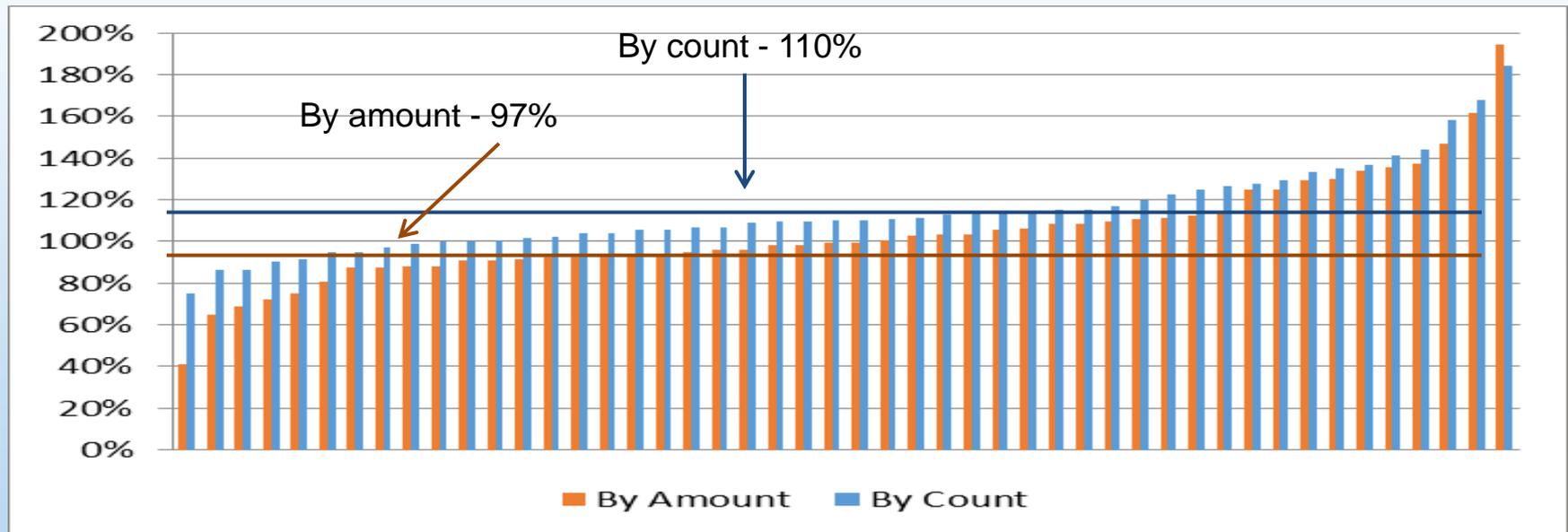
Expected basis = 2008 VBT RR 100 Table

Table structure

- Similar structure as 2008 VBT, with Primary and RR Tables, but not currently proposing a limited underwriting table. This will be revisited after the guaranteed issue/simplified issue tables are completed.
- Primary tables:
    - SM/NS and Composite Smoker
    - Age nearest birthday (ANB) and Age last birthday (ALB)
    - Select and Ultimate and Ultimate forms
- Relative Risk (RR) Tables – currently in development
    - RR Tables expected to be same in number but perhaps have different relativity amongst the classes.
- Select factors vary by gender and issue age
- Omega rate per 1,000 (500.0 per 1,000 at attained age 112) but no omega age

Select period

- Varies by issue age and gender
- Considered both observable as well as prospective select period
- Underlying select period independent of preferred wear-off
- Observable select period
  - Based on underlying data of both common companies as well as all companies
  - Data analyzed based on count rather than amount to remove influence of variations/fluctuations by size of claim
  - Attempted to normalize the socio-economic impact over time
  - Focused on gender/smoker status level, quinquennial age groupings
  - Used GAM (Generalized Additive Model) to test fit of actual mortality to mortality predicted by the GAM model by duration; results shown as ratios to ultimate mortality, averaged across all attained ages

Select period, cont'd

- Prospective select period
  - Looked to "events" or changes in underwriting that have impacted the select period in the underlying 2002-2009 data
  - E.g., Movement from unismoker to smoker/non-smoker rates (1980s), movement from smoker/non-smoker to non-tobacco/tobacco distinction (1990s), liberal underwriting period with increased level of underwriting exceptions (2000-2005), development of mature age underwriting requirements such as cognitive function (2005-present)
  - Most "events" thought to shorten select period from that in observed data; a couple such as NT versus NS and older age cognitive function testing may elongate
- Modified the observed select period for changes in smoker prevalence

Select period, cont'd

Select Period

Issue Age	MALE	FEMALE	Issue Age	MALE	FEMALE
0-17	0	0	79	12	12
18-54	25	20	80-81	11	11
55	24	19	82	10	10
56-57	23	19	83	9	9
58-59	22	19	84-85	8	8
60-61	21	19	86	7	7
62-63	20	18	87	6	6
64-65	19	17	88-89	5	5
66-69	18	16	90	4	4
70-72	17	15	91	3	3
73-74	16	14	92-94	2	2
75	15	14	95	1	1
76	14	14	96+	0	0
77-78	13	13			

Juvenile rates

- Consider ages 0-17 as juveniles
- Examined mortality relative to population mortality and insured mortality (2008 VBT)
  - No clear relationship to population mortality
- No smoker/non-smoker distinction
- No observable select period
  - Proposed table juvenile rates attained age only
  - Some grading/graduation was necessary to smoothly grade at attained age 26 into adult attained ages

3 adjustments to underlying experience

1. Adjust data to remove post level term anti-selective mortality;

2. Adjust data to recognize differences in experience from different underwriting eras; and

3. Improve the underlying experience to start date of table (2014).

1. Adjustment to remove effects of post level term mortality

- Examined underlying experience for term plans only
- Calculated actual to expected (A/E) ratios based on face amount by issue age group and duration in total and for 10, 15 and 20 year term plans
- The ratios were calculated for male and female separately and for both genders combined and were not split by smoker status (that is, the ratios were calculated for all smoker statuses combined)
- Recalculated the A/E ratios estimating impact of removing the post level term experience
- Determined the ratio of the A/E excluding post-level term to the total A/E. This provided the proposed adjustment to decrease the total rates to account for the impact of post-level term experience.
- Factors vary by issue age/duration
  - Average 2.9% at duration 13 versus 1.3% at duration 18

