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Tetraeffective Causes of Mortality and Survivorship

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Abstract

Any cause that negatively affects mortality, positively affects mortality, negatively affects survivorship, and positively affects survivorship is tetraeffective (i.e., having four kinds of effects). However, until now, tetraeffective causes of mortality and survivorship have been undescribed, unidentified, unnamed, unrecognized, unclear, misconceived, unspecified, and unexplained. Here I describe, identify, name, recognize, elucidate, conceptualize, specify, and explain tetraeffective causes of mortality and survivorship. I show that every tetraeffective cause of mortality and survivorship combines corresponding at least one mortacause and at least one vitacause; "mortacause" refers here to a cause that positively affects mortality and negatively affects survivorship, and "vitacause" refers to a cause that positively affects survivorship and negatively affects mortality. I present strong rationales that suggest that every cause of mortality and survivorship is tetraeffective, and I present references to considerable previous evidence that I interpret to be suggestive evidence of tetraeffective causes of mortality and survivorship. Moreover, rigorous and thorough multivariable analyses of mortality and survivorship of humans and medflies provide here direct evidence of tetraeffective causes of mortality and survivorship, revealing best-fitting specifications $dY/d(X^p) = a + bX^p$ *such that* $sign(a) = -sign(bX^p)$, where: Y indicates mortality or survivorship; X indicates age, lifespan, contemporary aggregate size, lifespan aggregate size, or historical time; $dY/d(X^p)$ indicates composite effects of X^p on Y; a indicates an X-specific mortacause or vitacause; bX^p indicates the corresponding opposite X-specific mortacause or vitacause; and coefficients a, b, and p denote respective X-specific and entity-specific constants. Thus description, identification, naming, recognition, elucidation, conception, specification, explanation, and demonstration of tetraeffective causes of mortality and survivorship usher a new paradigm of causes of mortality and survivorship and enable and promote further scientific research and practical applications.

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Introduction

Bieffective and tetraeffective causes of mortality and survivorship

Scientific research on causality remains problematic and challenging [1-6], scientific research on causes of mortality and survivorship remains particularly problematic and challenging [7-15], and mortality and survivorship and their interrelationships are particularly prone to elicit errors and biases [16-21]. Moreover, every bieffective cause has two kinds of effects, every tetraeffective cause has four kinds of effects, and particular problems and challenges are revealed in considerations of bieffective and tetraeffective causes of mortality and survivorship.

"Mortacause" refers here to any bieffective cause that positively affects mortality and negatively affects survivorship; figure 1 depicts a causal structure of a mortacause (e.g., illustrating an increasing mortacause leading to increasing mortality and decreasing survivorship). "Vitacause" refers here to a bieffective cause that positively affects survivorship and negatively affects mortality; figure 2 depicts a causal structure of a bieffective vitacause that positively affects survivorship and negatively affects mortality (e.g., illustrating an increasing vitacause leading to increasing survivorship and decreasing mortality). Every bi-effective cause of mortality and survivorship is consistent with laws of identity, non-contradiction, and excluded middle [1,22,23].

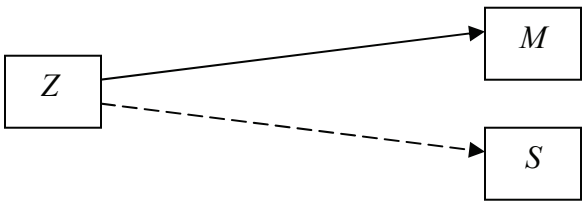

Figure 1. A causal structure of a mortacause (i.e., a bieffective cause that positively affects mortality and negatively affects survivorship). *Z* denotes a mortacause of mortality *M* and survivorship *S*, arrow → denotes positive effects, and arrow **---->** denotes negative effects.

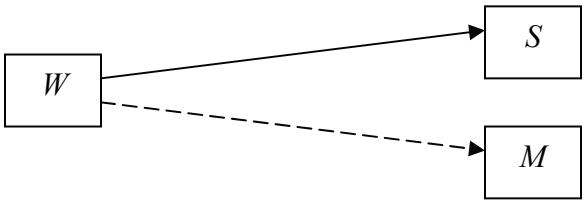

Figure 2. A causal structure of vitacause (i.e., a bieffective cause that positively affects survivorship and negatively affects mortality). *W* denotes a vitacause of mortality *M* and survivorship *S*, arrow → denotes positive effects, and arrow **---->** denotes negative effects.

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Every tetraeffective cause of mortality and survivorship negatively affects mortality, positively affects mortality, negatively affects survivorship, and positively affects survivorship. Until now, tetraeffective causes of mortality and survivorship have been undescribed, unidentified, unnamed, unrecognized, unclear, misconceived, unspecified, and unexplained. Here I recognize, identify, and name these causes, and I present the following discoveries: (i) every tetraeffective cause of mortality and survivorship combines corresponding at least one mortacause and at least one vitacause, (ii) every tetraeffective cause of mortality and survivorship is consistent with laws of identity, non-contradiction, and excluded middle, (iii) every mortacause and every vitacause of every tetraeffective cause of mortality and survivorship is one of dominant and not dominant, and (iv) every tetraeffective cause of mortality and survivorship is hidden in a corresponding bieffective cause of mortality and survivorship [24].

