



**CARIBBEAN
ACTUARIAL
ASSOCIATION**



Indigenous Mortality Table Construction for Trinidad & Tobago and Jamaica

MR. STOKLEY SMART

H.B.Sc, LL.B, FSA, CERA, PRM

SENIOR LECTURER AND DIRECTOR OF THE BSc. IN ACTUARIAL SCIENCE AT THE UNIVERSITY OF THE WEST
INDIES, ST. AUGUSTINE.

This presentation has been prepared for the 2023 Caribbean Actuarial Association (CAA) Conference. The CAA wishes it to be understood that opinions put forward herein are not necessarily those of the CAA and the CAA takes no responsibility for those opinions.



GENESIS

How the idea came about...

- The idea for developing mortality tables indigenous to Trinidad and Tobago was precipitated by a conversation between Mr. Kyle Rudden and myself, circa 2015.
- Mr. Rudden commented that Kenya had already developed their own indigenous mortality tables. This revelation provided the incentive to construct Individual Age Mortality Tables for the Caribbean.



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How the idea came about...

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GENESIS

As a result, three indigenous Mortality Tables have been constructed:

- UWI-NIBTT 2014 - Employed Persons' Tables
- 2011 Trinidad and Tobago Population Tables
- 2011 Jamaica Population Tables



DATA SANITIZATION

What data was used for the construction of the UWI-NIBTT 2014 - Employed Persons' Tables?

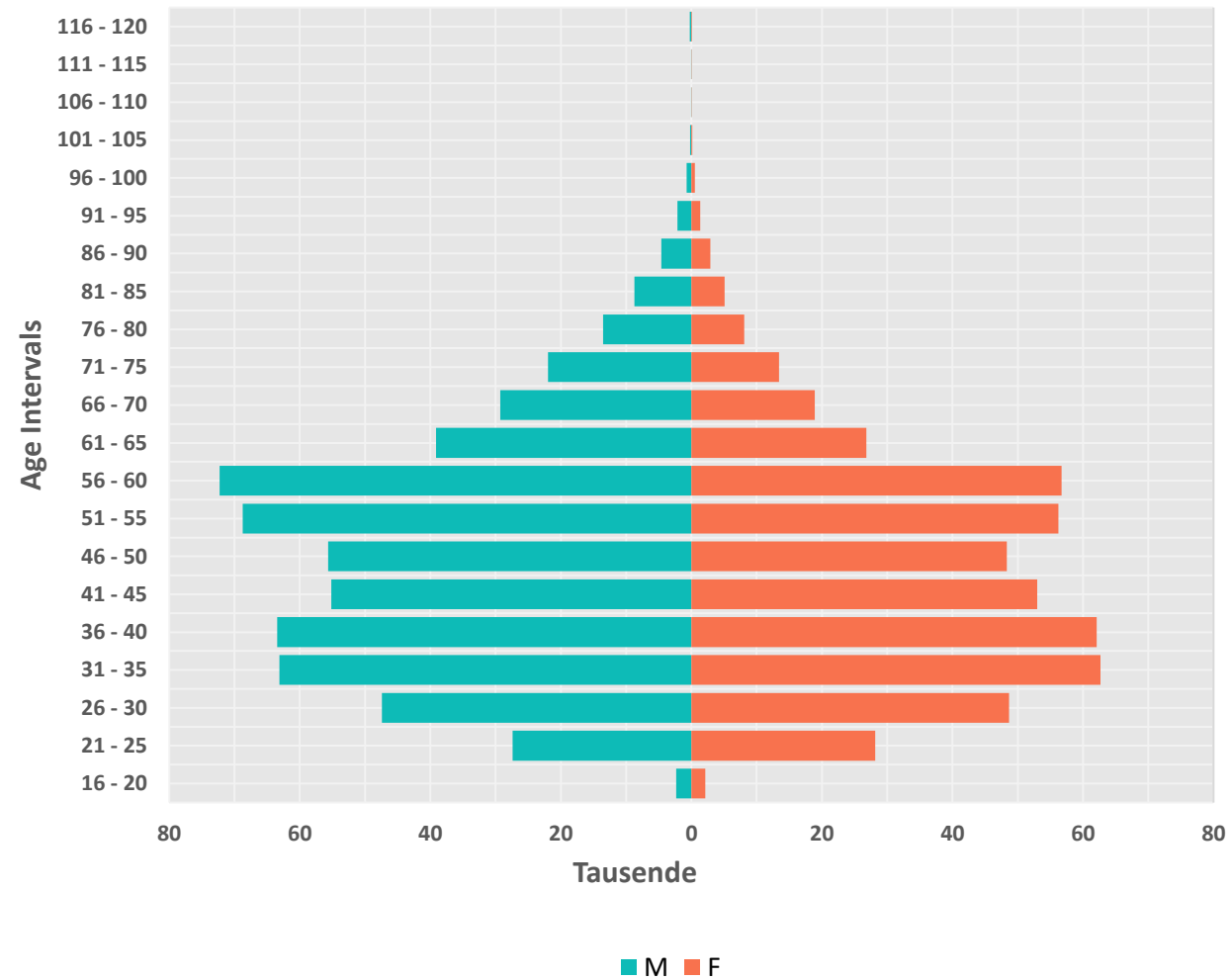
- The table reflects experience over the five (5) year period, January 1st 2012 to December 31st 2016.
- It consists of persons registered with NIBTT during this period.
- Persons with duplicate records were removed



DATA SANITIZATION

A total number of 1,305,428 records were used in the construction of the employed persons Mortality Tables for Trinidad and Tobago.

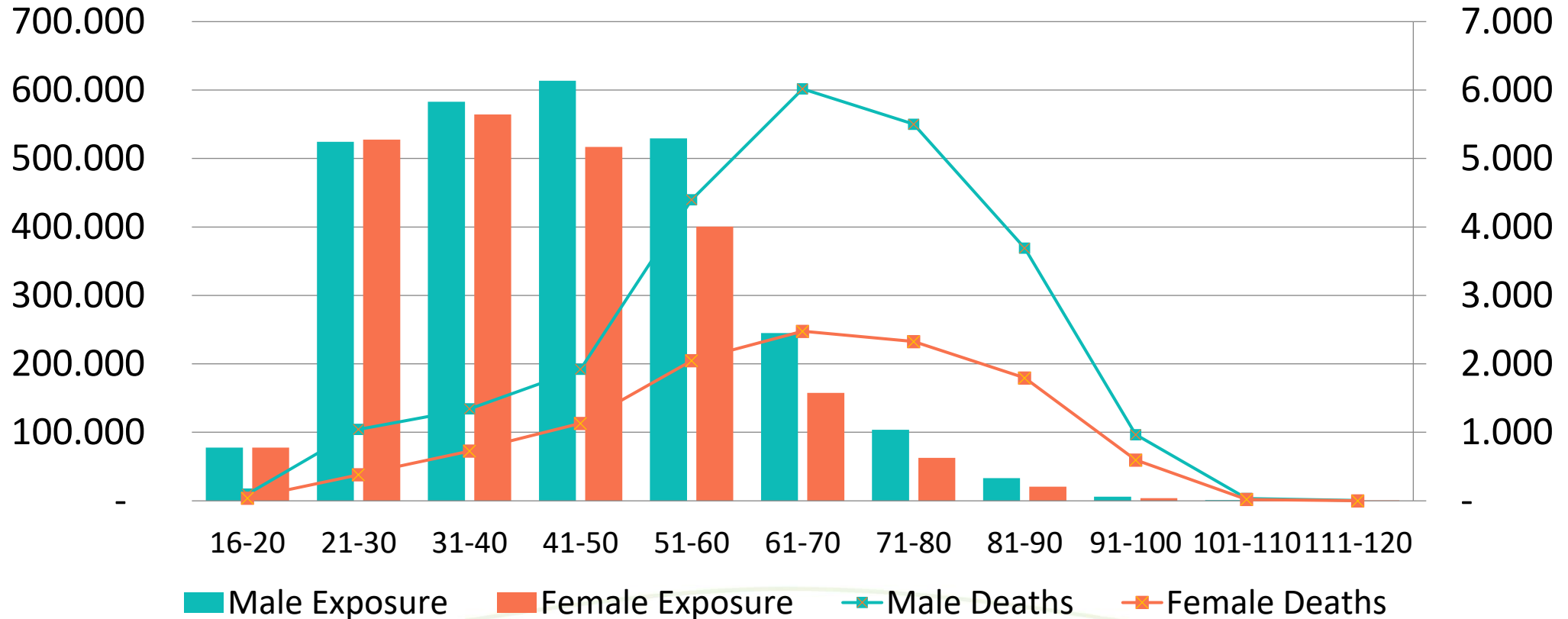
Age distribution of registered persons after the "Zombie Hunt"