1. Adjustment to remove effects of post level term mortality

Adjustment factors to remove effects of post level term

Issue Ages	Durs 11-15	Durs 16-20	Durs 21-25	Durs 26+
18-24	99.9%	99.3%	99.9%	99.2%
25-29	98.7%	99.6%	99.7%	97.4%
30-34	96.5%	98.8%	99.9%	98.1%
35-39	97.0%	99.3%	99.8%	98.1%
40-44	97.5%	99.2%	99.8%	99.4%
45-49	97.5%	98.4%	99.7%	100.0%
50-54	96.1%	97.1%	100.0%	100.0%
55-59	98.3%	99.1%	99.9%	100.0%
60-64	99.1%	99.6%	99.9%	100.0%
65-69	95.7%	99.8%	100.0%	100.0%
70-74	99.4%	100.0%	100.0%	100.0%
75-79	99.8%	100.0%	100.0%	100.0%
80-84	100.0%	100.0%	100.0%	100.0%
85-89	100.0%	100.0%	100.0%	100.0%

2. Select period adjustments for different underwriting eras

- The Select Period in the observed data reflects different and distinct product and underwriting eras:

Issue era	Underwriting	Consideration
Prior 1980	• Aggregate smoker basis	• This experience comprises the bulk of the ultimate data
Early to mid-1980s	• Introduction of Smoker/non-smoker distinct rates; • Introduction of blood testing	• High replacement activity amongst NS risks • Anti-selective mortality • High preponderance of SM risks in underlying data
Mid-1980's to early 1990's	• SM/NS distinct rates	• Preponderance of experience on aggregate NS or aggregate SM basis
Early 1990's and later	• Introduction of preferred underwriting and better utilization of blood profiles	• High replacement activity amongst Preferred risks • Anti-selective mortality • Exhibit lower overall mortality than the earlier generations of policies both through the select period and beyond

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2. Select period adjustments for different underwriting eras, cont'd

- Believe the slope of the select period mortality is affected by the changes in products and underwriting processes that occurred for policies issued that contribute to the underlying data.

- In the 2002-09 Study, about 64% of the duration 1 business was categorized as having a preferred class structure.

- In the more recent eras where preferred class structures are more prevalent, insureds with better expected mortality tend to buy more and bigger policies that over time improves the overall experience.

- Going forward we would expect the experience in later durations to look better than it has historically as the mix of preferred business in the later durations begins to look more like the mix in recent (and presumably future) years.

- Analyzed experience to try to determine how the experience might look different going back in time if the current mix of preferred business had been sold.

- Further discussion of the analysis performed will be in the written report.

Adjustment factors to select period mortality to account for differences in underwriting eras
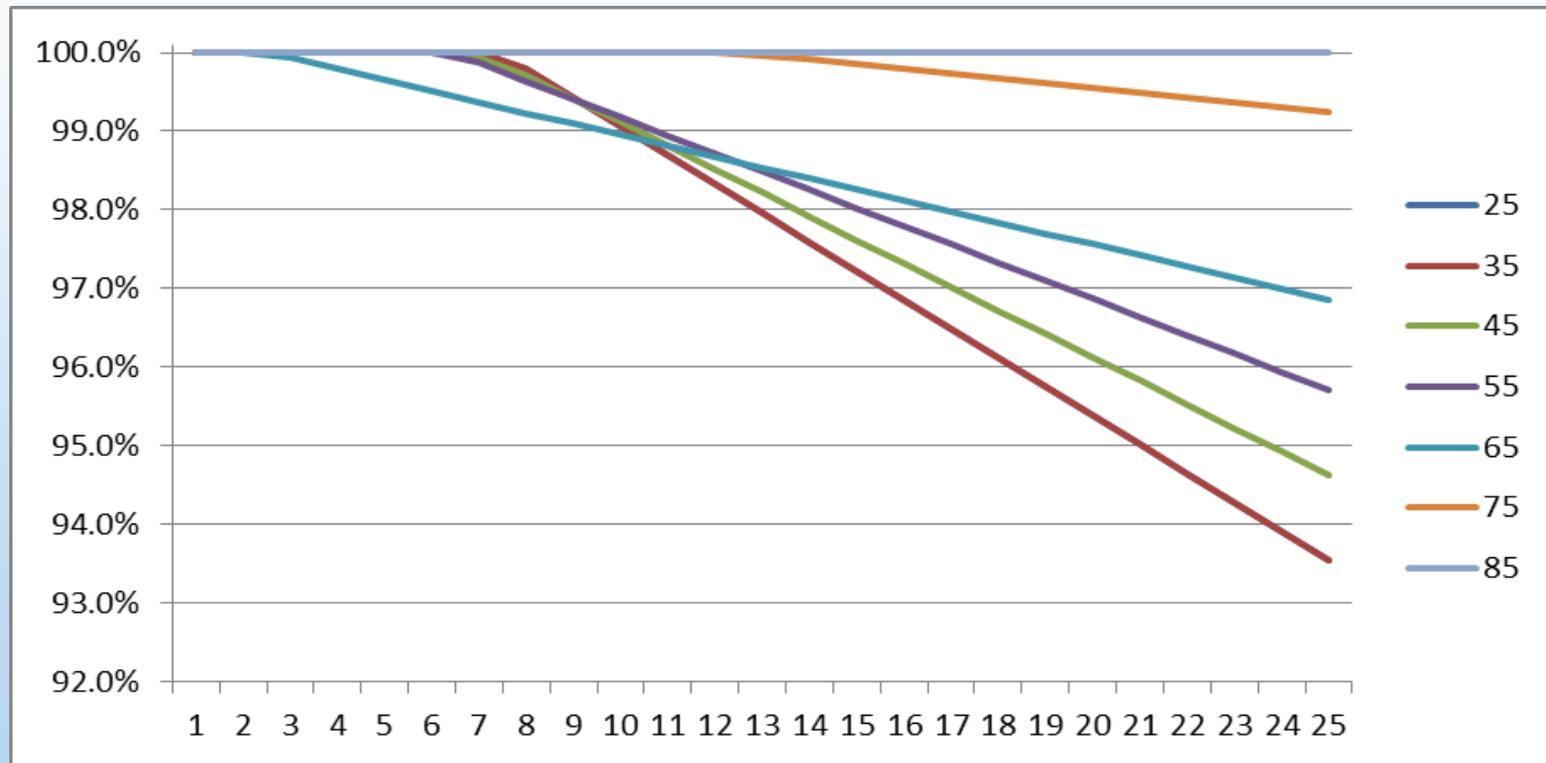
3. Mortality improvement

- Considerations
  - General population improvement
    - US Vital Statistics
    - Human Mortality Data Base (HMD)
    - Social Security Administration Data (SSA)

    After looking at 3 sources, SSA data selected as source for general population

  - Insured data
    - Common company data for period 2002-2009
    - Given short period of time for historical experience and volatility from year over year, believe general population data is preferable
  - Additional factors

3. Mortality improvement, cont'd

– Additional factors considered

- Gender;
- Attained age;
- Smoker status;
- Socio-economic status; and
- Differences in cause of death for insured lives vs general population.