Figure 3 illustrates a causal structure of a tetraeffective cause of mortality and survivorship. Figure 3 depicts positive effects of an *X*-specific mortacause *Xm* on mortality *M* (e.g., illustrating an increasing *Xm* leading to increasing *M*), negative effects of an *X*-specific mortacause *Xm* on survivorship *S* (e.g., illustrating an increasing *Xm* leading to decreasing *S*), negative effects of an *X*-specific vitacause *Xv* on mortality *M* (e.g., illustrating an increasing *Xv* leading to decreasing *M*), and positive effects of an *X*-specific vitacause *Xv* on survivorship *S* (e.g., illustrating an increasing *Xv* leading to increasing *S*), where *X* denotes a tetraeffective cause of mortality and survivorship. Figure 4 depicts effects of corresponding more than one mortacause and more than one vitacause. Figures 3 and 4 illustrate that diverse tetraeffective causes of mortality and survivorship could be structured in diverse ways.

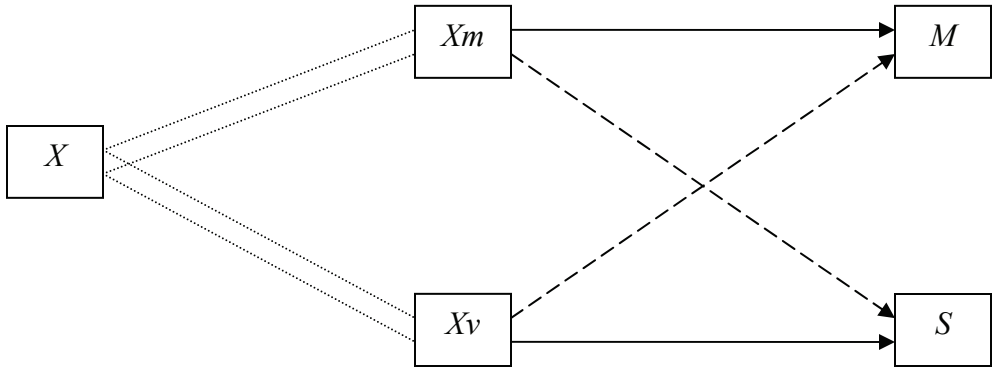

Figure 3. A causal structure of a tetraeffective cause of mortality and survivorship. *X* denotes a cause of mortality *M* and survivorship *S*, *Xm* denotes an *X*-specific mortacause, *Xv* denotes an *X*-specific vitacause, double dotted lines denote that *Xm* and *Xv* are *X*-specific, arrow → denotes positive effects, and arrow **---->** denotes negative effects.

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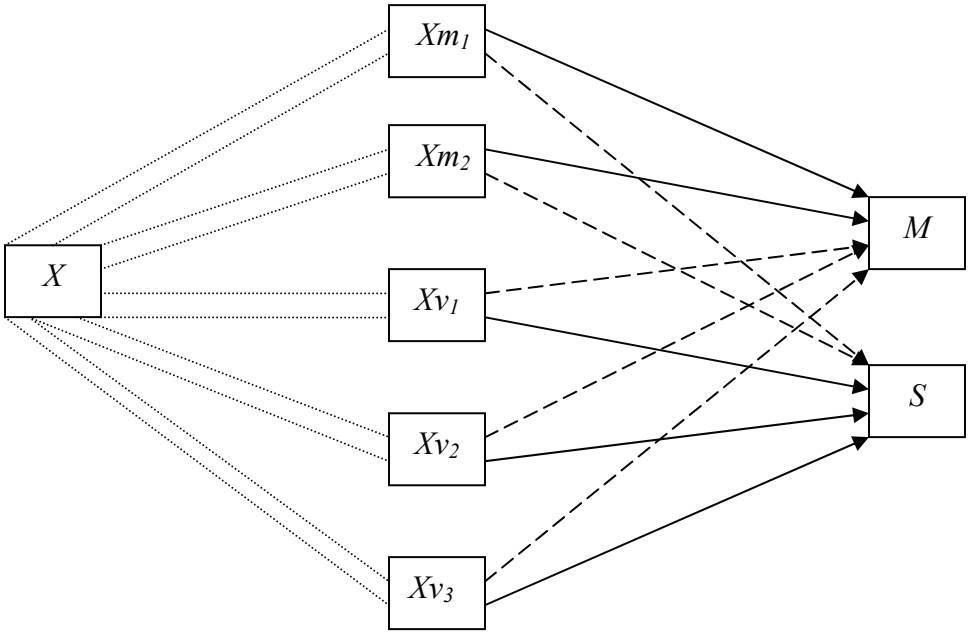

Figure 4. A causal structure of a tetraeffective cause of mortality and survivorship. *X* denotes a cause of mortality *M* and survivorship *S*, *Xm* denotes an *X*-specific mortacause, *Xv* denotes an *X*-specific vitacause, double dotted lines denote that *Xm* and *Xv* are *X*-specific, arrow → denotes positive effects, and arrow **---->** denotes negative effects.

Figures 3 and 4 illustrate causal structures of tetraeffective causes of mortality and survivorship that are consistent with laws of identity, non-contradiction, and excluded middle. This consistency with laws of identify, non-contradiction, and excluded middle is elucidated when contrasted with the causal structure in figure 5; figure 5 illustrates a causal structure of a non-existent and invalid tetraeffective cause of mortality and survivorship that is inconsistent with laws of identity, non-contradiction, and excluded middle.