EXPOSURE AND OBSERVED DEATHS

Observed Exposure & Deaths by 10 Year Age Groups





ANALYSIS

- Graduation
- Extension to younger ages and older ages
 - Observed vs. Expected Mortality
 - Expected Financial Impact



GRADUATION

- There was sufficient data for constructing a table in the mid-range of ages, but much less at the younger and older ages, especially for females.
- Age ranges chosen: Male: 25 – 90 Female: 35 – 90



GRADUATION

- Whittaker-Henderson (WH) graduation was used to smoothen the raw findings within the chosen age ranges.
- WH graduation allows practitioners to customize the tradeoff between goodness of fit and smoothness and has been extensively employed:

The Canadian Institute of Actuaries CPM-RPP14
Singapore Complete Life Tables



GRADUATION

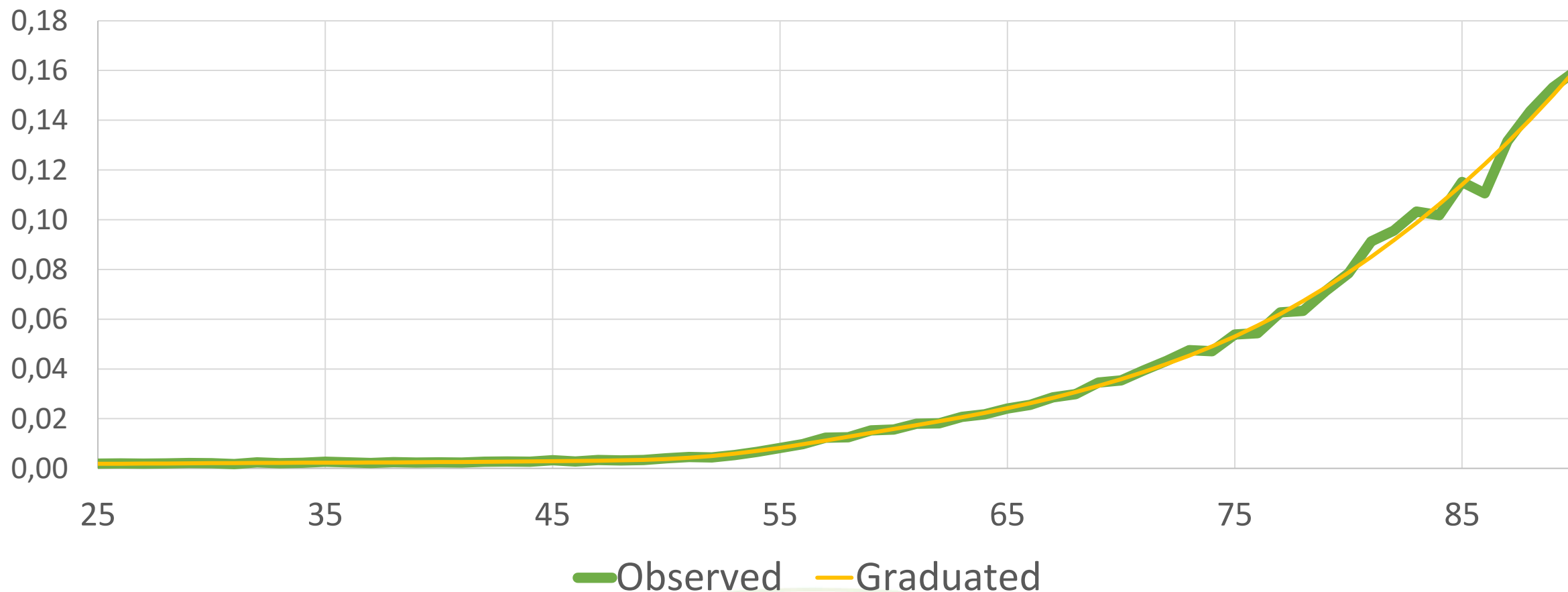
- The standard expression to be optimized is given below:

$$\sum Wt(Grad - Raw)^2 + h \sum (\Delta^n Grad)^2$$

- Where:
 - Raw* – the mortality rates determined by the study
 - Wt* – the weights corresponding to each raw rate
 - Grad* – the graduated mortality rates
 - n* – the order of difference equation being used to express smoothness
 - h* – the balancing factor between fit and smoothness.

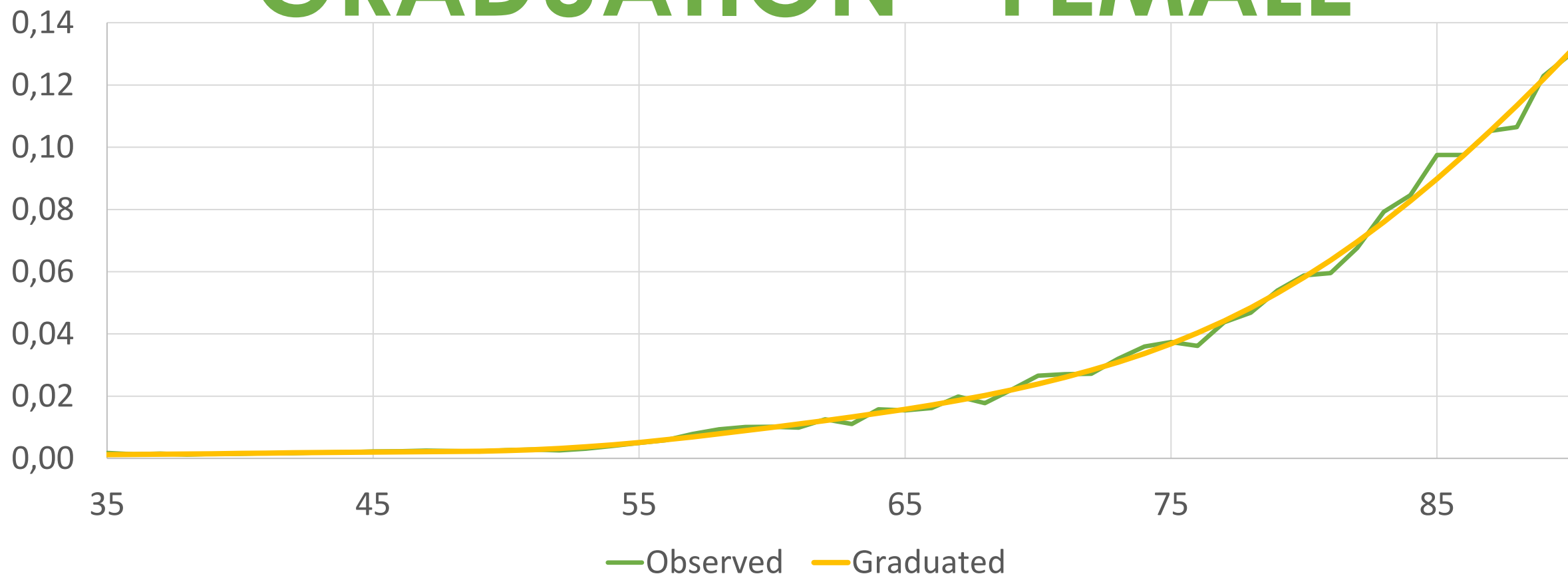


GRADUATION - MALE





GRADUATION - FEMALE





GRADUATION

- Heligman-Pollard (HP) method was used to transform the Trinidad & Tobago CSO 2011 abridged life tables to complete individual life tables (**2011 Trinidad and Tobago Population Tables**).
- The method was also applied to the Jamaica 2011 Census abridged life tables to transform them to individual life tables (**2011 Jamaica Population Tables**).