3. Mortality improvement, cont'd

- Recommendation
  - For period 2002-2009:
    - Apply actual mortality improvement to adjust each experience year.
  - For period 2009-2014:
    - Apply average annual improvement rates varying by attained age and gender.
    - Based on general population data (SSA) = average of:
    - (a) Average annual improvement rates implied by the SSA's most recent intermediate level projection of mortality for the social security population; and
    - (b) Actual average annual improvement rates from historical SSA data for the most recent 10-year period.

3. Mortality improvement, cont'd

2014 VBT Sample Mortality Improvement Factors

Attained Age	Male	Female
25	0.4%	0.4%
35	1.5%	0.8%
45	0.7%	0.0%
55	1.1%	1.2%
65	1.8%	1.2%
75	1.4%	0.8%
85	1.0%	0.4%
90	0.5%	0.1%

Graduation approach

- Explored 3 separate approaches to graduating data and resulting fit
  - Projection pursuit regression (PPR);
  - Whittaker-Henderson (WH); and
  - Generalized Additive Model (GAM).
- For the ultimate date, all three models produced reasonable results; however, for the select data, the models did not perform equally. The GAM approach was therefore chosen. The GAM approach allowed for consideration of potential predictors of mortality other than gender and smoker status in a single model, without over-fitting the model to the data
  - PPR – good fit with ultimate model but loss of monotonicity and over-fit data in select period
  - WH – loss of monotonicity in select period
  - GAM – best fit overall, little to no loss of monotonicity

Graduation approach, cont'd

- Split the data into a select dataset and an ultimate dataset.
- Created 2 models using the Generalized Additive Model (GAM) approach to graduate the raw mortality rates by amount:
  1. Unismoker ultimate model (rates by attained age and gender only); and
  2. Select model with rates by gender, smoker status, issue age, and duration.
- Both models used all of the available data in their respective domains.

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Graduation approach – Ultimate data

- The GAM approach to modelling the ultimate data identified the significant predictors of mortality available in the dataset as:
  - Gender;
  - Attained age;
  - Issue age;
  - Issue year era; and
  - Face amount band.
- The overwhelming majority of the ultimate data was from the pre-1980 issue era for face amounts under $10,000
  - Due to the interaction of issue year era and face amount band as mortality predictors, it was decided to not include those predictors in the final model.

Graduation approach – Ultimate data, cont'd

- The issue age effect on the ultimate data was determined to be primarily due to a measurable difference between juvenile issue ages and adult issue ages in the ultimate period. Therefore, two separate submodels were fit to the data: one for juvenile issue ages only (under 18), and one for adult issue ages only (18 and over).
  - Attained age 0 was excluded from the juvenile issue age model and handled separately to avoid causing smoothing anomalies.
  - All durations for juvenile issue ages were considered as ultimate
  - The youngest adult issue ages exhibited a 25 year select period for males and a 20 year select period for females.
  - Therefore, for attained ages 35 and under, the juvenile issue age GAM model was used for the final ultimate unismoke model. For issue ages 45 and over, the adult issue age GAM model was used for the final ultimate unismoke model. For issue ages between 35 and 45, the two models were blended by log-linear interpolation.

- The adult issue age GAM model was used for ultimate mortality rates up to age 95.

- Above age 95, the rates were extrapolated with cubic curves to reach the maximum rate of 0.5 at attained age 112 for both males and females.

Graduation approach – Ultimate data, cont'd

- A significant proportion of the underlying select data is smoker/non-smoker distinct whereas the ultimate data was almost all issued as uni-smoker.
- Therefore, needed to determine smoker prevalence rates for the ultimate data to split into respective smoker class. To do so, the team:
  - Extrapolated smoker-distinct select rates at late durations to predict the mortality rate at the first ultimate duration;
  - Determined the implied smoker prevalence rates by comparing the extrapolated smoker-distinct ultimate rates to the initial unismoker ultimate model and the implied smoker-to-non-smoker mortality ratio; and
  - Applied smoker prevalence to the initial unismoker ultimate GAM model to create the smoker-distinct ultimate rates.
- The smoker/non-smoker mortality ratios and the smoker prevalence rates were then applied to the raw experience data for the ultimate period to create a split of the ultimate data by presumed smoking status.
- See Appendix 1 to this report for further details on determination of the smoker prevalence.

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Graduation approach – Select data

- The GAM approach to modelling the select data identified the significant predictors of mortality available in the dataset as:
  - Gender;
  - Smoker status;
  - Issue age;
  - Duration;
  - Issue year era; and
  - Face amount band.
- However, due to complexity of modelling and presenting mortality tables based on all these predictors, issue year era and face amount band were removed as predictors in the final model.
  - Adjustments for issue year or underwriting era were made outside the GAM model
- Exposures and claims for issue ages greater than 90 and for attained ages greater than 105 were excluded from the select period dataset that was fit with a GAM. The amount of exposure and claims excluded was trivial.

Graduation approach – Select data, cont'd

- Identified 5 constraints that the select model graduation should meet:
  1. Above attained age 30, mortality rates should not decrease as issue age increases for the same duration, gender, smoker status, issue year era, and face amount band (vertical constraint)
  2. Above attained age 30, mortality rates should not decrease as duration increases for the same issue age, gender, smoker status, issue year era, and face amount band (horizontal constraint)
  3. Mortality rates should not decrease as duration increases for the same attained age, gender, smoker status, issue year era, and face amount band (diagonal constraint)
  4. Mortality rates for males should not be lower than those for females for the same issue age, duration, smoker status, issue year era, and face amount band
  5. Mortality rates for smokers should not be lower than those for non-smokers for the same issue age, duration, gender, issue year era, and face amount band

Graduation approach – Select data, cont'd

- Different techniques were used to adjust for violations in the identified constraints, including:
    - Linear interpolation between adjacent rates;
    - Linearly interpolating between selection wearoff patterns of adjacent rates;
    - Fitting smooth selection wearoff patterns such as quadratic arcs along the attained age diagonals; and
    - Manual adjustments by pure judgment
- The majority of these adjustments were less than +/- 5%

Graduation approach – Select data, cont'd

Additional adjustments were made to young adult issue ages and older issue ages

- Young adult issue age rate adjustments
  - The crude select model mortality rates for male young adult issue ages appeared to be too low in comparison to the raw experience
  - Therefore, a smooth set of adjustment factors was developed for male non-smokers, issue ages 18 to 31, durations 1 to 15, and another smooth set of adjustment factors was developed for male smokers, issue ages 29 to 36, durations 1 to 7

Graduation approach – Select data, cont'd

- Older issue age rate adjustments
  - Significant feedback from industry had been provided to the Joint POG suggesting the level of 2008 VBT mortality rates at the older issue ages was too high
  - Therefore, the 2014 table development team spent considerable time examining the level and resulting slope of the older issue age mortality rates
  - The 2014 table development team examined the resulting select mortality rates from the initial GAM model (after adjustment to meet the various constraints) and determined they were too high in comparison to the raw ILEC 02-09 experience data at issue ages 70 and above for male non-smokers

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Graduation approach – Select data, cont'd

- Older issue age rate adjustments, cont'd
  - To further support the conclusion, the 2014 table development team obtained experience information from two independent older issue age mortality studies (TOAMS, from Towers-Watson and MIMSA, from Milliman USA). While there was overlap of some data across all three studies (ILEC, TOAMS and MIMSA), the studies were determined to have sufficient variation to be reasonably representative of independent studies
  - These studies added further support to warrant additional adjustment to the rates for male non-smokers, issue ages 70 to 90, durations 1 to 10, and to the rates for male smokers, issue ages 61 to 81, durations 5 to 14
  - The final rates in the proposed ILEC 02-09 experience table were deemed to provide a reasonable balance between the raw experience data and prior estimates of these rates, given the need for a smooth transition from select to ultimate rates and the relatively small number of claims underlying the raw experience data

Relative risk (RR) tables

- Have developed initial set of preferred wear-off factors.