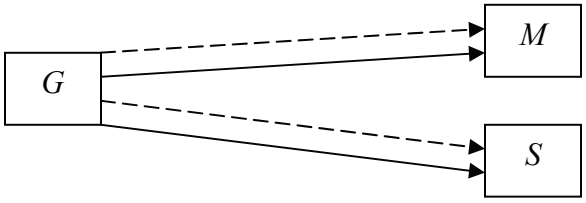

Figure 5. A causal structure of a non-existent and invalid tetraeffective cause of mortality and survivorship that is inconsistent with laws of identity, non-contradiction, and excluded middle. *G* denotes a non-existent and invalid tetraeffective cause of mortality *M* and survivorship *S*, arrow → denotes positive effects, and arrow **---->** denotes negative effects.

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Dominance in a tetraeffective cause of mortality and survivorship could be indicated by one or more characteristics (e.g., intensity, effectiveness, force, potency) of respective corresponding cause-specific at least one mortacause and at least one vitacause. Every tetraeffective cause of mortality and survivorship is characterized by one of the following conditions of dominance: (i) the total at least one cause-specific mortacause is more dominant than the corresponding total at least one cause-specific vitacause, (ii) the total at least one cause-specific mortacause is as dominant as its corresponding total at least one cause-specific vitacause, and (iii) the total at least one cause-specific mortacause is less dominant than its corresponding total at least one cause-specific vitacause. If the total at least one cause-specific mortacause is more dominant than the total at least one cause-specific vitacause then the effects of the tetraeffective cause are hidden and they appear as restricted effects of a bieffective mortacause. If the total at least one cause-specific vitacause is more dominant than the total at least one cause-specific mortacause then the effects of the tetraeffective cause are hidden but they appear as restricted effects of a bieffective vitacause. If the total at least one cause-specific mortacause is as dominant as its corresponding total at least one cause-specific vitacause then the effects of the tetraeffective cause are hidden and they do not appear as restricted effects of a bieffective cause (i.e., no effects are apparent). Therefore, every cause of mortality and survivorship appears to be a bieffective cause (i.e., bieffective causes of mortality and survivorship appear to be universal), and tetraeffective causes of mortality and survivorship remain hidden.

The hiddenness of tetraeffective causes of mortality and survivorship leads to undescription, unidentification, unnaming, unrecognition, unclarity, misconception, unspecification, and unexplanation of these causes. Moreover, the hiddenness of tetraeffective causes of mortality and survivorship involves the following implicit dominant conventional invalid assumptions: (i) Every cause of mortality and survivorship is exclusively bieffective, (ii) tetraeffective causes of mortality and survivorship do not exist, and (iii) any tetraeffective cause of mortality and survivorship that would exist would be invalidly inconsistent with laws of identity, non-contradiction, and excluded middle. However, strong rationales suggest that every cause of mortality and survivorship is tetraeffective (i.e., these strong rationales suggest that tetraeffective causes of mortality and survivorship are universal), and considerable previous evidence of causes of mortality and survivorship can be interpreted as being suggestive evidence of tetraeffective causes of mortality and survivorship.

Rationales for the universality of tetraeffective causes of mortality and survivorship

Mortality refers to cessation of existence, survivorship refers to continuation of existence, that which continues or ceases to exist is an entity, and previous research elucidates that

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entities' existences are regulated [25-33]; thus implying that mortality, survivorship, and their causes are regulated regulators of existence. Additionally, the cessation of existence of all previous entities, and the expected cessation of existence of the universe and all its entities [34,35] – and conceptions of limited existence in diverse (but not all) cultures, religions, and philosophies [36,37] – indicate that every entity's existence is limited. Therefore, if every cause of mortality and survivorship is a tetraeffective cause of mortality and survivorship, then tetraeffective causes are intimately involved in the existence – and the regulation and limitation of existence – of all entities. However, if diverse but not all causes of mortality and survivorship are tetraeffective causes of mortality and survivorship, then existences – and regulations and limitations of existences – do not consistently apply to all entities. Similarly, if no causes of mortality and survivorship are tetraeffective causes of mortality and survivorship, then existences, regulations, and limitations of existences do not consistently apply to all entities. Therefore, every cause of mortality and survivorship is a tetraeffective cause of mortality and survivorship. Moreover, the number of causes in a system that involves mortacauses and vitacauses in the regulated regulations and limitations of existence of all entities is smaller than the number of causes that are involved in a corresponding system that is restricted to bieffective causes of mortality and survivorship but excludes tetraeffective causes of mortality and survivorship. Therefore, a system that involves tetraeffective causes of mortality and survivorship in the regulated regulations and limitations of existence of all entities is more parsimonious than a corresponding system that excludes tetraeffective causes of mortality and survivorship. This parsimony provides an additional rationale for the universality of tetraeffective causes of mortality and survivorship. Furthermore, symbioses between corresponding at least one cause-specific mortacause and at least one cause-specific vitacause of every tetraeffective cause of mortality and survivorship are illustrated by the observation that any positive effect of age on mortality and any negative effect of age on survivorship require entities of ages greater than zero, and any entity of age greater than zero requires corresponding negative effects of age on mortality and positive effects of age on survivorship; these symbioses and requirements imply that effects of age on mortality and survivorship are tetraeffective, further implying that age is a tetraeffective cause of mortality and survivorship. Similar symbioses, requirements, and implications apply to every entity and every cause of mortality and survivorship.