HP Method

$$\frac{q_x}{p_x} = A(x + B)^C + D \exp(-E(\ln(x/F))^2) + GH^x$$

For the Left-Hand Side:

q_x is the model probability that an individual who has reached age x will die before reaching age $x + 1$, while $p_x = 1 - q_x$. The quotient $\frac{q_x}{p_x}$ thus represents the odds that an individual of age x will die before he attains age $x + 1$.



HP Method

$$\frac{q_x}{p_x} = A(x + B)^C + D \exp(-E(\ln(x/F))^2) + GH^x$$

For the Right-Hand Side:

The first term reflects the fall in mortality at the infant and early childhood ages. The second term reflects the middle life mortality. The third term reflects the exponential rise in mortality at the later adult ages.

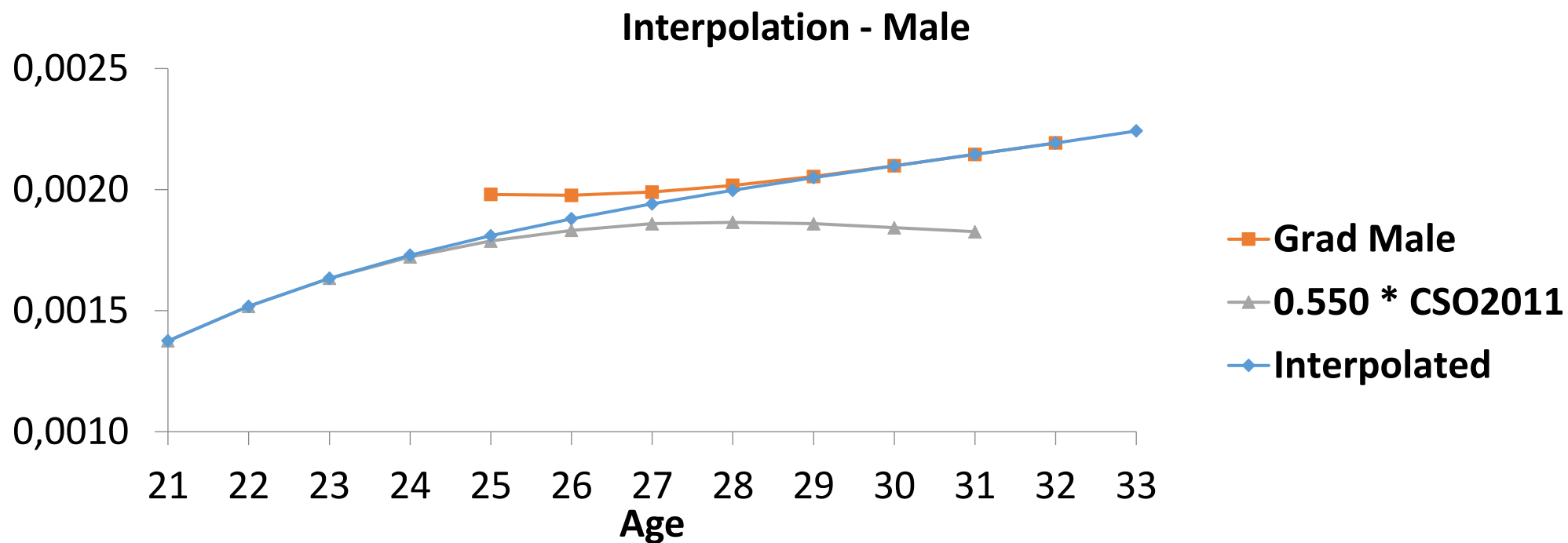


HP METHOD

- At younger ages, where data was very scarce for the UWI-NIBTT 2014 Tables, we fit our graduated table to the transformed 2011 Trinidad and Tobago Population Tables complete life table using 5th Order Polynomials.



