Linger Thermo Theory

Part II: A Weight Unbiased Methodology for Setting Life Insurance Premiums

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Abstract — A nascent linger thermo theory is found to lead to a weight unbiased methodology for setting life insurance premiums. The approach is based on a theoretical adult lifespan τ calculated according to:

$$\tau = \Delta\tau\left(\frac{M}{\Delta M}\right)^2$$

where M is the adult's mass, ΔM is the daily food mass (e.g., 0.4 *kg* for a daily 2,000 kcal diet of a M=70 *kg* adult) and $\Delta\tau$ is the duration of one day. Since τ is proportional to the ratio of an individual's mass to the consumed food per day squared, i.e., $(M/\Delta M)^2$, it predicts that the theoretical adult life expectancy of an individual can be weight independent as long as the ratio $M/\Delta M$ remains constant as he gains or loses fat. Most importantly, this 2010 theoretical prediction is supported by United States National Institute of Aging (NIA) rhesus monkey study results, first reported in a 2012 Nature journal article, which surprised and shocked the researchers when they discovered that higher weight (obese) monkeys had a similar life expectancy as lower weight ones. It is thus expected that the proposed premium acquisition method should improve on traditional calculations and actuarial tables that often presume that obese individuals have lower life expectancies.

Keywords — thermodynamics, lingerdynamics, entropy, ectropy, information, latency, statistical physics, lifespan, life insurance, premium, actuarial tables, weight

I. Introduction

LIFE insurance premiums are calculated [1] on the basis of a series of parameters including demographic data, medical history, and weight. It is customary for insurance companies to utilize actuarial tables and other calculations in an attempt to predict the individual's life expectancy. This predicted life expectancy, in turn, impacts the individual's life insurance premium. Those individuals with an estimated short life expectancy would pay high premiums while those with relatively long life expectancy pay lower premiums. Unfortunately, the actuarial tables used by insurance companies only correlate some variables which are currently believed to impact life expectancy. Additional medical studies have discovered new variables that the current tables fail to consider. For instance, these tables often presume that obese individuals have lower life expectancies, when this 'by itself' may not be the case at all as a major study with rhesus monkeys has recently revealed [2]-[3]. It is thus desirable to provide an improved method for calculating life insurance premiums that takes into account additional variables so as to provide more accurate life expectancy predictions.

In this paper a weight unbiased methodology for setting life insurance premiums is advanced. The derivation of the premium has at its core a theoretical adult lifespan τ calculated according to:

$$\tau = \Delta\tau\left(\frac{M}{\Delta M}\right)^2 \qquad (1)$$

where M is the mass of the adult, ΔM is the mass of the consumed food per day (e.g., 0.4 *kg* for a daily 2,000 *kcal* diet of a M=70 *kg* adult, where a conversion factor of 5,000 *kcal* per *kg* was used) and $\Delta\tau$ is the duration of one day. In Section II it will be found that the quadratic equation (1) inherently surfaces from within a *universal linger-thermo equation* of linger thermo theory (LTT) [4]-[7]. LTT is a nascent theory that is solidly anchored in statistical physics and information systems and thus can be a judicious predictor of wide ranging phenomena as is highlighted in [4] and also touched on in Section II of this paper. Since τ is proportional to the ratio of the individual's mass to the consumed food per day squared, i.e., $(M/\Delta M)^2$, equation (1) predicts that the theoretical adult lifespan of an individual can be weight independent as long as the ratio $M/\Delta M$ remains constant as he gains or loses fat. Most importantly, this 2010 theoretical prediction [6] is supported by a recent United States National Institute of Aging (NIA) study published September 13, 2012 in the journal Nature [3], which surprised and shocked the researchers when they discovered that higher weight (obese) rhesus monkeys had a similar life expectancy as lower weight ones. One of the reasons why these NIA study results have attracted such attention [2] is because the study started in the 1980s, which is sufficient time to start deriving conclusions since the lifespan of rhesus monkeys, is around 35 years. Unfortunately, however, in the case of humans a similar type of study is not feasible since our lifespan is around 120 years. Yet, due to the similarities of our two species, it is reasonable to assume that the rhesus monkeys study results would also apply to humans. It is thus expected that the proposed LTT method should improve on traditional calculations and actuarial tables that often presume that obese individuals have lower life-expectancies.

The organization of this paper is as follows: In Section II a background section is given that succinctly explains the most basic elements of LTT that, in turn, lead to (1). In Sections III and IV a weight unbiased methodology for setting life-insurance premiums is advanced. In Section V the method is illustrated with five examples. Finally in Section VI conclusions are drawn.