- Work ongoing to develop the tables once the aggregate VBT is complete

Preferred wear-off factors

- Analyzed level of wear-off but experience still emerging.
- There is virtually no additional information available from the 2008 VBT analysis, which was extensive.
- The preponderance of aggregate NS data in early durations further complicated the analysis; therefore, also examined Milliman's MIMSA study.
- Therefore, the preferred wear-off factors are the same as for the 2008 VBT, with the exception that they grade off to age 95, same as the underlying select period rather than 90.
- The factors used to grade from age 90 to 95 were based on professional judgment.

Preferred wear-off factors, cont'd

2014 VBT Preferred wear-off factors

Issue Age	Dur 6	Dur 16	Dur 26	Att. Age
25	0.0%	0.0%	2.8%	50
35	0.0%	2.7%	13.0%	60
45	2.3%	12.6%	32.6%	70
55	6.7%	27.8%	61.6%	80
65	14.0%	51.0%	84.0%	90
75	29.0%	76.0%	100.0%	100
85	34.7%	100.0%	100.0%	110

2008 VBT Preferred wear-off factors

Issue Age	Dur 6	Dur 16	Dur 26	Att. Age
25	0.0%	0.0%	4.0%	50
35	0.0%	0.0%	34.0%	60
45	0.0%	0.0%	34.0%	70
55	0.0%	0.0%	50.0%	80
65	0.0%	0.0%	84.0%	90
75	0.0%	36.0%	100.0%	100
85	34.7%	100.0%	100.0%	110

The 2014 preferred wear-off factors are subject to change as the relative risk tables are further developed.

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Resulting experience – Sample Ages and Durations

Male Risks

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Resulting experience table
Male, NS, Issue ages 40-49

M   NS   Ages 40 to 49   Durs 1-35

Legend: Raw ILEC Data — 02-09 Experience Table — 2001 VBT — 2008 VBT

Resulting experience table
Male, NS, Issue ages 40-49

M NS   Ages 40 to 49   Durs 1-35

Legend:
- A/E Raw Data to 02-09 Experience Table
- A/E Raw Data to 2008 VBT
- A/E Raw Data to 2001 VBT

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Resulting experience table
Male, NS, Issue ages 40-49

Resulting experience table
Male, SM, Issue ages 40-49

M SM   Ages 40 to 49   Durs 1-35

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Resulting experience table
Male, SM, Issue ages 40-49

M SM   Ages 40 to 49   Durs 1-35

Legend: A/E Raw Data to 02-09 Experience Table, A/E Raw Data to 2008 VBT, A/E Raw Data to 2001 VBT

Resulting experience table
Male, SM, Issue ages 40-49

M SM Ages 40 to 49 Durs 1-13 with Confidence Interval

M SM Ages 40 to 49 Durs 14-35 with Confidence Interval

Resulting experience table
Male, NS, Issue ages 60-69

M NS   Ages 60 to 69   Durs 1-35

Legend: Raw ILEC Data, 02-09 Experience Table, 2001 VBT, 2008 VBT

Resulting experience table
Male, NS, Issue ages 60-69

M NS   Ages 60 to 69   Durs 1-35

Legend: A/E Raw Data to 02-09 Experience Table — A/E Raw Data to 2008 VBT — A/E Raw Data to 2001 VBT

Resulting experience table
Male, NS, Issue ages 60-69

Resulting experience table
Male, SM, Issue ages 60-69

M SM   Ages 60 to 69   Durs 1-35

Legend: Raw ILEC Data, 02-09 Experience Table, 2001 VBT, 2008 VBT

Resulting experience table
Male, SM, Issue ages 60-69

Resulting experience table
Male, SM, Issue ages 60-69

M SM   Ages 60 to 69   Durs 1-13   with Confidence Interval

Mortality Rate per 1,000 — Duration — Raw Qx, CI Lower Limit, CI Upper Limit

M SM   Ages 60 to 69   Durs 14-35   with Confidence Interval

Mortality Rate per 1,000 — Duration — Raw Qx, CI Lower Limit, CI Upper Limit

Resulting experience table
Male, NS, Issue ages 70-79

M NS   Ages 70 to 79   Durs 1-30

Legend: Raw ILEC Data | 02-09 Experience Table | 2001 VBT | 2008 VBT

Resulting experience table
Male, NS, Issue ages 70-79

Resulting experience table
Male, NS, Issue ages 70-79

Resulting experience table
Male, SM, Issue ages 70-79

M SM   Ages 70 to 79   Durs 1-30

Legend: Raw ILEC Data, 02-09 Experience Table, 2001 VBT, 2008 VBT

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Resulting experience table
Male, SM, Issue ages 70-79