There is an extensive and long-standing legacy of considerations of oppositions in religion and philosophy [1,22,36-47], quantum theory [48,49], structuralism [50-52], biology [53-55], and art [56-61]. These considerations imply that every mortacause is opposed by – and opposes – a corresponding at least one vitacause; these considerations also imply that every vitacause is opposed by – and opposes – a corresponding at least one mortacause. Tetraeffective causes oppose – and are opposed by other tetraeffective causes. However, if every cause of mortality and survivorship is exclusively bieffective and is not tetraeffective

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(i.e., if tetraeffective causes of mortality and survivorship do not exist) then at least some bieffective mortacauses will not be opposed by – and will not oppose – vitacauses, in violation of the opposition of every mortacause and vitacause. Similarly, if every cause of mortality and survivorship is exclusively bieffective and is not tetraeffective (i.e., if tetraeffective causes of mortality and survivorship do not exist) then at least some bieffective vitacauses will not be opposed by – and will not oppose – mortacauses, in violation of the opposition of every mortacause and vitacause. Therefore, corresponding at least one mortacause and at least one vitacause must be intrinsic to every cause of mortality and survivorship and, therefore, every cause of mortality and survivorship is tetraeffective. These considerations thus amplify, deepen, and elucidate previous considerations of intrinsic and extrinsic causes of mortality and survivorship [62-78] as well as previous considerations of essential and coincidental properties [1,79].

As noted, every tetraeffective cause of mortality and survivorship can be interpreted as a bieffective cause whose tetraeffective components are hidden (e.g., unknown, unobserved, ignored, or misconceived). Additionally, every cause that is known or observed to be a bieffective cause can be interpreted to be a tetraeffective cause whose components are hidden. Moreover, the hiddenness of at least one mortacause of a tetraeffective cause of mortality and survivorship does not imply the following: (i) the at least one mortacause does not exist, and (ii) the cause is not tetraeffective. Similarly, the hiddenness of at least one vitacause of a tetraeffective cause of mortality and survivorship does not imply the following: (i) the at least one vitacause does not exist, and (ii) the cause is not tetraeffective. Therefore, it is invalid to conclude that a cause – e.g., every cause, any cause, a specific cause – of mortality and survivorship is an exclusively bieffective cause; it is also invalid to conclude that this cause is not a tetraeffective cause.

Utilitarian, practical, moral, and ethical considerations provide additional rationales for the universality of tetraeffective causes of mortality and survivorship. These rationales emphasize that considerations of tetraeffective causes of mortality and survivorship are useful, practical, moral, and ethical. For example, tetraeffective causes of mortality and survivorship imply that it is useful, practical, moral, and ethical to search for vitacauses and mortacauses in effects of cancer or any other disease as well as in effects of nuclear holocaust, global warming, poverty, injustice, or any other cause of mortality and survivorship. Similarly, tetraeffective causes of mortality and survivorship imply that it is useful, practical, moral, and ethical to assume that every vitality is accompanied by an opposite frailty and vice versa, every damage is accompanied by an opposite repair and vice versa, every injury or disease is accompanied by an opposite remedy and vice versa, and so on; further implying that it is invalid, impractical, immoral, unethical, and not useful to assume that elixirs, thanatoses, or destroyers of worlds are unopposed.

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Suggestive evidence of tetraeffective causes of mortality and survivorship

New interpretations of previous evidence of causes of mortality and survivorship provide suggestive evidence of tetraeffective causes of mortality and survivorship. Iatrogenic effects on mortality and survivorship refer to negative and positive medical effects on mortality and survivorship [80,81]; such effects include, for example, iatrogenic effects of surgery [82], pharmacologic medication (e.g., antibiotics [83]), or public health campaigns [84-86]; iatrogenic medical effects on mortality and survivorship provide suggestive evidence of medical-specific mortacauses and vitacauses that negatively and positively affect mortality and survivorship. Similarly, nonlinear or varying respective effects of radiation [60,64,87,88], insecticides [89], and food intake [90] on mortality and survivorship provide suggestive evidence of respective radiation-specific, insecticides-specific, and food-intake-specific mortacauses and vitacauses that negatively and positively affect mortality and survivorship. Additionally, Strehler-Mildvan correlations [66,78,91-95], compensations [66,67,88,95], decelerations [64,95-108], and hysteresis or delays [89,109,110] in effects of age on mortality and survivorship provide suggestive evidence of age-specific mortacauses and vitacauses that negatively and positively affect mortality and survivorship. Moreover, there is ample evidence of nonlinear or varying effects of socioeconomic causes on mortality and survivorship; such socioeconomic effects include, for example, effects of educational attainment, race, gender, income, and economic development [15,84-86,111-121]; nonlinear or varying effects provide suggestive evidence of socioeconomic-specific mortacauses and vitacauses that negatively and positively affect mortality and survivorship. Furthermore, evidence of negative and positive effects of wildfires on mortality and survivorship also provides suggestive evidence of mortacauses and vitacauses that negatively and positively affect mortality and survivorship [122]. Thus diverse effects on mortality and survivorship provide suggestive evidence of tetraeffective causes of mortality and survivorship. Additionally, rigorous and thorough multivariable analyses of humans' and medflies' mortality and survivorship are employed here in a search for direct evidence of tetraeffective causes of mortality and survivorship.