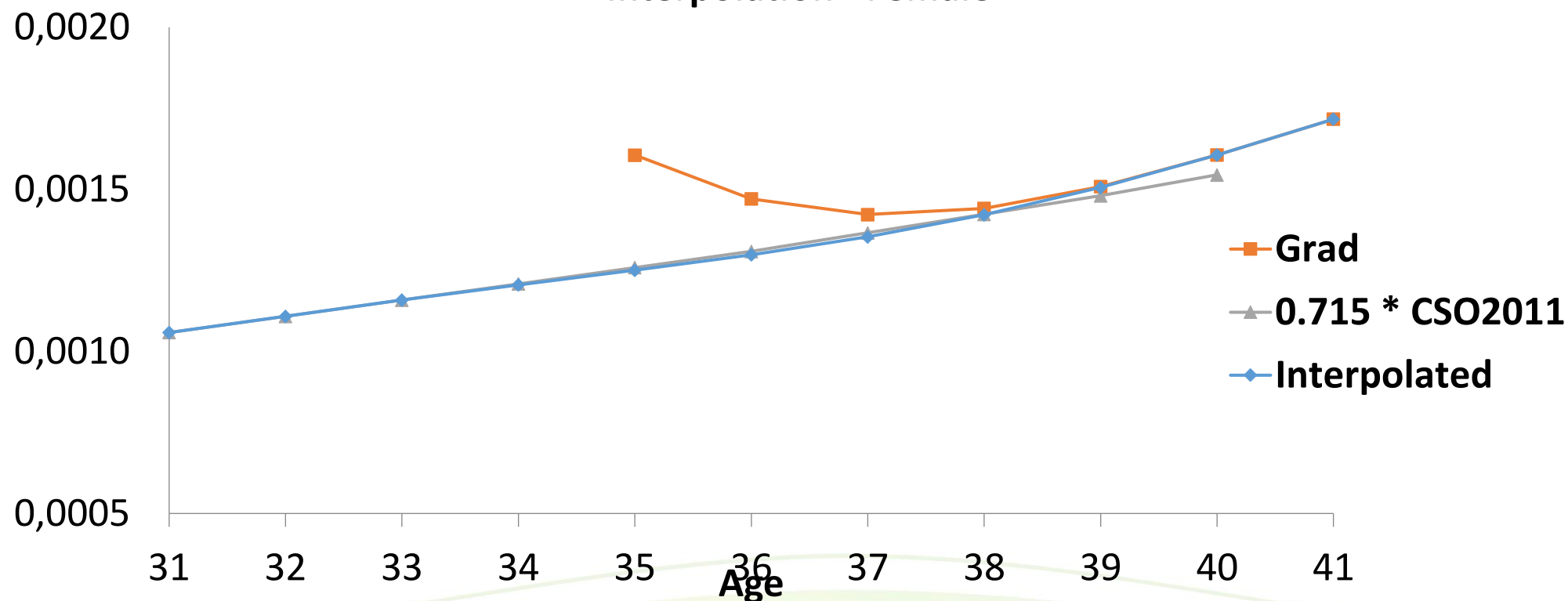
EXTENSION TO YOUNGER AGES





EXTENSION TO YOUNGER AGES

Interpolation - Female





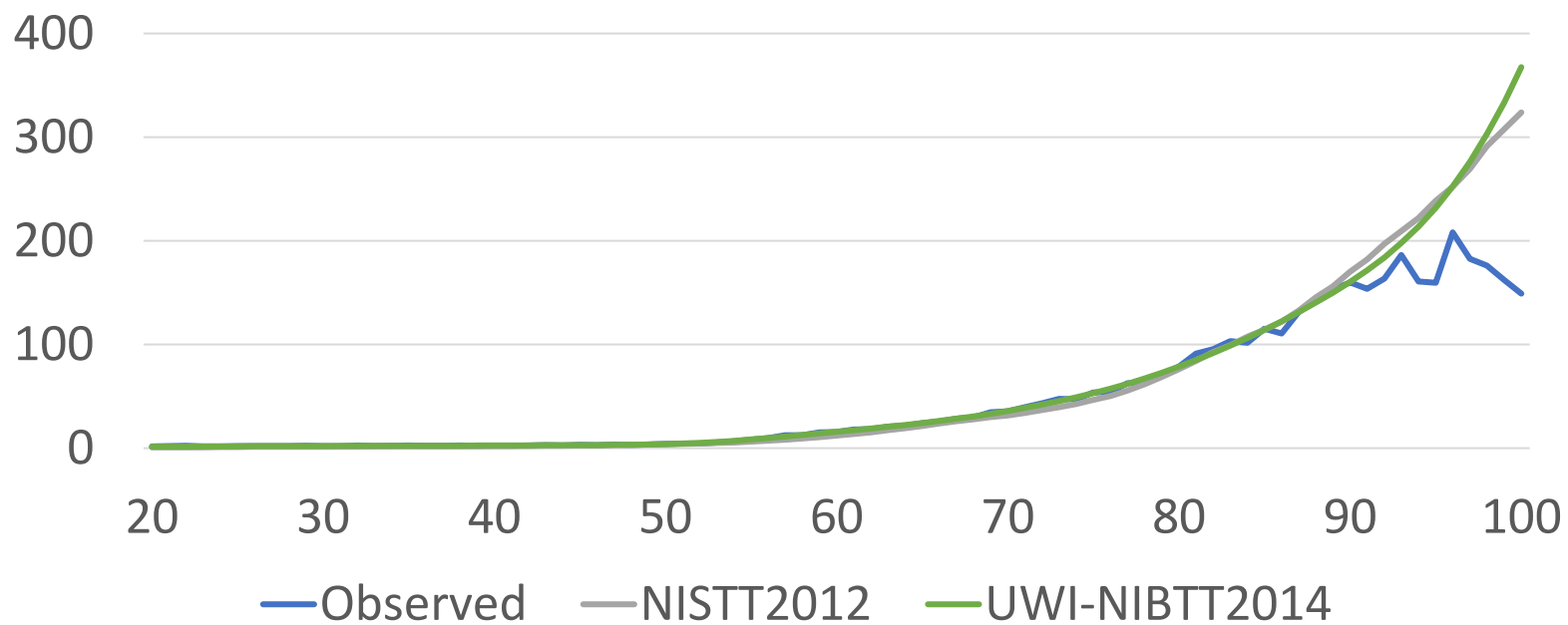
EXTENSION TO OLDER AGES

- The oldest verified Trinidadian male lived to age 108 and oldest verified female is alive at age 110.
- A terminal age of 110 was chosen and a 3rd order polynomial was fit using ages 88, 89, 90 & 110 as nodes.