M SM   Ages 70 to 79   Durs 1-30

Resulting experience table
Male, SM, Issue ages 70-79

M SM Ages 70 to 79 Durs 1-13 with Confidence Interval

M SM Ages 70 to 79 Durs 14-30 with Confidence Interval

Resulting experience table
Male, NS, Issue ages 80-89

M NS   Ages 80 to 89   Durs 1-20

Resulting experience table
Male, NS, Issue ages 80-89
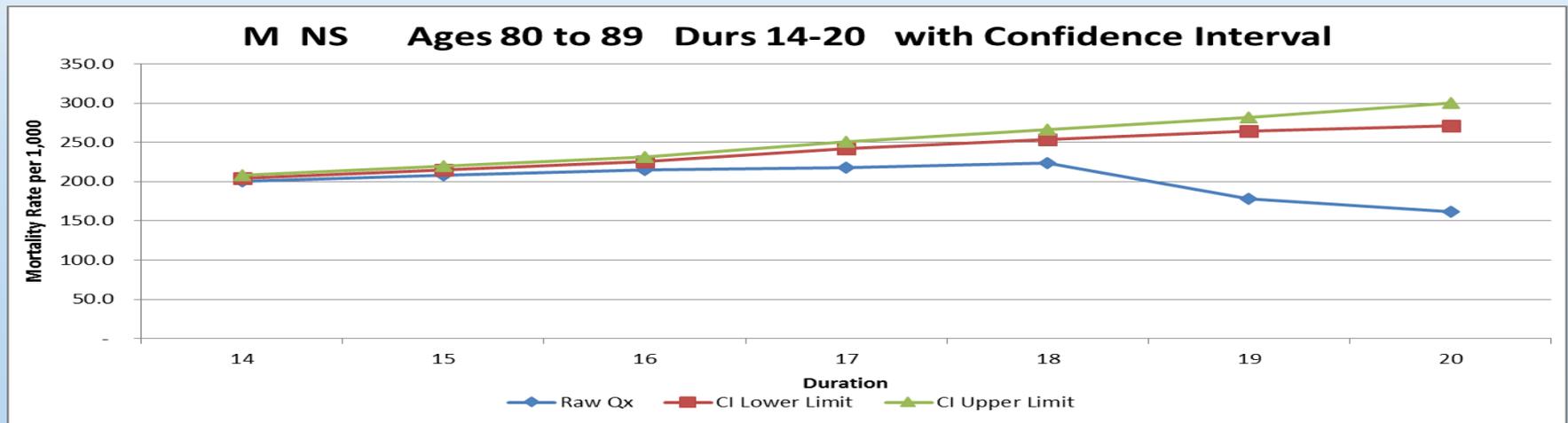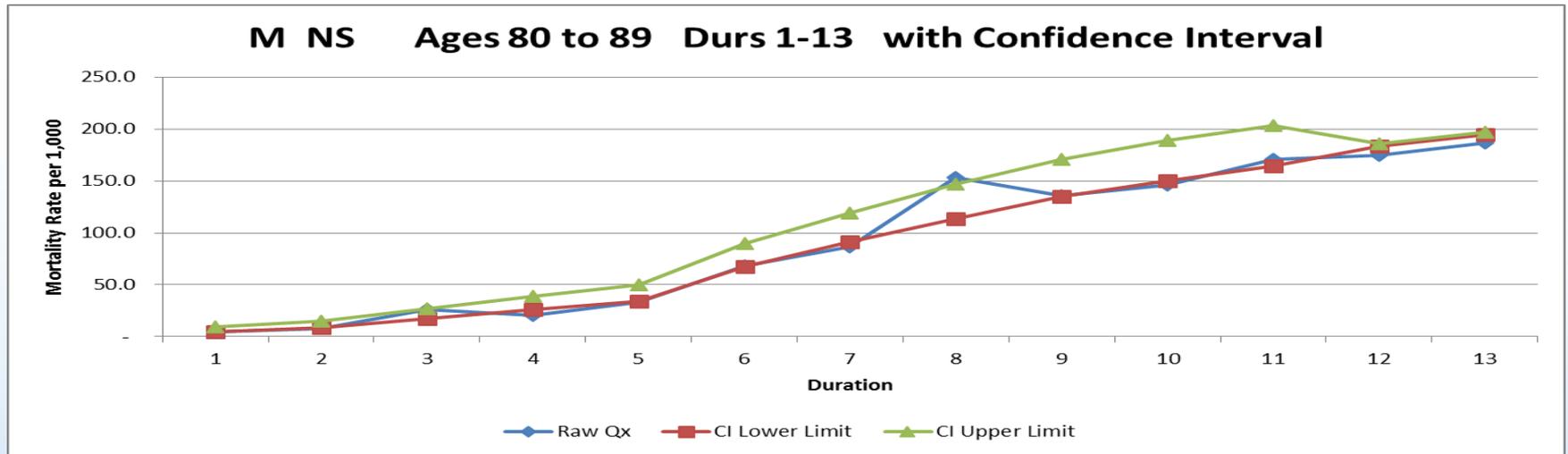
M NS   Ages 80 to 89   Durs 1-20

Legend: A/E Raw Data to 02-09 Experience Table; A/E Raw Data to 2008 VBT; A/E Raw Data to 2001 VBT

Resulting experience table
Male, NS, Issue ages 80-89

Resulting experience table
Male, SM, Issue ages 80-89

M SM   Ages 80 to 89   Durs 1-20

Legend: Raw ILEC Data, 02-09 Experience Table, 2001 VBT, 2008 VBT

X-axis: Duration (1–20)
Y-axis: Mortality Rate per 1,000

Resulting experience table
Male, SM, Issue ages 80-89

M SM   Ages 80 to 89   Durs 1-20

Legend: A/E Raw Data to 02-09 Experience Table; A/E Raw Data to 2008 VBT; A/E Raw Data to 2001 VBT