II. Background

In this section, the emergence of the theoretical adult lifespan equation (1)—first disclosed in [6]—from linger thermo theory is explored. The discussion begins with a study of the lifespan τ of the source-information bits in LTT (or life-bits in short) that are assumed responsible for enabling the observation of some *physical entity* in a closed-system, or universe as is called in thermodynamics [8], where the physical entity can either be of a non-living, e.g., an image, or living, e.g., a human, nature. Moreover, it is assumed that LTT's life-bits can only leave the closed-system as radiation with the caveat that if their mass-energy is later restored to the system it may no longer represent life-bits. Thus if a sufficient number of enabling life-bits are emitted without replacement from the system it can then be said that the physical entity represented by these life-bits is not longer there. An image source coding example can be used to illustrate these ideas. Consider a subbands based minimum mean square error (MMSE) predictive-transform (PT) source coder [9] that encodes a single monochrome 512x512 pixels image, say the often encoded Lena image, in seven subbands innovation-transform-coefficient vectors $\{\delta\underline{c}'_k\text{:k=1,.,7}\}$. Our closed-system would then consist of the mass-energy representing the MMSE PT source-coder plus the mass-energy representing $\{\delta\underline{c}'_k\text{:k=1,.,7}\}$. The lifespan τ of the physical entity of interest can then be defined, for instance, as the emission time of the expected number of life-bits encoding the innovations $\{\delta\underline{c}'_k\text{:k=1,.,7}\}$ whose mass-energy may vary. Clearly similar ideas can be applied to human lifespan with life-bits radiated each day from the body cells as black-body radiation [10]. In [4] a *theoretical* estimate of the number of these daily life-bits is determined for a 70 kg individual who consumes 0.4 kg of food daily. The number is 0.3 megabytes with a radiation energy that is approximately 10% of the individual's daily radiation of 8.368 *MJ* [10]. The loss of LTT's life-bits for a biological system produce the effects of aging after childhood (like lost subbands of an image [9], [11]), say after 18 years of age for a human when it is assumed that neither *new or lost* life-bits are being *created or replaced*, by whatever means, at a satisfactory rate. We next proceed to a discussion of LTT's origin and basic assumptions.

LTT inherently surfaced as the dynamics dual of the stationary entropy/ectropic based latency information theory [4]. In LTT four interacting information system types exist in a closed-system whose volume V contains a fixed amount of mass-energy $E=Mc^2$ where E is energy, M is mass and c is the speed of light in a vacuum. The four information systems are:

1) An *'information-source'* whose source-information expectation—called the thermo source-entropy, in binary digit (*bit*) space-units, with symbol $\tilde{H}$—is found according to:

$$\tilde{H} = \log_2\Omega = S/k\ln 2 \tag{2}$$

where Ω is the number of possible microstates that the universe can assume, S is the thermodynamics entropy and k is the Boltzmann's constant, both in physical SI J/K units.

2) An *'information-retainer'* whose retainer-information expectation—called the thermo retainer-entropy, in SI squared meter (m^2) space-units, with symbol $\tilde{N}$—is given by:

$$\tilde{N} = 4\pi r^2 = 4\pi\left(2GM/v_e^2\right)^2 \tag{3}$$

where $4\pi r^2$ is a spherical retainer's surface area with r being the radius, which is the smallest possible surface area for retained mass-energy in a fixed volume V, M is a point-mass residing at the sphere's center, G is the gravitational constant and v_e is the escape speed of mass-energy at the volume's edge that is also inversely related to r according to: $r = 2GM/v_e^2$. While the mass-energy $E=Mc^2$ remains constant for a closed-system, or universe, the magnitude of v_e varies as the universe's physical characteristics, or medium, changes with time. Extreme values are found for v_e in black-hole mediums where it attains the upper bound of the speed of light c, i.e., $v_e=c$, and photon-gas mediums where it approaches the lower bound of zero. The thermodynamics entropy for a 'spherically shaped' photon-gas is given by $S = 16\pi^3(kT)^3kr^3/135c^3\hbar^3$ [4]-[5] where T is absolute temperature, $\hbar$ is the reduced Planck constant and all the other quantities were defined earlier. When $r = 2GM/v_e^2$ is substituted in this entropy expression the photon-gas's escape velocity equation $v_e^2 = 8\pi\, kTGM/3c\hbar\sqrt[3]{20S/k}$ surfaces. From this equation it is then noted that v_e goes to zero with the passing of time as the universe's entropy S continuously increases due to the 2nd law of thermodynamics (or equivalently the 2nd law of source-thermodynamics [4]), while the thermal energy kT continuously decreases due to the 1st law of thermodynamics (which requires the conservation of energy). Using these bounds for v_e in $r = 2GM/v_e^2$, it is then found that the minimum radius of a minimum surface area spherical universe is that of a black-hole which is given by $r_{Min} = 2GM/c^2$, and its maximum radius is that of a photon-gas which is given by r_{Max} = $3c\hbar\sqrt[3]{20S/k}/4\pi kT$ where the value of r_{Max} approaches infinity with the passing of time. These retainer-entropy enhanced thermodynamics results reveal an increase in the Universe's volume as it transitions from a black-hole to a photon-gas medium that has the merit of being consistent with observations positing that our Universe has been continuously increasing its volume since more than 13.7 billion years ago when it is believed it started with the explosion of a maximally dense mass-energy medium (the so-called Big Bang Theory for our Universe's creation). This result confirms the existence in our LTT of a nascent 'first principles' retainer-entropy enhanced thermodynamics that inherently predicts the observed expansion of a closed-system, or universe [12]. Thus a new 2nd law of retainer-thermodynamics has surfaced that is the retainer dual of the source 2nd law of source-thermodynamics. While in the source case the 2nd law tells us that $\tilde{H}$ increases (or the *mass-energy order* decreases) with time, in the retainer case the 2nd law informs us that $\tilde{N}$ increases (or the *mass-energy retention* decreases) with time.

3) An *'information-processor'* whose processor-latency delay—called the linger processor-ectropy, in binary operator (*bor*) time-units, with symbol $\tilde{K}$—is given by:

$$\tilde{K} = \sqrt{\tilde{H}} \quad (4)$$

where $\tilde{H}$ denotes the expected number of bits inputted to the information-processor and $\tilde{K}$ denotes, for this expected number, the maximum number of computational delay levels (or *bors*) from input to output of the processor. For instance if $\tilde{H}$ is 10^{24} *bits*, then the maximum number of computational levels from input to output $\tilde{K}$ for the expected number of 10^{24} input bits is 10^{12} *bors*. From (4) a monotonically increasing relation between $\tilde{H}$ and $\tilde{K}$ is observed that inherently gives rise to a processor time-dual [4]-[5] for the 2nd law of source-thermodynamics. This time-dual has been called the 2nd law of processor-lingerdynamics telling us that $\tilde{K}$ increases (or the *mass-energy connections* of computation decreases) with time.