qx Comparison

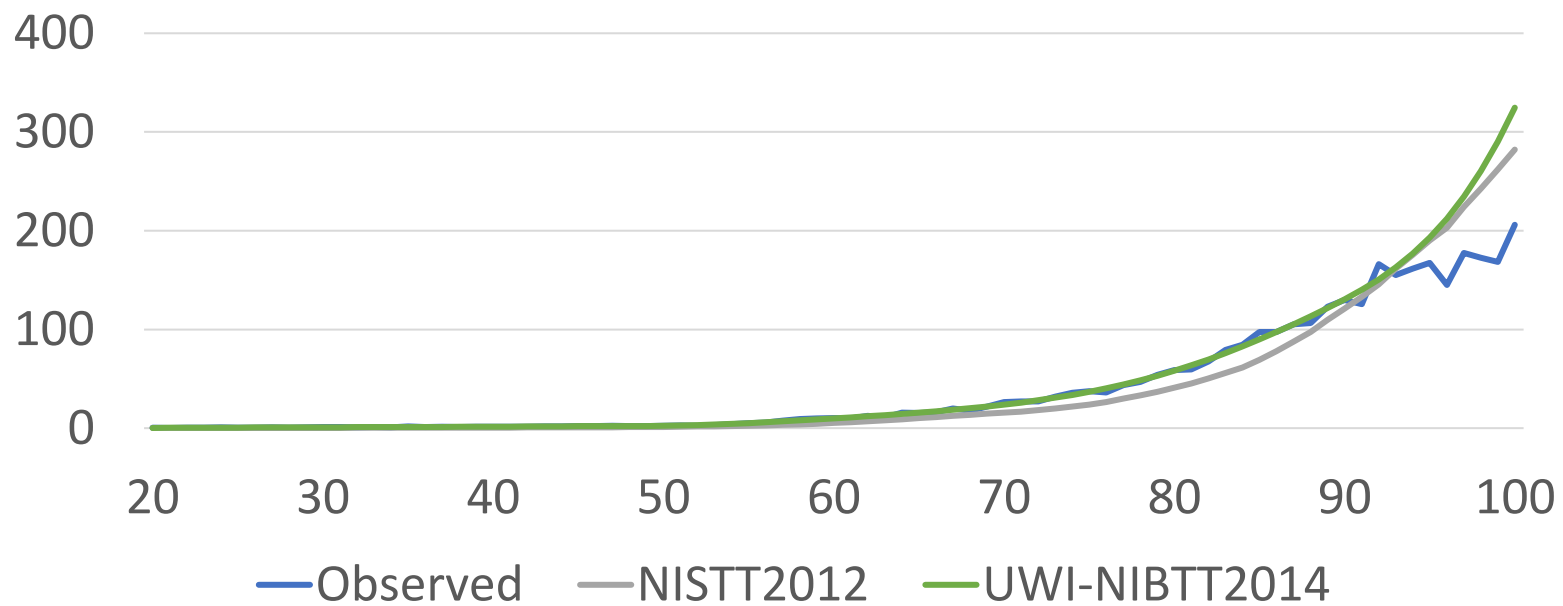
Males - 1000* q_x





qx Comparison

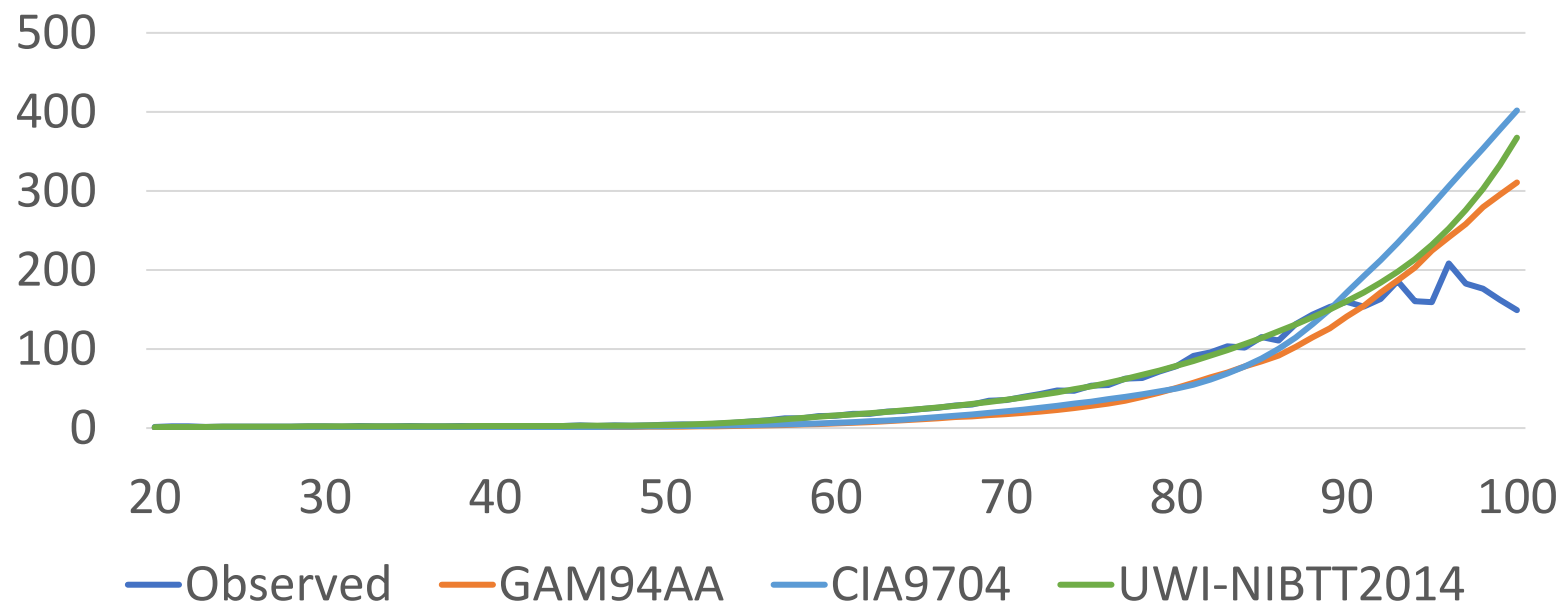
Females - $1000 * q_x$





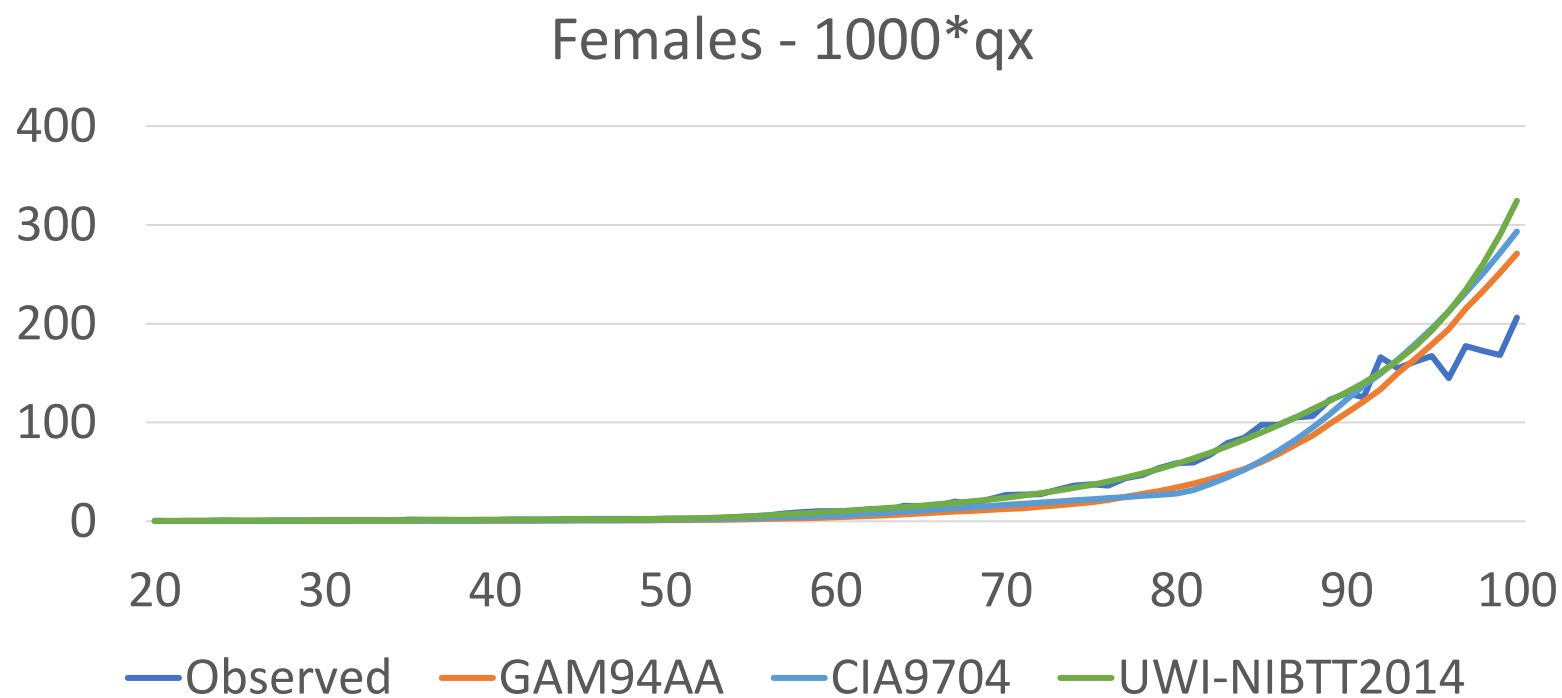
qx Comparison

Males - 1000* q_x





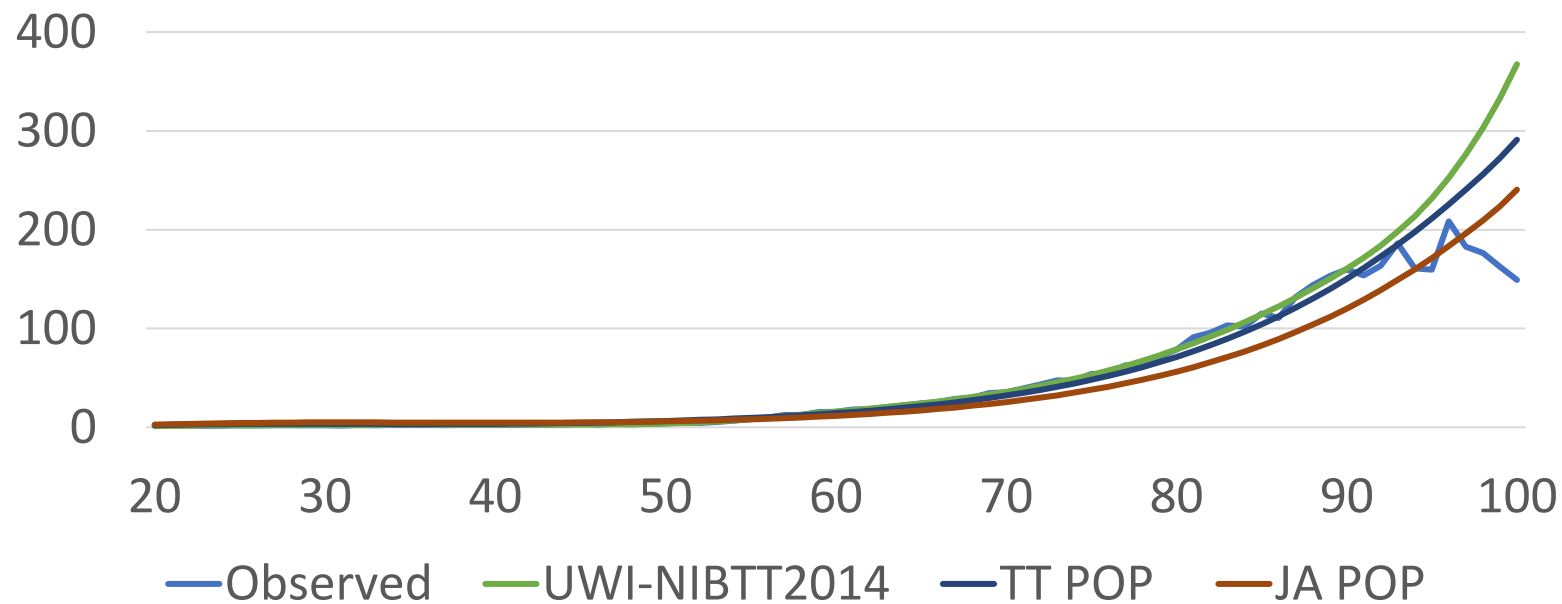
qx Comparison





qx Comparison

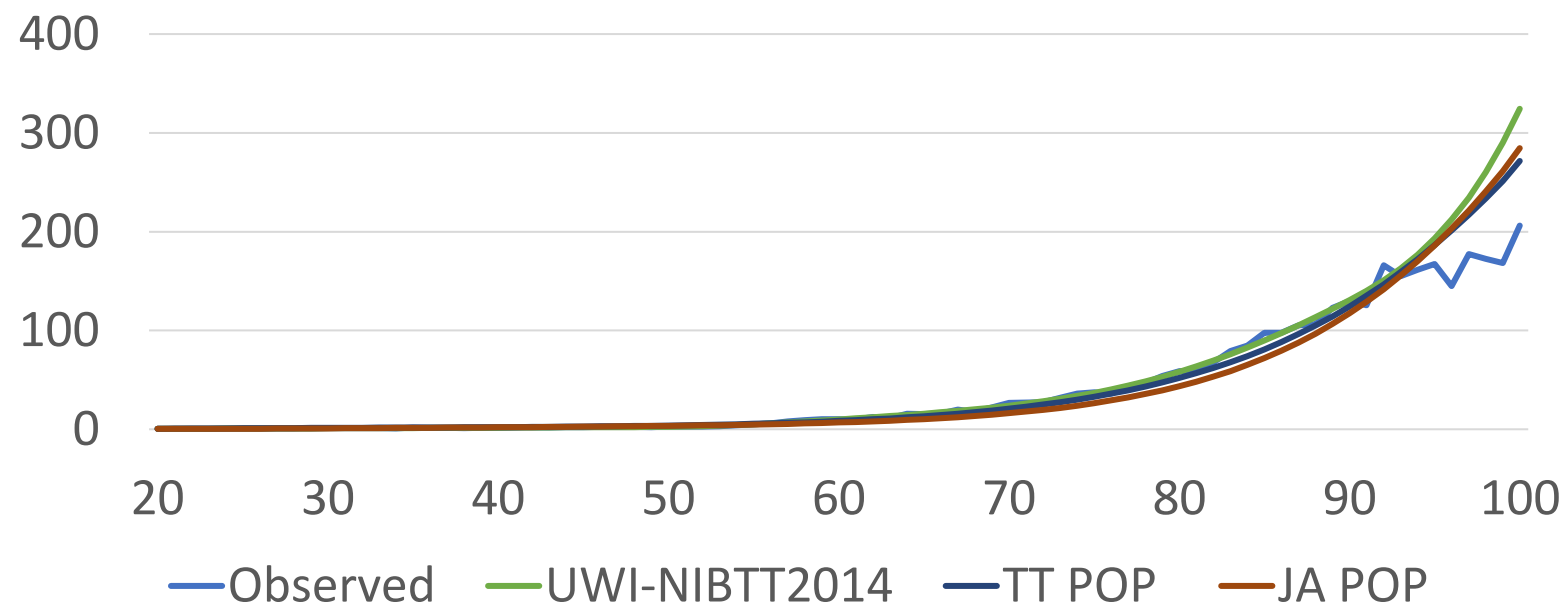
Males - $1000 * q_x$





qx Comparison

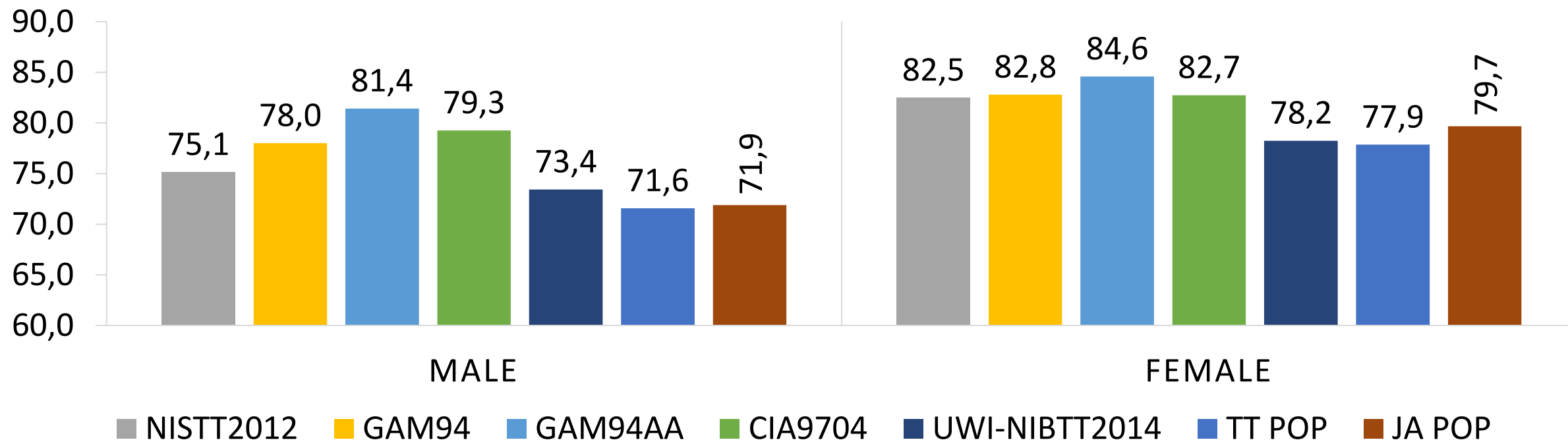
Females - $1000 * q_x$





EXPECTED FINANCIAL IMPACT

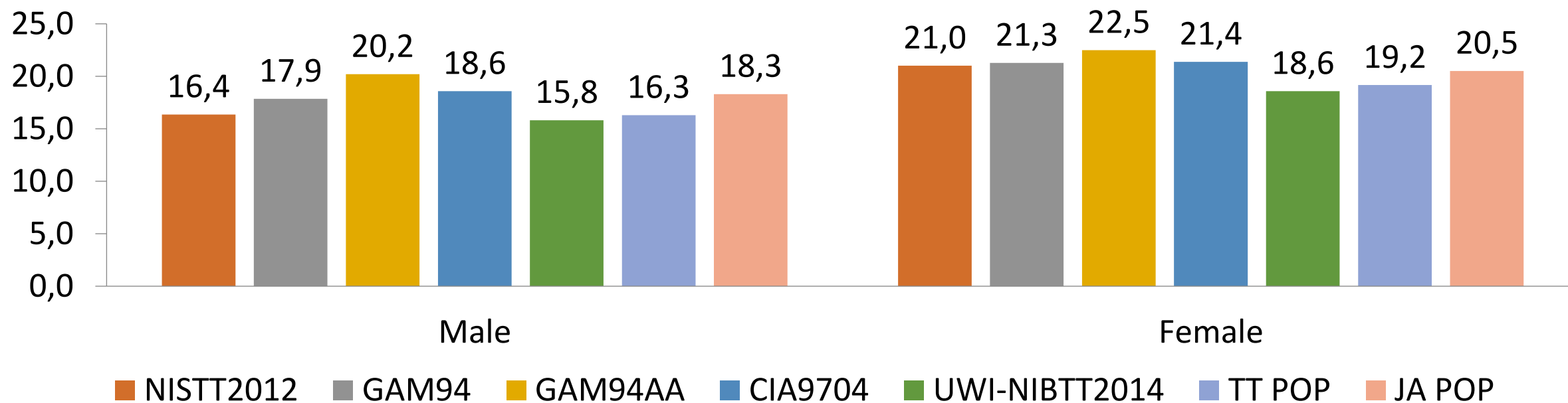
LIFE EXPECTANCY AT BIRTH





EXPECTED FINANCIAL IMPACT

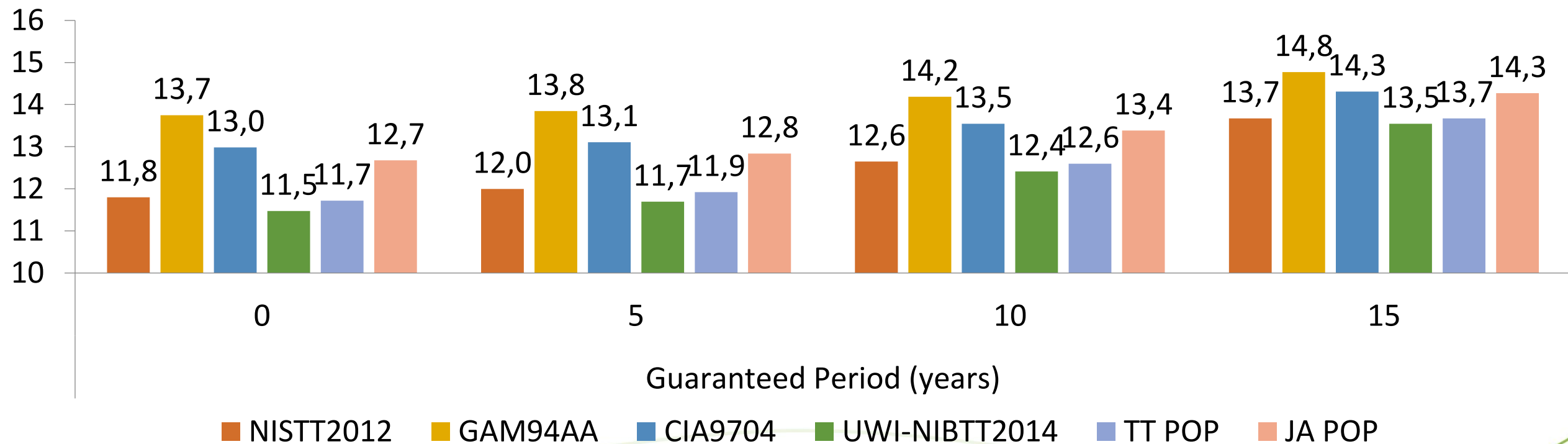
Life Expectancy at Age 65





EXPECTED FINANCIAL IMPACT

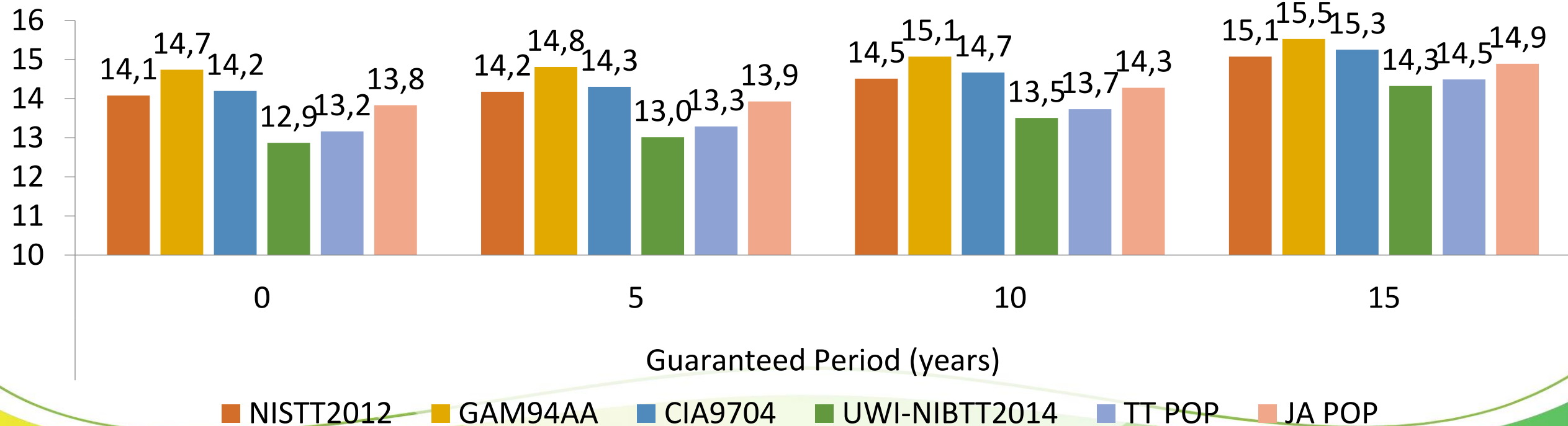
Annuity of \$1.00 per year, payable annually in advance, for a male aged 65 and 4% level interest





EXPECTED FINANCIAL IMPACT

Annuity of \$1.00 per year, payable annually in advance, for a female aged 65 and 4% level interest



UWI-NIBTT14 Tables

Age	Male	Female	Age	Male	Female	Age	Male	Female	Age	Male	Female