Resulting experience table
Male, SM, Issue ages 80-89

M SM   Ages 80 to 89   Durs 1-13   with Confidence Interval

Raw Qx — CI Lower Limit — CI Upper Limit

M SM   Ages 80 to 89   Durs 14-20   with Confidence Interval

Raw Qx — CI Lower Limit — CI Upper Limit
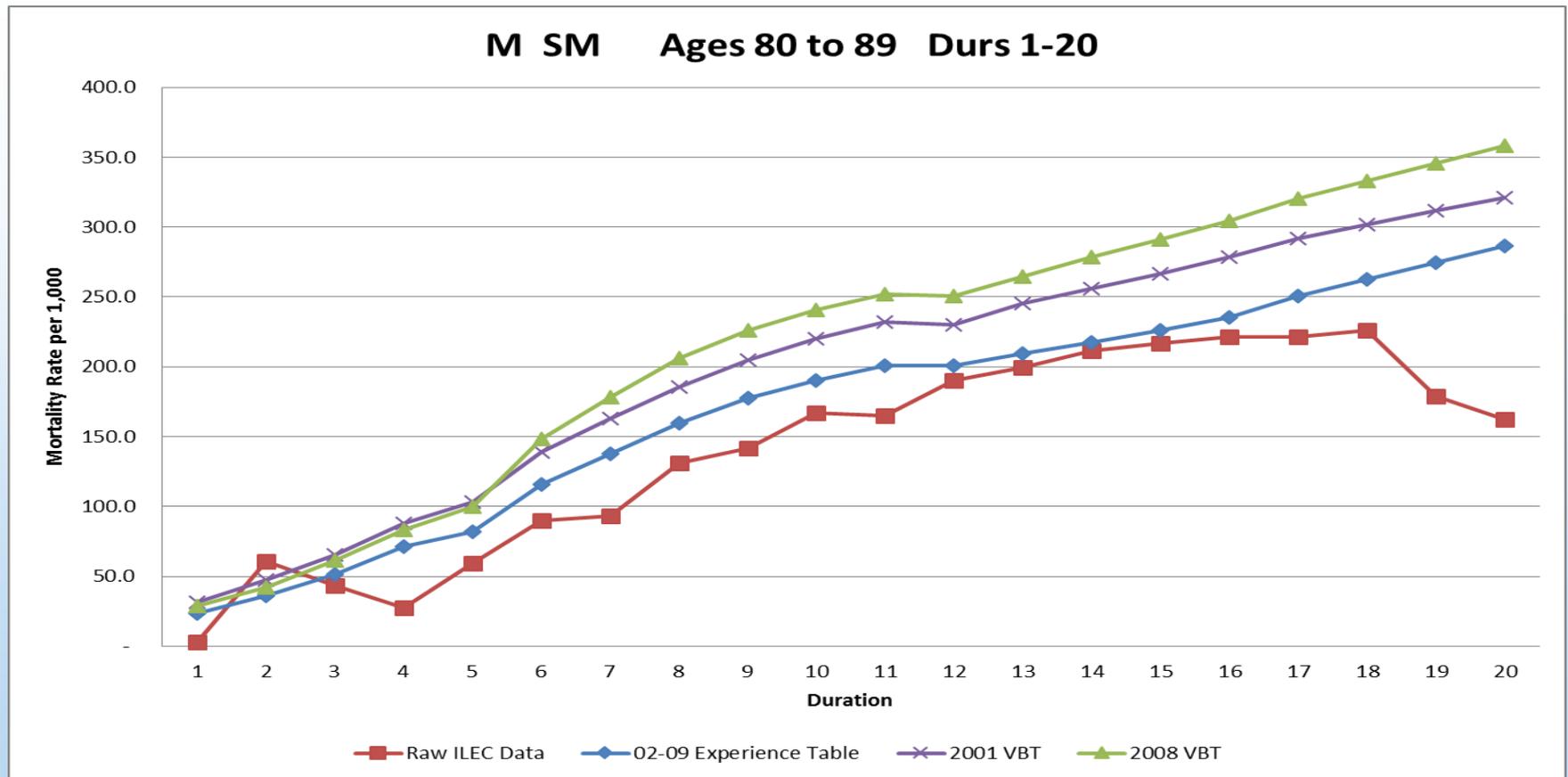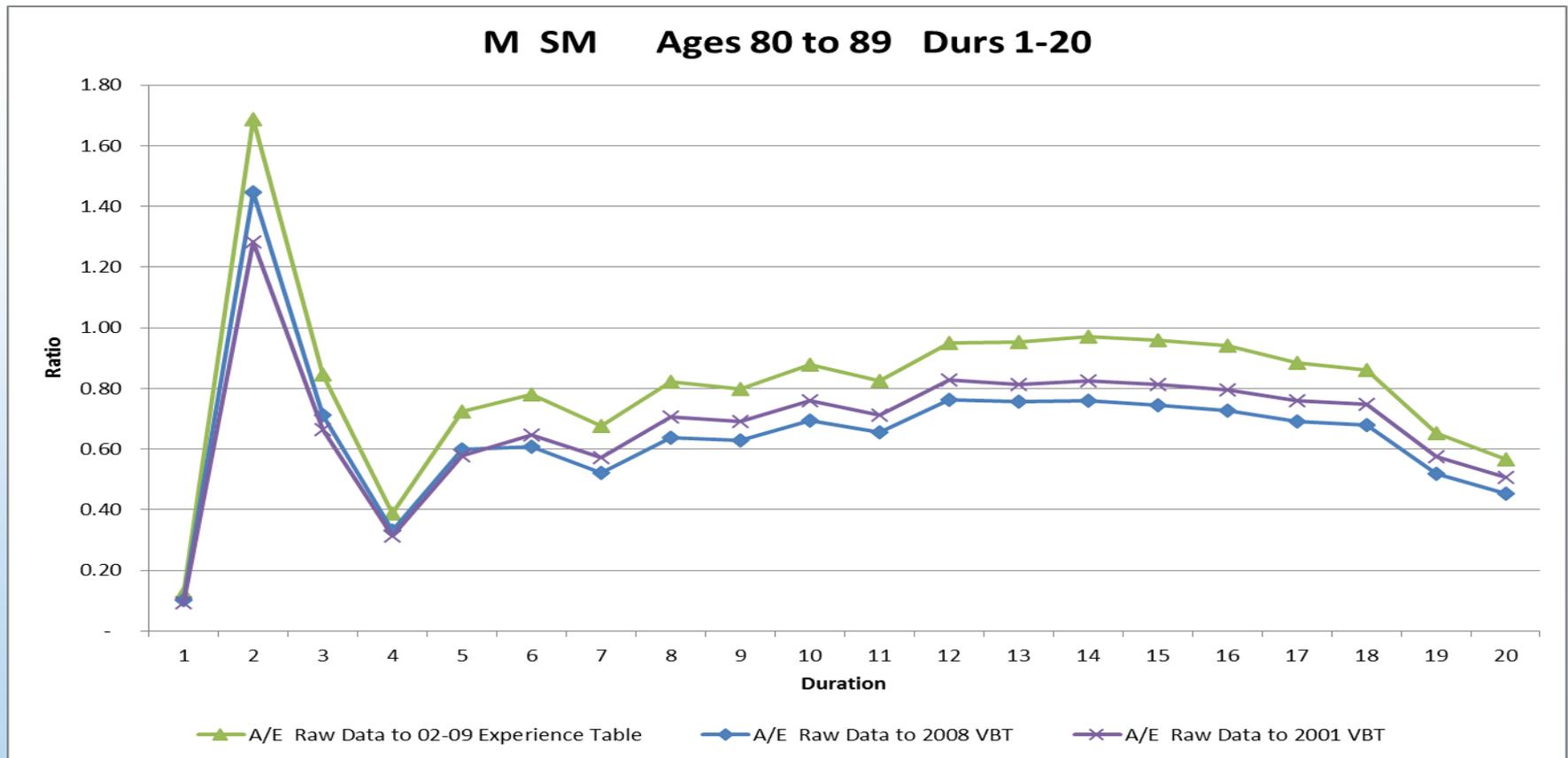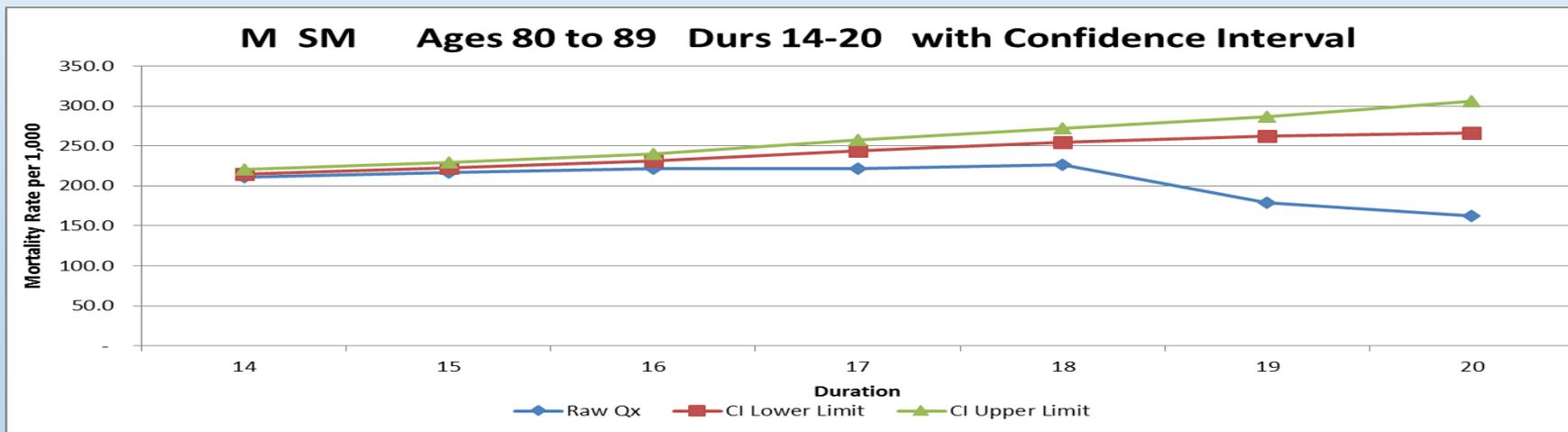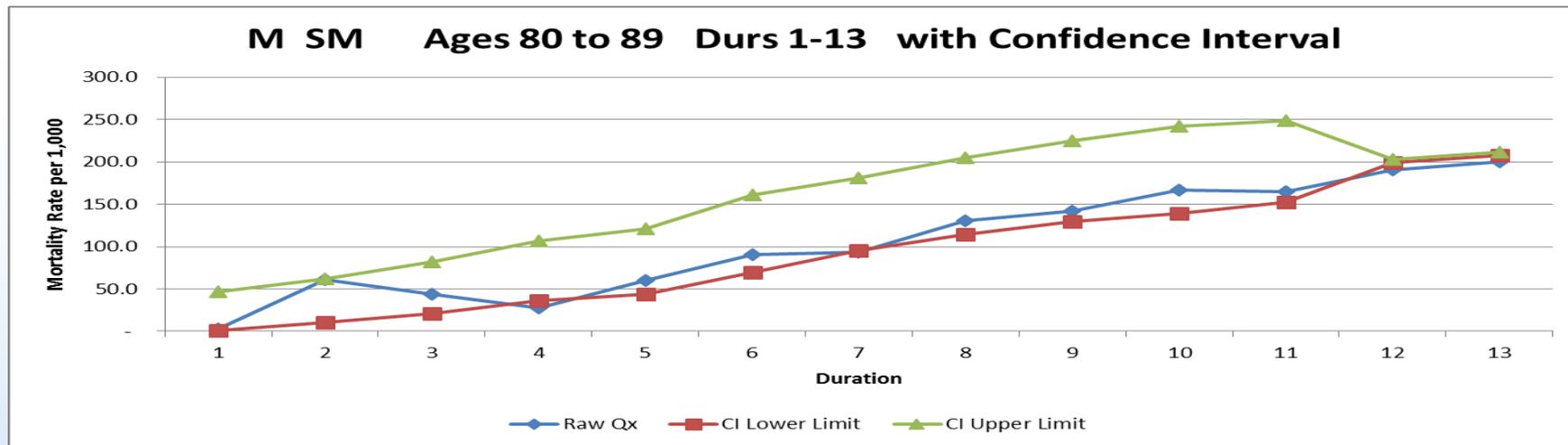
Resulting experience – Sample Ages and Durations