4) An *'information-mover'* whose mover-latency delay—called the linger mover-ectropy, in SI second (*s*) time-units, with symbol $\tilde{A}$—is evaluated according to:

$$\tilde{A} = \pi r / v = \sqrt{\pi \tilde{N} / 4v^2} \quad (5)$$

where $\tilde{N}$ is the expected thermo retainer-entropy, $\tilde{A}$ is half the period of an object's circular motion driven by the point-mass M on the surface of a sphere of radius r, and v is the constant speed of the circular motion (which is the same as the escape speed v_e divided by $\sqrt{2}$, i.e., $v = v_e / \sqrt{2}$, since $r = GM/v^2 = 2GM/v_e^2$). From (5) a monotonically increasing relationship between $\tilde{N}$ and $\tilde{A}$ is observed that inherently gives rise to a mover time-dual [4]-[5] for the 2nd law of retainer-thermodynamics. This time-dual has been called the 2nd law of mover-lingerdynamics telling us that $\tilde{A}$ increases (or the *mass-energy mobility* decreases) with time.

In [4] after investigating the thermo source-entropy (1) for black-hole, ideal-gas and photon-gas mediums and making use of the following lifespan pace Π expression in SI *sec*/m^3 units:

$$\Pi = \tau / V \quad (6)$$

where τ denotes the *lifespan of life-bits* stored in a closed-system's mass-energy M=E/c^2 of spherical volume V=$4\pi r^3/3$ [4], the following *universal linger-thermo equation* surfaced:

$$\tilde{\boldsymbol{H}} = g_{Med}\left(\frac{\tilde{\boldsymbol{N}}}{\Delta\tilde{\boldsymbol{N}}} = \frac{\boldsymbol{V}}{\Delta\boldsymbol{V}} = \frac{\tau}{\Delta\tau} = \left(\frac{\boldsymbol{M}}{\Delta\boldsymbol{M}}\right)^2 = \left(\frac{\boldsymbol{r}}{\Delta\boldsymbol{r}}\right)^2 = \left(\frac{\tilde{\boldsymbol{A}}}{\Delta\tilde{\boldsymbol{A}}}\right)^2\right) = \tilde{\boldsymbol{K}}^2 \quad (7)$$

where g_{Med} is a medium dependent function that relates the mathematical-units entropy-ectropy pair ($\tilde{H}, \tilde{K}$) to: 1) the physical-units entropy-ectropy pair ($\tilde{N}, \tilde{A}$) and its *so-called quantum of operation* (QOO) [4] version ($\Delta\tilde{N}$: called the 'breath of space', $\Delta\tilde{A}$: called the 'bell of time'); and 2) the physical spherical-volume V, lifespan τ, mass M and radius r and their QOO-volume ΔV, QOO-lifespan $\Delta\tau$, QOO-mass ΔM and QOO-radius Δr. An example of g_{Med} is for a black-hole where g_{BH} is a unity gain, thus (7) becomes: $\tilde{H} = \tilde{N}/\Delta\tilde{N}$ = $V/\Delta V$ = $\tau/\Delta\tau$ = $(M/\Delta M)^2$ = $(r/\Delta r)^2$=$(\tilde{A}/\Delta\tilde{A})^2$= $\tilde{K}^2$. Moreover, the lifespan pace for a black-hole has been found and is given by Π=τ/V= $\chi = 480c^2/\hbar G$ =6.1203x10^{63} *sec*/m^3 [4]. This pace expression gives the largest possible pace value with symbol χ for any medium since a black-hole is the medium that offers the least resistance to the retention of mass-energy. Furthermore, χ has been called the *pace of dark in a black-hole* since it is the maximum-retention space-dual of the maximum-motion *speed of light in a vacuum c*. Finally it is noted that expression (1) emerges naturally from within the linger-thermo equation (7), where the physical meaning of τ is in terms of radiated life-bits as discussed in some detail in [4].

III. Setting Life-Expectancy Premiums

When solved for the kilograms of food consumption per day, i.e., ΔM, the theoretical adult lifespan τ equation (1) yields the following linear equation on M:

$$\Delta M = \sqrt{\Delta\tau / \tau}\, M \quad (8)$$

where $\sqrt{\Delta\tau/\tau}$ is the slope. In Fig. 1 expression (8) is plotted for four different cases of τ with the duration of one day $\Delta\tau$ being 1/365 in year units. The four cases displayed for τ are 42, 62, 82 and 102 years of theoretical adult lifespan. In the vertical axis of this figure the amount of *kcal/day* linked to ΔM is shown with the conversion factor of 5,000 from *kg* to *kcal* used. In the horizontal axis the mass of the individual is plotted. To the theoretical adult lifespan an additional childhood lifespan of 18 years has been added to yield four cases of total lifespan of 60, 80, 100 and 120 years—the maximum total lifespan believed to be around 120 years [13].