0	0.01508	0.01395	28	0.00200	0.00089	56	0.00971	0.00599	84	0.10625	0.08274
1	0.00045	0.00065	29	0.00205	0.00095	57	0.01120	0.00692	85	0.11411	0.08988
2	0.00024	0.00035	30	0.00210	0.00100	58	0.01274	0.00791	86	0.12239	0.09738
3	0.00018	0.00024	31	0.00215	0.00106	59	0.01430	0.00894	87	0.13113	0.10523
4	0.00015	0.00019	32	0.00219	0.00111	60	0.01586	0.00999	88	0.14037	0.11341
5	0.00013	0.00016	33	0.00224	0.00116	61	0.01742	0.01106	89	0.15011	0.12188
6	0.00013	0.00014	34	0.00228	0.00121	62	0.01900	0.01217	90	0.16041	0.13064
7	0.00013	0.00012	35	0.00231	0.00125	63	0.02064	0.01332	91	0.17158	0.14009
8	0.00013	0.00011	36	0.00234	0.00130	64	0.02236	0.01452	92	0.18398	0.15065
9	0.00014	0.00011	37	0.00237	0.00135	65	0.02420	0.01580	93	0.19794	0.16273
10	0.00015	0.00011	38	0.00241	0.00142	66	0.02619	0.01717	94	0.21379	0.17673
11	0.00017	0.00011	39	0.00247	0.00151	67	0.02835	0.01865	95	0.23187	0.19309
12	0.00020	0.00012	40	0.00253	0.00161	68	0.03068	0.02025	96	0.25252	0.21220
13	0.00025	0.00014	41	0.00260	0.00172	69	0.03320	0.02200	97	0.27608	0.23447