Female Risks

Resulting experience table
Female, NS, Issue ages 40-49

F NS   Ages 40 to 49   Durs 1-35

Legend: Raw ILEC Data, 02-09 Experience Table, 2001 VBT, 2008 VBT

Resulting experience table
Female, NS, Issue ages 40-49

F NS   Ages 40 to 49   Durs 1-35

Legend:
- A/E Raw Data to 02-09 Experience Table
- A/E Raw Data to 2008 VBT
- A/E Raw Data to 2001 VBT

Resulting experience table
Female, NS, Issue ages 40-49

Resulting experience table
Female, SM, Issue ages 40-49

Resulting experience table
Female, SM, Issue ages 40-49

F SM Ages 40 to 49 Durs 1-35

Legend: A/E Raw Data to 02-09 Experience Table · A/E Raw Data to 2008 VBT · A/E Raw Data to 2001 VBT

Resulting experience table
Female, SM, Issue ages 40-49

F SM   Ages 40 to 49   Durs 1-13   with Confidence Interval

F SM   Ages 40 to 49   Durs 14-35   with Confidence Interval

Resulting experience table
Female, NS, Issue ages 60-69

F NS   Ages 60 to 69   Durs 1-35

Legend: Raw ILEC Data, 02-09 Experience Table, 2001 VBT, 2008 VBT

Resulting experience table
Female, NS, Issue ages 60-69

F NS   Ages 60 to 69   Durs 1-35

Legend:
- A/E Raw Data to 02-09 Experience Table
- A/E Raw Data to 2008 VBT
- A/E Raw Data to 2001 VBT

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Resulting experience table
Female, NS, Issue ages 60-69

F NS   Ages 60 to 69   Durs 1-13   with Confidence Interval

F NS   Ages 60 to 69   Durs 14-35   with Confidence Interval

Resulting experience table
Female, SM, Issue ages 60-69

F SM   Ages 60 to 69   Durs 1-35

Legend: Raw ILEC Data — 02-09 Experience Table — 2001 VBT — 2008 VBT

Resulting experience table
Female, SM, Issue ages 60-69

F SM   Ages 60 to 69   Durs 1-35

Resulting experience table
Female, SM, Issue ages 60-69

F SM   Ages 60 to 69   Durs 1-13   with Confidence Interval

F SM   Ages 60 to 69   Durs 14-35   with Confidence Interval

Resulting experience table
Female, NS, Issue ages 70-79

F NS   Ages 70 to 79   Durs 1-30

Legend: Raw ILEC Data, 02-09 Experience Table, 2001 VBT, 2008 VBT

Resulting experience table
Female, NS, Issue ages 70-79

F NS   Ages 70 to 79   Durs 1-30

Legend: A/E Raw Data to 02-09 Experience Table; A/E Raw Data to 2008 VBT; A/E Raw Data to 2001 VBT

Resulting experience table
Female, NS, Issue ages 70-79

Resulting experience table
Female, SM, Issue ages 70-79

F SM   Ages 70 to 79   Durs 1-30

Legend: Raw ILEC Data, 02-09 Experience Table, 2001 VBT, 2008 VBT

Resulting experience table
Female, SM, Issue ages 70-79

F SM   Ages 70 to 79   Durs 1-30

Legend: A/E Raw Data to 02-09 Experience Table — A/E Raw Data to 2008 VBT — A/E Raw Data to 2001 VBT