Materials and methods

The analyses here expand the analyses that are presented in [123]. The analyses here and in [123] analyze 188,087 weighted cases with 79,164,608 events of death or survival of all entities that were born in Sweden in decennial years 1760 – 1930 and died between 1760 and 2008. The analyses here and in [123] also analyze 50,716 weighted cases with 2,211,782 events of death or survival of caged Mediterranean fruit flies, *Ceratitis capitata*, commonly known as medflies. The analyses here and in [123] analyze these data employing AIC and

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BIC information criteria and the following multivariable binary limited powered polynomial random-effects regression model of an individual's mortality and survivorship

$$\eta_{ij} = \beta_0 + \sum_{q=1}^{n}\sum_{k=1}^{r_q}[\beta_{qk}\{(X_{qij})^{p_q}\}^k] + \sum_{v=1}^{u}(\beta_v W_{vij}) + \xi_{ij}, \quad \text{such that } P(Y_{ij}) = f(\eta_{ij}), \tag{1}$$

where Y_{ij} denotes mortality M_{ij} or survivorship S_{ij} of individual i that continues to exist (i.e., $M_{ij} = 0$ and $S_{ij} = 1$) or ceases to exist (i.e., $M_{ij} = 1$ and $S_{ij} = 0$) at observation j, $P(Y_{ij})$ denotes the probability of mortality (i.e., $P(M_{ij})$) or the probability of survivorship (i.e., $P(S_{ij})$) of individual i at observation j, $f(\eta_{ij})$ is a link function that denotes a transformation of η_{ij} (e.g., a logit transformation $P(Y_{ij}) = exp(\eta_{ij})/\{1+ exp(\eta_{ij})\}$), $\boldsymbol{\beta}$ denote regression coefficients β, $\boldsymbol{X_q}$ denote ordinal or higher-level variables, and $\boldsymbol{W_v}$ denote categorical variables. The specific $\boldsymbol{X_q}$ variables in this investigation are: $X = A$ denotes humans' or medflies' age, $X = L$ denotes humans' or medflies' lifespan, $X = C$ denotes humans' or medflies' contemporary aggregate size (i.e., this size refers to the number of individuals whose age, sex, and location in time or space are identical to those of the criterion individual), $X = \Lambda$ denotes humans' or medflies' lifespan aggregate size (i.e., this size refers to the number of individuals whose lifespan, age, sex, and location in time or space are identical to those of the criterion individual), and $X = H$ denotes humans' historical time (i.e., a specific year). The specific $\boldsymbol{W_v}$ variables in this investigation are: $W = F$ denotes being female in reference to humans' or medflies' sex, and $W = Z$ denotes medflies' respective cages. Coefficients q denote sequential indicators of n distinct variables X, p_q denotes a power coefficient of variable X_q, k are sequential indicators of the r_q polynomial length of variable X_q. Coefficients v denote sequential indicators of u distinct variables W, and each ξ_{ij} denotes a random-effects coefficient corresponding to individual i at observation j. The original data for this investigation are available in [124,125]; further information on the data and regression analyses is available in [123].

Going beyond the analyses in [123], respective best-fitting models 1 yield here

$$dY/d(X^p) = \sum_{k=1}^{r_x} k\beta_k\{(X^p)^{(k-1)}\}, \tag{2}$$

where $dY/d(X^p)$ denotes the first derivative of Y with respect to X^p, p denotes a power coefficient of variable X in model 1, β_k denotes a k regression coefficient of variable X^p in model 1, and r_x denotes the limited length of the polynomial of variable X^p in model 1. Model 2 transforms to $dY/d(X^p) = a + bX^p$ when $r_x = 2$, but Model 2 transforms to $dY/d(X^p) = a + bX^p + c(X^p)^2$ when $r_x = 3$, and so on for higher values of r_x. Best-fitting values of coefficients a, b, c, p, and r_x for a specific Y, a specific X, and a specific kind of entities (i.e., humans or medflies) are determined by the AIC and BIC information criteria that are employed in the respective regression analyses. Derivatives – and respective confidence

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intervals for these derivatives – for humans' and medflies' mortality or survivorship with respect to age, lifespan, contemporary aggregate size, and lifespan aggregate size are calculated here using procedure "margins" in the Stata software for best-fitting regression models [123,126], verifying consistency with model 2.

Specifications $dY/d(X^p) = a + bX^p$ are employed here for testing whether $dY/d(X^p) = a + bX^p$ *such that* $sign(a) = -sign(bX^p)$. Specifications $dY/d(X^p) = a + bX^p$ *such that* $sign(a) = -sign(bX^p)$ provide simple, parsimonious, and meaningful specifications for tetraeffective causes of mortality and survivorship. First derivative $dY/d(X^p)$ in specifications $dY/d(X^p) = a + bX^p$ is interpreted here as indicative of the intensity of the total effects of at least one X-specific mortacause and at least one X-specific vitacause on mortality or survivorship Y, component a of $dY/d(X^p) = a + bX^p$ is interpreted as indicative of the intensity of the effects of one of an X-specific mortacause and an X-specific vitacause on mortality or survivorship Y, and component bX^p of $dY/d(X^p) = a + bX^p$ is interpreted as indicative of the intensity of the effects of the opposite other one of an X-specific mortacause and an X-specific vitacause on mortality or survivorship Y.