14	0.00033	0.00016	42	0.00268	0.00183	70	0.03591	0.02392	98	0.30287	0.26033
15	0.00043	0.00019	43	0.00276	0.00192	71	0.03883	0.02602	99	0.33325	0.29018
16	0.00057	0.00022	44	0.00284	0.00200	72	0.04197	0.02834	100	0.36754	0.32444
17	0.00072	0.00026	45	0.00291	0.00206	73	0.04536	0.03089	101	0.40609	0.36351
18	0.00089	0.00031	46	0.00298	0.00210	74	0.04904	0.03373	102	0.44923	0.40781
19	0.00106	0.00036	47	0.00308	0.00215	75	0.05304	0.03687	103	0.49729	0.45776
20	0.00122	0.00041	48	0.00322	0.00221	76	0.05739	0.04035	104	0.55062	0.51376
21	0.00138	0.00047	49	0.00345	0.00233	77	0.06212	0.04420	105	0.60955	0.57623
22	0.00152	0.00054	50	0.00380	0.00251	78	0.06725	0.04844	106	0.67441	0.64557
23	0.00163	0.00059	51	0.00432	0.00280	79	0.07279	0.05310	107	0.74556	0.72221
24	0.00173	0.00066	52	0.00502	0.00319	80	0.07871	0.05818	108	0.82331	0.80655
25	0.00181	0.00072	53	0.00592	0.00372	81	0.08503	0.06369	109	0.90801	0.89901
26	0.00188	0.00078	54	0.00702	0.00436	82	0.09172	0.06963	110	1.00000	1.00000
27	0.00194	0.00084	55	0.00830	0.00513	83	0.09879	0.07598			