A close scrutiny of Fig. 1 reveals that lower weight and higher weight (obese) individuals would have the same theoretical life-expectancy when their $M/\Delta M$ ratios are identical. For instance, note that 70 *kg* and 100 *kg* individuals would have the same theoretical adult lifespan of 102 years if the 70 *kg* individual consumes 1814 *kcal/day* and the 100 *kg* one consumes 2591 *kcal/day*. When referring to a single individual this result similarly tells us that as long as the $M/\Delta M$ ratio remains constant the theoretical life-expectancy will not change when the individual's weight changes. This property is consistent with the results obtained with rhesus monkeys [3]. In addition, it is shown in the same figure that an individual that maintains his/her weight constant at 70 kg would decrease the theoretical adult lifespan if he consumes a larger amount of kilocalories per day. For instance, an increase of 209 kilocalories per day by a 70 kg individual who normally consumes 1,814 kcal per day to maintain this mass will reduce his τ by 20 years. This result is expected since the increased burning of calories per day to maintain a constant 70 kg mass is accompanied by a metabolism surge [14], or equivalently, an increased wear down of the individual's biological engine, which in turn lowers his lifespan.

Using the theoretical adult lifespan equation results displayed in Fig. 1 at its core, the flowchart of Fig. 2 is then advanced as a framework for the evaluation of a life insurance premium that should improve on traditional calculations and actuarial tables that often presume that obese individuals have lower life-expectancies. The flowchart has six steps. They are:

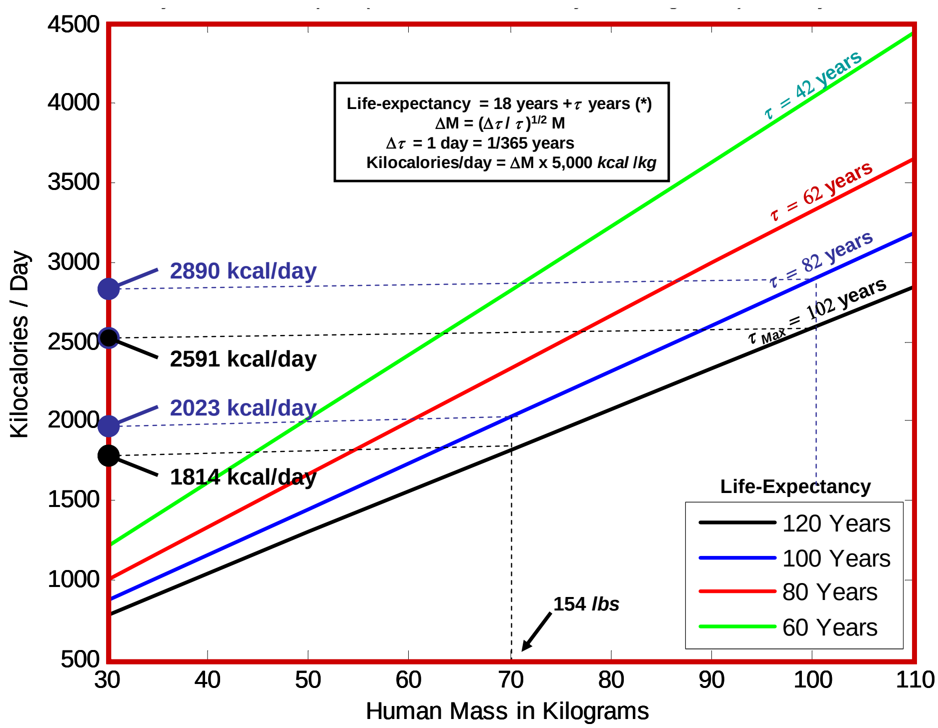

Fig. 1 Theoretical Adult Lifespan τ of Individual as a Function of Mass and Kilocalories/Day

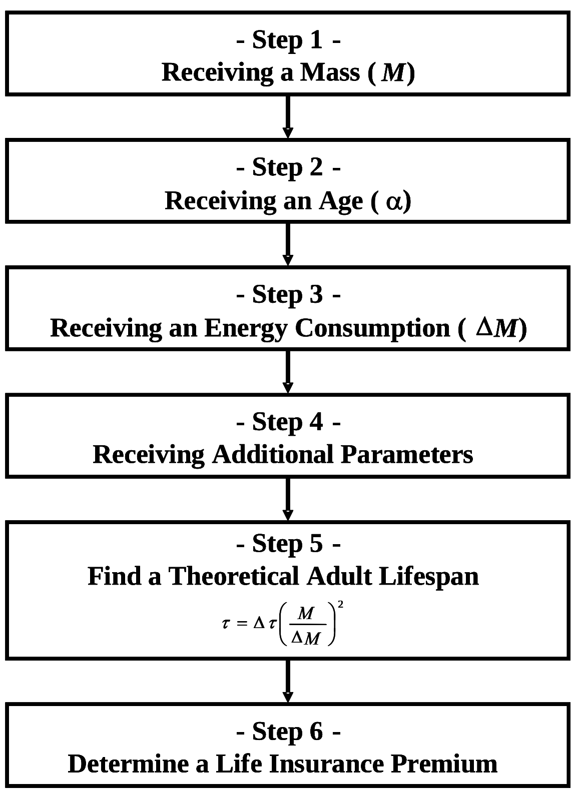

Fig. 2 Flowchart

Step 1

In this initial step the individual's mass M is given.

Step 2

In this second step the individual's age α is given.

Step 3

In this third step the individual's energy consumption per day is requested, e.g., of 2,000 kcal/day or equivalently 0.4 kg/day which is the value assigned to ΔM. When the ΔM value is unknown a good estimate may be available using a health index. For instance, one approach discussed in Section IV is to use the body mass index (BMI) [14]—defined as the ratio of the individual's mass M to his height h squared—to make a correction of the following ΔM prediction which gives rise to the longest possible lifespan:

$$\Delta M_{Opt} = \sqrt{\frac{\Delta\tau}{\tau_{Max}}M} \;\leq\; \Delta M = \sqrt{\frac{\Delta\tau}{\tau}M} \tag{9}$$

where ΔM_{Opt} is a prediction of ΔM which denotes the optimum energy consumption per day that will generate the assumed maximum theoretical adult lifespan τ_{Max} of the scheme, e.g., of 102 years. Also note from (9) that the estimated ΔM can never be less than ΔM_{Opt} since the theoretical adult lifespan τ will then be greater than τ_{Max}, which cannot occur since $\tau_{Max} \geq \tau$.