Results

Best-fitting specifications of humans' and medflies' $dM/d(A^p)$, $dS/d(A^p)$, $dM/d(L^p)$, $dS/d(L^p)$, $dM/d(C^p)$, $dS/d(C^p)$, $dM/d(\Lambda^p)$, and $dS/d(\Lambda^p)$ reveal here that $dY/d(X^p) = a + bX^p$, where $Y = M$ denotes mortality, $Y = S$ denotes survivorship, $X = A$ denotes age, $X = L$ denotes lifespan, $X = C$ denotes contemporary aggregate size, $X = \Lambda$ denotes lifespan aggregate size, $dY/d(X^p)$ indicates total effects of X^p on Y, a indicates an X-specific mortacause or vitacause, bX^p indicates the corresponding opposite X-specific mortacause or vitacause, and coefficients a, b, and p denote respective X-specific and entity-specific constants. Additionally, best-fitting specifications of humans' $dM/d(H^p)$ and $dS/d(H^p)$ reveal here that $dY/d(H^p) = a + bH^p + c(H^p)^2$, where $X = H$ denotes humans' historical time. Table 1 shows that $sign(a) = -sign(bX^p)$ in best-fitting specifications $dY/d(X^p) = a + bX^p$ of $dM/d(A^p)$, $dS/d(A^p)$, $dM/d(L^p)$, $dS/d(L^p)$, $dM/d(C^p)$, $dS/d(C^p)$, $dM/d(\Lambda^p)$, and $dS/d(\Lambda^p)$. Table 1 also shows that $sign(a) = -sign(bH^p)$ in best-fitting specifications $dY/d(H^p) = a + bH^p + c(H^p)^2$ of $dM/d(H^p)$ and $dS/d(H^p)$.

The results of the multivariable analyses of humans' and medflies' mortality and survivorship reveal mortacauses and vitacauses in best-fitting specifications $dY/d(X^p) = a + bX^p$ *such that* $sign(a) = -sign(bX^p)$; where $dY/d(X^p)$ denotes the first derivative of mortality or survivorship Y with respect to X^p; coefficients a, b, and p denote specific X-specific and entity-specific constants; and X respectively indicates age, lifespan, contemporary aggregate size, lifespan aggregate size, or historical time. In these best-fitting specifications, component a is interpreted as indicative of the intensity and effectiveness of effects of an

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Table 1. Values of coefficients of humans' and medflies' best-fitting $dY/d(X^p) = a + bX^p$.*

Entities	*Y*	*X*	*p*	*a*	*b*	low *a*	high *a*	low *b*	high *b*
humans	M	A	0.16	-1074.55	1092.24	-1076.92	-1072.19	1089.83	1094.64
humans	S	A	0.16	1074.55	-1092.24	1072.19	1076.92	-1094.64	-1089.83
medflies	M	A	0.13	-2648.52	2591.52	-2681.20	-2615.85	2559.53	2623.51
medflies	S	A	0.16	1402.49	-1413.24	1373.72	1431.25	-1442.58	-1383.90
humans	M	L	0.88	-17.12	0.20	-17.16	-17.08	0.20	0.20
humans	S	L	0.88	17.12	-0.20	17.08	17.16	-0.20	-0.20
medflies	M	L	0.98	-16.67	0.19	-16.88	-16.46	0.19	0.19
medflies	S	L	0.94	19.24	-0.24	18.82	19.65	-0.24	-0.23
humans	M	C	0.75	0.00623	-8.78E-07	0.00619	0.00627	-8.92E-07	-8.66E-07
humans	S	C	0.75	-0.00623	8.78E-07	-0.00627	-0.00619	8.66E-07	8.92E-07
medflies	M	C	1.02	-0.00632	1.37E-06	-0.00652	-0.00612	1.31E-06	1.43E-06
medflies	S	C	1.02	0.00407	-8.06E-07	0.00388	0.00427	-8.64E-07	-7.48E-07
humans	M	Λ	0.3	6.18689	-0.69738	6.16888	6.20490	-0.69938	-0.69536
humans	S	Λ	0.3	-6.18689	0.69737	-6.20490	-6.16888	0.69537	0.69938
medflies	M	Λ	0.95	-0.09025	0.00053	-0.09327	-0.08723	0.00051	0.00055
medflies	S	Λ	0.88	0.11285	-0.00098	0.10723	0.11846	-0.00104	-0.00092
humans	M	H	1.41	-7.84E-03	3.84E-06	-7.91E-03	-7.77E-03	3.72E-06	3.94E-06
humans	S	H	1.41	7.84E-03	-3.84E-06	7.77E-03	7.91E-03	-3.94E-06	-3.72E-06

**Y = M* denotes mortality, *Y = S* denotes survivorship, *X = A* denotes age, *X = L* denotes lifespan, *X = C* denotes contemporary aggregate size, *X = Λ* denotes lifespan aggregate size, and respective low and high *a* and *b* values respectively denote low and high 95% confidence intervals. Best-fitting specifications $dY/d(H^p) = a + bH^p + c(H^p)^2$ where *X = H* denotes humans' historical time, *c* = -2.39E-09 (low *c* = -2.44E-09, high *c* = -2.35E-09 at confidence interval $CI_{0.95}$) at *Y = M*, and *c* = 2.39E-09 (low *c* = 2.35E-09, high *c* = 2.44E-09 at $CI_{0.95}$) at *Y = S*.