2011 Trinidad and Tobago Population Tables

Age	Male	Female	Age	Male	Female	Age	Male	Female	Age	Male	Female
0	0.01508	0.01395	28	0.00339	0.00125	56	0.01029	0.00601	84	0.09667	0.07415
1	0.00082	0.00091	29	0.00338	0.00133	57	0.01116	0.00653	85	0.10421	0.08097
2	0.00044	0.00049	30	0.00335	0.00140	58	0.01211	0.00710	86	0.11227	0.08837
3	0.00032	0.00034	31	0.00332	0.00148	59	0.01314	0.00773	87	0.12086	0.09637
4	0.00027	0.00026	32	0.00328	0.00155	60	0.01426	0.00843	88	0.13002	0.10501
5	0.00024	0.00022	33	0.00325	0.00162	61	0.01547	0.00921	89	0.13976	0.11433
6	0.00023	0.00019	34	0.00323	0.00169	62	0.01679	0.01006	90	0.15011	0.12437
7	0.00023	0.00017	35	0.00322	0.00176	63	0.01821	0.01099	91	0.16107	0.13515
8	0.00024	0.00016	36	0.00323	0.00183	64	0.01976	0.01203	92	0.17268	0.14672
9	0.00025	0.00015	37	0.00326	0.00191	65	0.02144	0.01316	93	0.18494	0.15909
10	0.00027	0.00015	38	0.00332	0.00199	66	0.02326	0.01442	94	0.19786	0.17230
11	0.00030	0.00016	39	0.00340	0.00207	67	0.02524	0.01579	95	0.21144	0.18636
12	0.00037	0.00017	40	0.00351	0.00216	68	0.02737	0.01730	96	0.22570	0.20129
13	0.00046	0.00019	41	0.00364	0.00226	69	0.02968	0.01896	97	0.24063	0.21710
14	0.00060	0.00022	42	0.00381	0.00237	70	0.03218	0.02078	98	0.25622	0.23379
15	0.00079	0.00026	43	0.00401	0.00249	71	0.03488	0.02278	99	0.27245	0.25135
16	0.00103	0.00031	44	0.00424	0.00263	72	0.03781	0.02498	100	0.29109	0.27152
17	0.00131	0.00037	45	0.00451	0.00277	73	0.04096	0.02738	101	0.31392	0.29605
18	0.00161	0.00043	46	0.00481	0.00294	74	0.04437	0.03001	102	0.34270	0.32667
19	0.00192	0.00051	47	0.00515	0.00312	75	0.04805	0.03289	103	0.37921	0.36512
20	0.00222	0.00058	48	0.00552	0.00332	76	0.05202	0.03605	104	0.42522	0.41315
21	0.00250	0.00066	49	0.00594	0.00355	77	0.05629	0.03950	105	0.48250	0.47250
22	0.00276	0.00075	50	0.00641	0.00380	78	0.06089	0.04326	106	0.55282	0.54492
23	0.00297	0.00083	51	0.00692	0.00408	79	0.06585	0.04738	107	0.63796	0.63213
24	0.00313	0.00092	52	0.00748	0.00439	80	0.07117	0.05186	108	0.73969	0.73589
25	0.00325	0.00101	53	0.00809	0.00473	81	0.07689	0.05675	109	0.85978	0.85793
26	0.00333	0.00109	54	0.00876	0.00512	82	0.08303	0.06207	110	1.00000	1.00000
27	0.00338	0.00117	55	0.00950	0.00554	83	0.08962	0.06786			

2011 Jamaica Population Tables

Age	Male	Female	Age	Male	Female	Age	Male	Female	Age	Male	Female
0	0.01995	0.01486	28	0.00480	0.00076	56	0.00862	0.00509	84	0.07669	0.06516
1	0.00070	0.00059	29	0.00488	0.00084	57	0.00926	0.00545	85	0.08277	0.07200
2	0.00052	0.00048	30	0.00492	0.00093	58	0.00996	0.00585	86	0.08928	0.07951
3	0.00044	0.00043	31	0.00493	0.00101	59	0.01073	0.00630	87	0.09625	0.08775
4	0.00040	0.00039	32	0.00491	0.00111	60	0.01158	0.00680	88	0.10371	0.09677
5	0.00037	0.00037	33	0.00488	0.00120	61	0.01250	0.00735	89	0.11167	0.10663
6	0.00035	0.00035	34	0.00483	0.00130	62	0.01351	0.00797	90	0.12016	0.11738
7	0.00035	0.00033	35	0.00478	0.00141	63	0.01461	0.00865	91	0.12920	0.12908
8	0.00034	0.00032	36	0.00472	0.00151	64	0.01580	0.00942	92	0.13882	0.14177
9	0.00035	0.00031	37	0.00467	0.00162	65	0.01710	0.01027	93	0.14903	0.15550
10	0.00037	0.00030	38	0.00462	0.00174	66	0.01852	0.01121	94	0.15985	0.17030
11	0.00040	0.00030	39	0.00459	0.00185	67	0.02005	0.01227	95	0.17130	0.18622
12	0.00047	0.00029	40	0.00458	0.00197	68	0.02172	0.01345	96	0.18339	0.20328
13	0.00058	0.00029	41	0.00459	0.00209	69	0.02352	0.01476	97	0.19613	0.22148
14	0.00074	0.00029	42	0.00461	0.00222	70	0.02548	0.01622	98	0.20953	0.24084
15	0.00095	0.00029	43	0.00467	0.00235	71	0.02760	0.01784	99	0.22360	0.26132
16	0.00121	0.00030	44	0.00475	0.00249	72	0.02989	0.01965	100	0.24036	0.28446
17	0.00153	0.00031	45	0.00486	0.00264	73	0.03237	0.02167	101	0.26183	0.31179
18	0.00188	0.00032	46	0.00500	0.00279	74	0.03506	0.02391	102	0.29002	0.34485
19	0.00226	0.00034	47	0.00517	0.00295	75	0.03796	0.02640	103	0.32696	0.38517
20	0.00265	0.00036	48	0.00539	0.00312	76	0.04109	0.02916	104	0.37466	0.43430
21	0.00303	0.00039	49	0.00563	0.00330	77	0.04447	0.03223	105	0.43515	0.49377
22	0.00340	0.00042	50	0.00592	0.00349	78	0.04812	0.03564	106	0.51044	0.56512
23	0.00374	0.00046	51	0.00625	0.00370	79	0.05205	0.03941	107	0.60255	0.64988
24	0.00405	0.00051	52	0.00663	0.00393	80	0.05629	0.04359	108	0.71350	0.74959
25	0.00430	0.00057	53	0.00705	0.00418	81	0.06085	0.04821	109	0.84531	0.86578
26	0.00452	0.00063	54	0.00752	0.00446	82	0.06576	0.05332	110	1.00000	1.00000
27	0.00468	0.00069	55	0.00804	0.00476	83	0.07103	0.05895			



THE WAY FORWARD

- Limitations encountered
- Ideas for Further Research



LIMITATIONS

- The results presented are reliant on the accuracy of the data provided by the NIBTT.
- The lack of information on the younger and older ages as the data is based on salaried persons.



IDEAS FOR FURTHER RESEARCH

- Obtain empirical data for non-salaried ages to complete mortality tables, especially at the younger and older ages, for Trinidad and Tobago.
- Morbidity studies to get insight on what is contributing to the relatively high mortality of Trinbagonian nationals.
- Research into factors that may be contributing to the mortality rates observed in this current research.



IDEAS FOR FURTHER RESEARCH

- Creation of analogous Mortality tables for other Caribbean nations
- Publication of the UWI-NIBTT14 tables after peer review by the SoA.



IDEAS FOR FURTHER RESEARCH

- Adoption of the UWI-NIBTT14 Table for pricing and valuation of group and annuity products in Trinidad and Tobago.
- Adoption of future indigenous tables in the Caribbean for the pricing and valuation of insurance products in their native countries



Acknowledgements

I would like to thank the following individuals and organizations for their contributions to the 'Mortality Tables' project:

The National Insurance Board of Trinidad and Tobago

- Mr. Feyaad Khan
- Mr. Andy Edwards
- Mr. Michael Raymond
- Ms. Karlene Noreiga

The Caribbean Actuarial Association

- Mr. Marcus Bosland
- Ms. Sapna Chatlani
- Ms. Leah Major
- Ms. Simone Brathwaite



Acknowledgements

KR Services

- Mr. Kyle Rudden
- Ms. Roma Chatlani
- Ms. Sarika Chin Fong

Maritime Life

- Mr. Yasid Gilbert
- Mr. Resan Pakeerah



Acknowledgements

The University of the West Indies, St. Augustine

- Dr. Robin Antoine
- Ms. Alisha Estrada
- Ms. Chandini Gunpat

Bacon Woodrow & De Souza

- Mr. Simon Sutcliffe

The Society of Actuaries

- For providing the Access Experience Study Software Tool



THANK YOU