Step 4

In this fourth step the individual provides additional available data such as: height, waist circumference, hips circumference, gender, residence, diet, ethnicity, fitness, income, education, body volume index (BVI), medical history, etc. All of this data is encoded in the data vector $\underline{x}$ of appropriate dimensions, that may also include the mass M of the individual.

Step 5

In this fifth step the theoretical adult lifespan τ of the individual is found according to (1). For example, for a 70 *kg* (154 *lbs*) individual with an energy consumption of 2,000 kilocalories per day (*or* ΔM = 0.4 *kg*) and $\Delta\tau$ = 1/365 years τ is determined to be approximately 84 years. Moreover, when an additional childhood lifespan of 18 years is added to the 84 years, a total theoretical lifespan Γ of 102 years is determined for this person.

Step 6

In this final step a life insurance premium is determined by an insurance company from the value of the '*expectation of life'* ***F*** that is found according to:

$$\boldsymbol{F} = {}_{\alpha}p_{\Gamma}(\underline{x})\,(\Gamma - \alpha) \tag{10}$$

where ${}_{\alpha}p_{\Gamma}(\underline{x})$ is the individual's probability of survival from the current age α to the total theoretical lifespan Γ. The value of ${}_{\alpha}p_{\Gamma}(\underline{x})$ is derived using actuarial tables [1] in conjunction with the additional vector data set $\underline{x}$ provided by the individual in Step 4. As an illustration of the evaluation of (10), the expectation of life F would be of 59 years when α=40 years, Γ=102 years and ${}_{\alpha}p_{\Gamma}(\underline{x})$ =0.95. More examples will follow in Section V.

IV. The Food Consumption Per Day

When the individual's ΔM is not available, easily accessible health indexes can be used to obtain a reasonable estimate. One index would be the body mass index or BMI, which is the ratio of body mass to squared height of an individual, and another would be the waist to hips index or WHI, which is the ratio of waist circumference to hips circumference. Next a BMI based scheme for generating a ΔM estimate is described.

The BMI is a power of 2 height index that has been found to be the best proxy for body fat percentage among ratios of weight and height. Nevertheless, it should be noted that for very tall individuals powers of height between 2 and 3 may be better indexes since they are thought to better reflect significant body frame variations from standard frames. In Fig. 3 the BMI is displayed for a sufficiently large range of masses and heights. The connections between the BMI numbers and the weight health classifications displayed in this figure vary somewhat depending on the age and body type of the population that it represents. In particular, Fig. 3 is assumed to represent data from adult individuals in the United States where a BMI of 25 is often considered to be ideal or optimum. Three different ranges are identified. They are: 1) the normal/overweight BMI range from 18.5 to 30 where the optimum 25 value resides: this range is often said to be characteristic of healthy individuals; 2) the underweight/malnutrition BMI range of less than 18.5 values: this range is often said to be characteristic of unhealthy individuals; and 3) the overweight/obese BMI range of greater than 30 values: this range is often said to be characteristic of unhealthy individuals. From these observations it is noted that the 'deviation' of the measured BMI from the assumed optimum value of 25, expressed as the absolute value expression |BMI-25|, is all that is needed to determine if one is dealing with an unhealthy situation. That is, the larger the value of the deviation |BMI-25| is the more likely that an unhealthy individual will be found. If the deviation |BMI-25| is then used to derive an estimate $\Delta\hat{M}$ for ΔM that satisfies the inequality (9), $\Delta\hat{M}$ can be used in (1) to find an estimate $\hat{\tau}$ for τ that is less than or equal to τ_{Max}, i.e., $\hat{\tau} \leq \tau_{Max}$.

To derive $\Delta\hat{M}$ the following BMI-based prediction plus correction scheme [15]-[16] is proposed:

$$\Delta\hat{M} = \Delta\hat{M}_P + \Delta\hat{M}_C = \Delta M_{Opt} + K(\underline{x})\left|\Delta M_{Opt} - \beta\Delta M_{Opt}/\beta_{Opt}\right| \tag{11}$$

$$\beta = M/h^2 \tag{12}$$

$$\beta_{Opt} = 25 \tag{13}$$

where: 1) $\Delta\hat{M}_P = \Delta M_{Opt}$ is a prediction of ΔM with ΔM_{Opt}, which is the optimum theoretical daily food intake resulting in τ_{Max} (9); 2) β is the symbol used to represent the BMI=M/h^2 with h being the height in meters of the individual; 3) β_{Opt}=25