invariant *X*-specific mortacause or vitacause, such that the invariant *X*-specific mortacause positively affects mortality and negatively affects survivorship, and such that the invariant *X*-specific vitacause negatively affects mortality and positively affects survivorship. In these best-fitting specifications, component bX^p is interpreted as indicative of the intensity and effectiveness of effects of a variable *X*-specific mortacause or vitacause, such that the variable *X*-specific mortacause positively affects mortality and negatively affects survivorship, and such that the variable *X*-specific vitacause negatively affects mortality and positively affects survivorship. Best-fitting specifications $dY/d(X^p) = a + bX^p$ *such that* $sign(a) = -sign(bX^p)$ indicate that one of components *a* and bX^p indicates an *X*-specific

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mortacause and the other component indicates a corresponding *X*-specific vitacause. These results demonstrate and elucidate that every cause of humans' and medflies' mortality and survivorship in the present analyses is composed of at least one mortacause (positively affecting mortality and negatively affecting survivorship) and at least one vitacause (positively affecting survivorship and negatively affecting mortality). These empirical analyses provide direct evidence of tetraeffective causes of mortality and survivorship and direct evidence of mortacauses and vitacauses.

Discussion

This investigation shows that every tetraeffective cause of mortality and survivorship combines corresponding at least one mortacause and at least one vitacause and is, therefore, consistent with laws of identity, non-contradiction, and excluded middle. Additionally, strong rationales suggest here that every cause of mortality and survivorship is tetraeffective, and considerable previous evidence is interpreted here as being suggestive evidence of tetraeffective causes of mortality and survivorship. Moreover, results of rigorous and through multivariable analyses of humans' and medflies' mortality and survivorship provide here direct evidence of tetraeffective causes of mortality and survivorship, revealing best-fitting specifications $dY/d(X^p) = a + bX^p$ *such that* $sign(a) = -sign(bX^p)$ for effects of age, lifespan, contemporary aggregate size, lifespan aggregate size, and historical time on mortality and survivorship. Thus tetraeffective causes of mortality and survivorship are described, identified, named, recognized, elucidated, conceived, specified, explained, and demonstrated; thus ushering a new paradigm of causes of mortality and survivorship [24,127], and enabling and promoting further scientific research and practical applications.

There is an obvious affinity between the conception of mortacauses and conceptions of frailty, disease, damage, waste, harm, poison, injury, thanatos, destroyer of worlds, and related phenomena in diverse cultures, religions, philosophies, and scientific investigations [44-47,66,95,128-143]. Similarly, there is an obvious affinity between the conception of vitacauses and conceptions of vitality, conatus, élan vital, selfishness, repair, redundancy, defense, nutrition, elixirs, and related phenomena in diverse cultures, religions, philosophies, and scientific investigations [1,44,45,47,66,67,69,91,95,108,144-156]. The universality of tetraeffective causes of mortality and survivorship implies that frailty, disease, damage, waste, harm, poison, injury, thanatos, destroyer of worlds, and related phenomena are mortacause-dominant tetraeffective causes of mortality and survivorship. The universality of tetraeffective causes of mortality and survivorship also implies that vitality, conatus, élan vital, selfishness, repair, redundancy, defense, nutrition, elixirs, and related phenomena are vitacause-dominant tetraeffective causes of mortality and survivorship. The scientific investigation of these implications requires empirical analyses in further research.

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Dominances between corresponding mortacauses and vitacauses of tetraeffective causes of mortality and survivorship are some of the diverse characteristics, processes, or operations that are involved in these tetraeffective causes. Subject to critiques and debates [157-162], previous research shows that power laws and other invariants modulate effects on mortality and survivorship [112,123,163-168]. Previous research also shows that mortality and survivorship are affected by an invariant kind of frailty [44-46,128,129], a variable kind of frailty [130-133], an invariant kind of vitality [44,45,47,144,146,150], and a variable kind of vitality [69,91,108,151-155]. Furthermore, every mortacause and every vitacause – and interrelationships among mortacauses and vitacauses – could be stable or changing. Therefore, every mortacause and every vitacause is at least: one of dominant and not dominant, one of modulated and not modulated, one of invariant and variable, and one of stable and changing. Much remains to be learned about dominance, non dominance, modulation, non modulation, invariance, variability, stability, change, and other *modi operandi* of respective cause-specific mortacauses and vitacauses of respective tetraeffective causes of mortality and survivorship.