Resulting experience table
Female, SM, Issue ages 70-79

F SM   Ages 70 to 79   Durs 1-13   with Confidence Interval

F SM   Ages 70 to 79   Durs 14-30   with Confidence Interval

Resulting experience table
Female, NS, Issue ages 80-89

F NS   Ages 80 to 89   Durs 1-20

Legend: Raw ILEC Data, 02-09 Experience Table, 2001 VBT, 2008 VBT

Resulting experience table
Female, NS, Issue ages 80-89

F NS   Ages 80 to 89   Durs 1-20

Legend: A/E Raw Data to 02-09 Experience Table · A/E Raw Data to 2008 VBT · A/E Raw Data to 2001 VBT

Resulting experience table
Female, NS, Issue ages 80-89

Resulting experience table
Female, SM, Issue ages 80-89

Resulting experience table
Female, SM, Issue ages 80-89

F SM   Ages 80 to 89   Durs 1-20

Legend:
- A/E Raw Data to 02-09 Experience Table
- A/E Raw Data to 2008 VBT
- A/E Raw Data to 2001 VBT

Resulting experience table
Female, SM, Issue ages 80-89

F SM   Ages 80 to 89   Durs 1-13   with Confidence Interval

F SM   Ages 80 to 89   Durs 14-20   with Confidence Interval

Appendix I – Determination of Smoker Prevalence

Appendix I: Determination of smoker prevalence

The smoker distinct data in the ultimate period was deemed to be too thin to use for creating smoker distinct ultimate rates. Therefore, the smoker distinct data in the select period was used to split the unismoke ultimate model into a smoker distinct ultimate model.

1. **Extrapolated the select rates into the ultimate period**
   - For each attained age within each gender and smoker combination, the rates for the last three select durations were used to make an initial estimate of the ultimate rate. The ultimate rate was estimated as the last select rate plus half of the difference between the last select rate and the select rate for the prior duration for that attained age.
   - If the increase from the next-to-last select rate to the last select rate seemed unusually large, the ultimate rate was estimated as the last select rate plus the difference between the select rate for the prior duration and the one for the duration before that.

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2. Determine the mortality and prevalence ratios

- The smoker to non-smoker mortality ratio for each gender and attained age was found by dividing the estimated ultimate smoker rate by the estimated ultimate non-smoker rate.

- The implied prevalence ratio was determined algebraically to be the proportion of non-smokers in the ultimate data for which the combination of smoker and non-smoker data together would result in the unismoke ultimate rate, given the smoker to non-smoker mortality ratio.

3. Final Smoker Distinct Ultimate Rates

- The smoker to non-smoker mortality ratios were smoothed and extended so that the ratio reduced gradually to 100% at age 100 for each gender.

- The prevalence ratios were smoothed and extended to age 100.

- The non-smoker to unismoke mortality ratio was then calculated from the smoker to non-smoker mortality ratio and the non-smoker prevalence ratio.

- The final non-smoker ultimate rates were then calculated as the unismoke ultimate rates times the non-smoker to unismoke mortality ratios for each gender, and the final smoker ultimate rates were calculated as the non-smoker ultimate rates times the smoker to non-smoker mortality ratios.

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Appendix II – ALB Algorithm

Appendix II: ALB Algorithm

The following algorithm was used to convert the ANB mortality rates to ALB rates.

1. Naming convention
    - a. Template.　　　2014 VBT (Sex) Smoking Type Basis
    - b. Sex
        - M.　　　Male.
        - F.　　　Female.
    - c. Smoking.
        - NS.　　　Non-smoker
        - SM.　　　Smoker.
    - d. Type.
        - S&U　　　Select & ultimate
        - U　　　Ultimate
    - e.　Basis
        - ANB.　　　Age nearest birthday
        - ALB. Age last birthday.

- Example. 2014 VBT (M) NS U ALB is the male non-smoker table based on the ultimate portion of the table and is age last birthday for the primary underwriting tables. 2014 VBT (F) NS S&U ANB is the select and ultimate portion of the female non-smoker primary underwriting table and is age nearest birthday.

- Groups of tables. When an item is not identified, all versions of that item are included. For example, 2008 VBT (M) S&U would include all of the select & ultimate tables for males, including non-smoker, smoker, age nearest birthday and age last birthday.

2. **Starting basis**

    The starting point for building the age last birthday tables was the respective age nearest birthday table.

3.   **Select & Ultimate tables**

    - Values for these tables are calculated according to the following formulas. The mortality rates per 1000 lives are rounded to two decimal places. Select period values for all issue ages are developed from age nearest birthday rates that are in the same duration. For issue age 95, approximate issue age 96 ANB rates for duration 1 was created by assuming constant 3rd differences from the issue ages 92-95. Duration 2+ rates are on an ultimate period basis.

3. Select & Ultimate tables, cont'd

a. Issue ages less than 95.

$$q\frac{ALB}{[x]+t} = \left\{ \frac{q\frac{ANB}{[x]+t} + \left[\left(1 - q\frac{ANB}{[x]+t}\right) x\ q\frac{ANB}{[x+1]+t} \right]}{2 - q\frac{ANB}{[x]+t}} \right\}$$

b. Issue age 95.

$$q\frac{ALB}{[95]+t} = \left\{ \frac{q\frac{ANB}{[95]+t} + \left[\left(1 - q\frac{ANB}{[95]+t}\right) x\ q\frac{ANB}{[95]+t+1} \right]}{2 - q\frac{ANB}{[95]+t}} \right\}$$

c. Other ultimate rates.

$$q\frac{ALB}{x+t} = \left\{ \frac{q\frac{ANB}{x+t} + \left[\left(1 - q\frac{ANB}{x+t}\right) x\ q\frac{ANB}{x+t+1} \right]}{2 - q\frac{ANB}{x+t}} \right\}$$

3. Select & Ultimate tables, cont'd

d. Composite rates for young ages. All rates for attained ages 17 and younger are on a composite smoking basis. Smoker and non-smoker rates are the same. Rates for issue ages 10-17, durations 1-7 and attained age under 17 are set on a select and ultimate basis. The others are set at the ultimate rate calculated from issue age 0 rates.

The calculation of the attained age 17 select and ultimate ALB rates used a composite issue age 18 ANB rate. This age 18 ANB rate was extrapolated from attained ages 15-17 by assuming a constant 2nd difference at each duration. This ensured that the attained age 17 rates remained on a composite basis.

Age 0 ALB rates were set at 87.67% and 84.37% of age 0 ANB rates for females and males, respectively. This was based on an analysis of 2003 population age 0 rates. It was assumed that insurance coverage begins after 15 days and that 50% of issues would occur at age 15 days. The other 50% of issues occurred evenly throughout the remainder of the first year.

4. Ultimate tables

- Separate ultimate versions of the tables were not developed but can be extracted from the ultimate column of the respective select and ultimate tables