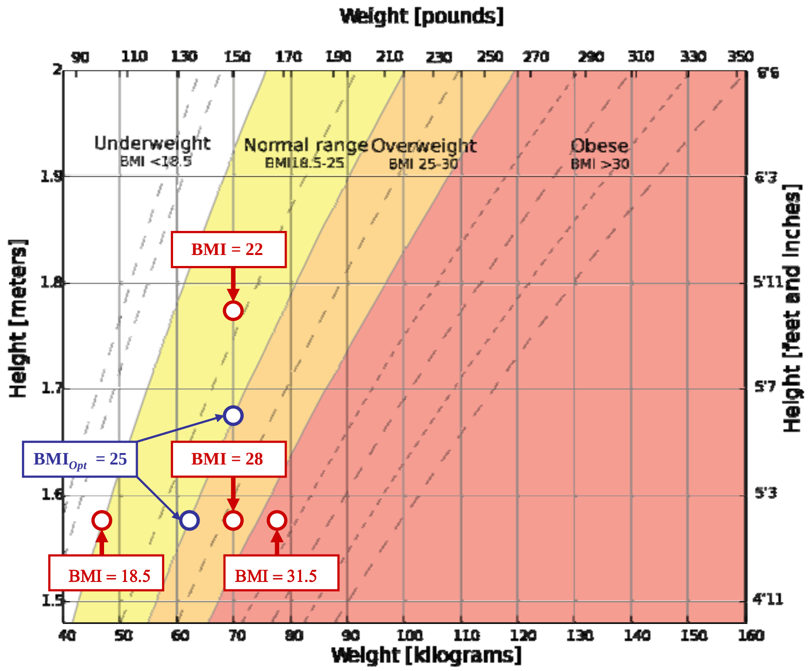

Fig. 3 The Body Mass Index (BMI) Plot

is the optimum BMI value extracted from Fig. 3; 4) $K(\underline{x})$ is a positive number whose value is determined in conjunction with the given demographic data $\underline{x}$ using actuarial tables; and 5) $\Delta\hat{M}_C = K(\underline{x})\left|\Delta M_{Opt} - \beta\Delta M_{Opt}/\beta_{Opt}\right|$ is both a $K(\underline{x})$ and β based correction of the first order prediction $\Delta\hat{M}_P$. More specifically, $\Delta\hat{M}_C$ is a non-negative number that when added to $\Delta\hat{M}_P$ yields a final estimate for ΔM, *i.e.*, $\Delta\hat{M} = \Delta\hat{M}_P + \Delta\hat{M}_C$ that is greater than or equal to $\Delta\hat{M}_P$. A close investigation of the height h of an individual with a fixed mass M reveals that: 1) when h is the same as h_{Opt}—which yields $\beta_{Opt}=M/(h_{Opt})^2$—the correction term $\Delta\hat{M}_C$ in (11) vanishes thus $\Delta\hat{M} = \Delta\hat{M}_P = \Delta M_{Opt}$ which in turn tells us from (9) that the best possible lifespan is achieved; 2) a height h that is less than h_{Opt}, i.e., $h < h_{Opt}$, yields $\beta > \beta_{\text{Opt}}$ (the overweight/obese case) with an estimated value for ΔM greater than ΔM_{Opt} which yields τ lower than τ_{Max}; and 3) a height h that is greater than h_{Opt}, i.e., $h > h_{Opt}$, yields $\beta < \beta_{\text{Opt}}$ (the normal/underweight case) with an estimated value for ΔM greater than ΔM_{Opt} which yields τ lower than τ_{Max}, with the caveat that the estimated ΔM is only a virtual, i.e., not real, value that nevertheless would give a realistic result for τ. Finally it is noted that for the WHI case similar types of equations as those of (11)-(13) can be used to get an estimate for ΔM.

V. Premium Setting Examples

Five premium setting examples are given next.

Example 1

A system for determining a life insurance premium is established that sets the childhood lifespan τ_{Child} to eighteen years, the maximum total lifespan Γ_{Max} to 120 years and thus the maximum theoretical adult lifespan τ_{Max} to 102 years. The parameters of an individual are received as follows: M = 70 kg; age α=40 years; ΔM=0.4 kg per day (based on 2,000 kcal per day at 5,000 kcal per kg); life-expectancy condition=1 (ideal); height=1.58 meters; waist circumference = 70 cm; hip circumference = 100 cm; gender = female; country = US; diet =1 (excellent); ethnicity = 1 (Hispanic); fitness = 1 (excellent); economic class = 1 (middle class); BVI =0 (denoting data is not available); height power = 2 (standard BMI index). When the aforementioned parameters are received Steps 1, 2, 3 and 4 of the flowchart of Fig. 2 have been performed. The individual theoretical adult lifespan is then determined as follows:

$$\tau = \Delta\tau(M/\Delta M)^2 = (1yr/365days)(70kg/0.4kg/day)^2 \approx 84\text{ yrs} \quad (14)$$

Using the set value of eighteen for the childhood lifespan τ_{Child}, a theoretical total lifespan Γ is given by:

$$\Gamma = \tau + \tau_{child} = 84 + 18 = 102\text{ yrs} \quad (15)$$

Actuarial tables are consulted [1] and a suitable probability of survival ${}_\alpha p_\Gamma(\underline{x})$ is chosen based on the individual's demographic data. In the hypothetical Example 1, ${}_\alpha p_\Gamma(\underline{x})$ is 0.95 and the current age α is 40 yrs. An expected lifespan F is as follow:

$$F = {}_\alpha p_\Gamma(\underline{x})(\Gamma - \alpha) = 0.95(102yrs - 40yrs) = 59yrs \quad (16)$$

Example 2

A system for determining a life insurance premium is established identical to Example 1 except in that the ΔM is not known. The ΔM is calculated based on the BMI of the individual. The individual's BMI or β is calculated using the mass M and the height h of the individual person as follows:

$$\beta = M / h^2 = 70/1.58^2 = 28 \quad (17)$$

Based on demographic information an optimum β_{Opt} is set to 25 and an optimum ΔM_{Opt} is set to 0.3628 kg via (9). A value of 0.85 is set for $K(\underline{x})$ based on the demographic profile of the individual. The estimate for ΔM is then calculated as shown below:

$$\Delta\hat{M} = \Delta M_{Opt}(1 + K(\underline{x})\,|1 - \beta/\beta_{Opt}\,|) \quad (18)$$

$$\Delta\hat{M} = 0.3628(1 + 0.85\,|1 - 28/25|) = 0.4\ \text{kg/day} \quad (19)$$