As noted, scientific research on causality remains problematic and challenging [1-6], scientific research on causes of mortality and survivorship remains particularly problematic and challenging [7-15], and mortality and survivorship and their interrelationships are particularly prone to elicit errors and biases [16-21]. The investigation here shows that consideration of tetraeffective causes of mortality and survivorship usefully elucidates – and deepens the consideration of, and expands the scope of scientific research on – causes of mortality and survivorship. Moreover, the empirical investigation addresses here diverse problems and challenges by employing best-fitting multivariable powered polynomial individual-level binary regression models of mortality and survivorship – and respective methods and procedures – that eliminate or reduce susceptibility to the following errors and biases: (i) errors of conflation of age and lifespan, (ii) errors of conflation of age, period, and cohort, (iii) ecological or aggregation errors or biases, (iv) errors of omission or conflation of contemporary-specific aggregates and lifespan-specific aggregates, (v) specification errors associated with omitted – or lurking, or confounding, or underlying – variables, (vi) unobserved heterogeneity bias, and (vii) specification errors associated with nonlinearity [123]. Furthermore, scientists and artists typically attribute force to mortality [57,58,60,61,106,169,170]; therefore, the consideration of mortacauses and vitacauses usefully elucidates here that attributions that ignore force and other characteristics of mortacauses and vitacauses commit errors of omission; additionally, attributions that attribute to mortality the forces of mortacauses and vitacauses commit errors of commission; attribution errors, errors of omission, and errors of commission belong to a large class of errors and biases that are commonly conceptualized as cognitive errors and biases [16,17,19-21,171-173]. Thus considerations of tetraeffective causes of mortality and survivorship –

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and the methods and procedures that are employed here – address diverse problems and meet some challenges. However, other diverse problems and challenges remain, and other problems and challenges come – and will continue to come – into focus; many of these problems and challenges require further research with diverse methods and procedures [1-15].

Specifications $dY/d(X^p) = a + bX^p$ are interpreted here as indicative of the respective intensity or effectiveness of respective tetraeffective causes, mortacauses, and vitacauses. This focus on intensity follows Gompertz's interpretation of derivatives as indicative of intensity [169], and the focus on effectiveness is based here upon the effectiveness of component a when $sign\{dY/d(X^p)\} = sign(a)$ and the effectiveness of component bX^p when $sign\{dY/d(X^p)\} = sign(bX^p)$ given $dY/d(X^p) = a + bX^p$ *such that* $sign(a) = -sign(bX^p)$. However, it is instructive to note that insights from Newton's analyses of motion promote the interpretation of derivative $dY/d(X^p)$ as indicative of the velocity of overall effects of X^p on mortality or survivorship Y, the interpretation of coefficient $|b|$ as indicative of the speed of the effects of the variable X-specific mortacause or vitacause, and the interpretation of component bX^p as indicative of the force of the effects of the variable X-specific mortacause or vitacause [174-177]. Furthermore, insights from the Hamiltonian conceptions of energy promote the interpretation of $dY/d(X^p)$ as indicative of the total energy of the overall effects of X^p on mortality or survivorship, the interpretation of component a as indicative of the potential energy of the invariant X-specific mortacause or vitacause, and the interpretation of component bX^p as indicative of the kinetic energy of the variable X-specific mortacause or vitacause [178,179]. Other specifications and interpretations could involve, for example, wave functions [180,181]. These possible interpretative insights show that causes, mortacauses, and vitacauses could be specified and interpreted in diverse fruitful productive ways that could yield diverse insights; these considerations promote further exploration of diverse specifications and diverse interpretations of meanings and characteristics of tetraeffective causes of mortality and survivorship, mortacauses, and vitacauses.

Specifications $Y = a + bX^p$ have been usefully employed in previous research on mortality and survivorship as well as in other research in biology, physics, chemistry, and other branches of science [74-76,182], but employment of specifications $dY/d(X^p) = a + bX^p$ in previous research on mortality or survivorship is not easy to find. Model $Y = a + bX^p$ is a powered first-degree polynomial model [123], it is also a first-degree fractional polynomial model [183,184], and it is also one of several kinds of Weibull models [66,74-76,95,104,106,185-187]. Model $dY/d(X^p) = a + bX^p$ differs from model $Y = a + bX^p$. Moreover, specification $dY/d(X^p) = a + bX^p$ *such that* $sign(a) = -sign(bX^p)$ is included in specification $dY/d(X^p) = a + bX^p + c(X^p)^2$ *such that* $sign(a) = -sign(bX^p)$, as illustrated here in analyses of effects of historical time on humans' mortality and survivorship. As noted, model $dY/d(X^p) = a + bX^p$ is based here upon differential equations analyses of best-fitting

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multivariable powered polynomial individual-level binary regression models of mortality and survivorship [123]. The best-fitting specification $dY/d(X^p) = a + bX^p$ *such that* $sign(a) = -sign(bX^p)$ that is found in this investigation is a specification of tetraeffective causes, mortacauses, and vitacauses. Specification $dY/d(X^p) = a + bX^p$ *such that* $sign(a) = -sign(bX^p)$ is simple, succinct, and meaningful but it is not the only possible simple, succinct, and meaningful mathematical specification – and may not be the best-fitting specification – of tetraeffective causes, mortacauses, and vitacauses. Therefore, it is prudent to investigate the scope of the simple, succinct, and meaningful specification $dY/d(X^p) = a + bX^p$ *such that* $sign(a) = -sign(bX^p)$ [188,189]; the investigation of this scope will indicate whether this specification provides best-fitting specifications of diverse kinds of tetraeffective causes of mortality and survivorship – and diverse kinds of mortacauses and vitacauses – of diverse kinds of entities in diverse times and places. Additional questions about scope apply to learning whether diverse kinds of binary outcomes (e.g., disease and health, war and peace, failure and success) are affected by tetraeffective causes.

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