The individual's estimated τ is then determined as follows:

$$\hat{\tau} = \Delta\tau\left(M / \Delta\hat{M}\right)^2 = (1yr/365days)(70kg/0.4kg/day)^2 \approx 84\ \text{yrs} \quad (20)$$

Using the set value of eighteen for the childhood lifespan τ_{Child}, an estimated theoretical total lifespan Γ is given by:

$$\hat{\Gamma} = \hat{\tau} + \tau_{child} = 84 + 18 = 102\ \text{yrs} \quad (21)$$

Actuarial tables are consulted and a suitable probability of survival ${}_{\alpha}p_I(\underline{x})$ is chosen based on the individual person's demographic data. In the hypothetical Example 1, ${}_{\alpha}p_I(\underline{x})$ is 0.95 and the current age α is 40 yrs. An expected lifespan $\hat{F}$ is as follow:

$$\hat{F} = {}_{\alpha}p_{\Gamma}(\underline{x})(\hat{\Gamma} - \alpha) = 0.95(102yrs - 40yrs) = 59yrs \quad (22)$$

By contrasting Examples 1 and 2 it is apparent both individuals have the same expected lifespan, i.e., $F = \hat{F}$, despite the calculation of Example 2 not having access to the nutritional consumption rate of the individual.

Example 3

A system for determining a life insurance premium is established identical to Example 1, except in that the ΔM is not known and M=46.18 kg. The ΔM is calculated based on the BMI of the individual. The individual's BMI or β is calculated using the mass M and the height h of the individual person as follows:

$$\beta = M / h^2 = 46.18/1.58^2 = 18.5 \quad (23)$$

Based on demographic information an optimum β_{Opt} is set to 25 and an optimum ΔM_{Opt} is set to 0.2393 kg via (9). A value of 0.4 is set for $K(\underline{x})$ based on the demographic profile of the individual. The estimate for ΔM is then calculated as shown below:

$$\Delta\hat{M} = \Delta M_{Opt}(1 + K(\underline{x})\,|1 - \beta/\beta_{Opt}\,|) \quad (24)$$

$$\Delta\hat{M} = 0.2393(1 + 0.4\,|1 - 18.5/25|) = 0.2639\ \text{kg/day} \quad (25)$$

The individual's estimated τ is then determined as follows:

$$\hat{\tau} = \Delta\tau\left(M / \Delta\hat{M}\right)^2 = (1yr/365days)(46.18kg/0.2639kg/day)^2 \approx 84\ \text{yrs} \quad (26)$$

Using the set value of eighteen for the childhood lifespan τ_{Child}, an estimated theoretical total lifespan Γ is given by:

$$\hat{\Gamma} = \hat{\tau} + \tau_{child} = 84 + 18 = 102\ \text{yrs} \quad (27)$$

Actuarial tables are consulted and a suitable probability of survival ${}_{\alpha}p_I(\underline{x})$ is chosen based on the individual person's demographic data. In the hypothetical Example 1, ${}_{\alpha}p_I(\underline{x})$ is 0.95 and the current age α is 40 yrs. An expected lifespan $\hat{F}$ is as follow:

$$\hat{F} = {}_{\alpha}p_{\Gamma}(\underline{x})(\hat{\Gamma} - \alpha) = 0.95(102yrs - 40yrs) = 59yrs \quad (28)$$

By contrasting Examples 2 and 3 it is apparent that the same expected lifespan $\hat{F}$ is derived despite one being underweight with BMI=18.5 < 25 ($M/\Delta\hat{M}$ =46.18/0.2639=175), and the other being overweight with BMI=28.0404>25 ($M/\Delta\hat{M}$ = 70/0.4=175). This result is consistent with (1) because in Examples 2 and 3 the same mass to QOO-mass ratio of 175 is derived.

Example 4

A system for determining a life insurance premium is established identical to Example 1 except in that the ΔM is not known or is not provided and M=78.64 kg. The ΔM is calculated based on the BMI of the individual. The individual's BMI or β is calculated using the mass M and the height h of the individual person as follows:

$$\beta = M / h^2 = 78.64/1.58^2 = 31.5 \quad (29)$$

Based on demographic information an optimum β_{Opt} is set to 25 and an optimum ΔM_{Opt} is set to 0.4076 kg via (9). A value of 0.4 is set for $K(\underline{x})$ based on the demographic profile of the individual. The estimate for ΔM is then calculated as shown below:

$$\Delta\hat{M} = \Delta M_{Opt}(1 + K(\underline{x})\,|1 - \beta/\beta_{Opt}\,|) \quad (30)$$

$$\Delta\hat{M} = 0.4076(1 + 0.4\,|1 - 31.5/25|) = 0.45\ \text{kg/day} \quad (31)$$

The individual's estimated τ is then determined as follows:

$$\hat{\tau} = \Delta\tau\left(M / \Delta\hat{M}\right)^2 = (1yr/365days)(78.64kg/0.45kg/day)^2 \approx 84\ \text{yrs} \quad (32)$$

Using the set value of eighteen for the childhood lifespan τ_{Child}, an estimated theoretical total lifespan Γ is given by:

$$\hat{\Gamma} = \hat{\tau} + \tau_{child} = 84 + 18 = 102\ \text{yrs} \quad (33)$$

Actuarial tables are consulted and a suitable probability of survival ${}_{\alpha}p_I(\underline{x})$ is chosen based on the individual person's demographic data. In the hypothetical Example 1, ${}_{\alpha}p_I(\underline{x})$ is 0.95 and the current age α is 40 yrs. An expected lifespan $\hat{F}$ is as follow:

$$\hat{F} = {}_{\alpha}p_{\Gamma}(\underline{x})(\hat{\Gamma} - \alpha) = 0.95(102yrs - 40yrs) = 59yrs \quad (34)$$

By contrasting Examples 3 and 4 it is apparent that the same expected lifespan $\hat{F}$ is derived despite one being underweight with BMI=18.5 < 25 ($M/\Delta\hat{M}$ =46.18/0.2639=175), and the other being obese with BMI=31.5>25 ($M/\Delta\hat{M}$ = 78.64/0.45 =175). This result is consistent with (1) because in Examples 3 and 4 the same mass to QOO-mass ratio of 175 is derived.

Example 5

A system for determining a life insurance premium is established identical to Example 1 except in that the ΔM is not known or is not provided and h=1.7838 meters. The ΔM is calculated based on the BMI of the individual. The individual's BMI or β is calculated using the mass M and the height h of the individual person as follows:

$$\beta = M / h^2 = 70/1.7838^2 = 22 \quad (35)$$

Based on demographic information an optimum β_{Opt} is set to 25 and an optimum ΔM_{Opt} is set to 0.3628 kg via (9). A value of 0.85 is set for $K(\underline{x})$ based on the demographic profile of the individual. The estimate for ΔM is then calculated as shown below:

$$\Delta\hat{M} = \Delta M_{Opt}(1 + K(\underline{x})\,|1 - \beta / \beta_{Opt}\,|) \quad (36)$$

$$\Delta\hat{M} = 0.3628(1 + 0.85\,|1 - 22/25\,|) = 0.4 \text{ kg/day} \quad (37)$$

The individual's estimated τ is then determined as follows:

$$\hat{\tau} = \Delta\tau\left(M / \Delta\hat{M}\right)^2 = (1yr/365days)(70kg/0.4kg/day)^2 \approx 84 \text{ yrs} \quad (38)$$

Using the set value of eighteen for the childhood lifespan τ_{Child}, an estimated theoretical total lifespan Γ is given by:

$$\hat{\Gamma} = \hat{\tau} + \tau_{child} = 84 + 18 = 102 \text{ yrs} \quad (39)$$

Actuarial tables are consulted and a suitable probability of survival ${}_{\alpha}p_{\Gamma}(\underline{x})$ is chosen is chosen based on the individual person's demographic data. In the hypothetical Example 1, ${}_{\alpha}p_{\Gamma}(\underline{x})$ is 0.95 and the current age α is 40 yrs. An expected lifespan $\hat{F}$ is as follow:

$$\hat{F} = {}_{\alpha}p_{\Gamma}(\underline{x})(\hat{\Gamma} - \alpha) = 0.95(102yrs - 40yrs) = 59yrs \quad (40)$$

By contrasting Examples 2 and 5 it is apparent that the same expected lifespan $\hat{F}$ is derived despite one being underweight with BMI=22 < 25 ($M/\Delta\hat{M}$ =70/0.4=175), and the other being overweight with BMI=28 > 25 ($M/\Delta\hat{M}$ = 70/0.4 =175). This result is consistent with (1) because in Examples 2 and 5 the same mass to QOO-mass ratio of 175 is derived. However, it should be noted that the QOO-mass estimate $\Delta\hat{M}$ of Example 5 (37) is virtual, i.e., not real, since it does not correspond to the actual amount that the individual is expected to consume from day to day which must be less than ΔM_{Opt}=0.3628 kg.

At this point it should be highlighted that $K(\underline{x})$ is a weight *unbiased* gain. This property is noted from Examples 2, 3 and 4 where regardless of the received mass value the gain $K(\underline{x})$ is adjusted to yield the same life expectancy—provided the demographic data $\underline{x}$, except for the M value, does not change. To further illustrate the point consider the case where the 0.85 value for $K(\underline{x})$ of Example 2 with M=70 kg is also applied to Example 3 with M=46.18 kg and Example 4 with M=78.64 kg, i.e., $K(\underline{x})$ is now weight independent. When this occurs a theoretical adult lifespan of 69 years is derived for both Examples 3 and 4, which is 15 years less than the 84 years of Example 2 (20). Thus it is concluded that the individuals of Examples 3 and 4 will benefit greatly from the use by life insurance companies of linger thermo theory's weight unbiased methodology for setting a life insurance premium.

VI. Conclusions

In this paper a nascent linger thermo theory was found to lead to a weight unbiased methodology for setting life insurance premiums. The approach was based on a theoretical adult lifespan equation that inherently surfaces from within the universal linger-thermo equation of linger thermo theory. The lifespan equation yielded a prediction proportional in value to the square of the ratio of an individual's mass to the mass of food consumed daily. This equation predicted that the life expectancy of a normal weight individual who significantly increased or lowered his/her weight could still have the same life expectancy. This theoretical prediction had the virtue of being consistent with United States National Institute of Aging (NIA) rhesus monkeys study results first reported in a 2012 Nature journal article. A scheme was then advanced using this lifespan equation that inherently led to a weight unbiased methodology for life expectancy premium evaluations. The method required an estimation of the mass of food consumed daily. To achieve this goal a body mass index (BMI) based prediction plus correction scheme was advanced that yielded reasonable estimates for the food amount consumed daily. Most importantly, this scheme had the merit of leading to the same theoretical life expectations for dissimilar weight individuals whose demographic data was otherwise identical.

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