Title: **Near-miss events as a measure of repeated survival**

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Research problem

In a world where people live ever longer lives, the need to rethink the definition and measurement of ageing becomes pressing. Over the last two decades, an increasing body of literature has indeed demonstrated why the concept of age, which stands at the centre of all demographic analysis, should actually be understood as a relative, not absolute, measure of ageing (Riffe et al., 2017; Sanderson and Scherbov, 2005). For example, in 2020, 90-year-old Japanese men could expect to live another 4.6 years, as long as their 80-year-old counterparts in 1950. For Japanese men, 90 is thus the new 80, illustrating that the number of years lived is an invalid indicator of someone's level of senescence when considering the big picture.

This conceptualization of ageing can build on the dominant model of ageing proposed more than sixty years ago and named after its authors (Strehler and Mildvan, 1960). The Strehler-Mildvan model postulates that survival is the result of a constant balance between intrinsic vitality and extrinsic challenges. In this framework, in order to reach old age, individuals need to overcome these challenges by relying on their level of vitality which tends to decrease with time, at a rate that can differ. Despite being very popular, this model is rarely (if ever) used in individual-level studies, probably because of the difficulty of operationalizing its main components: intrinsic vitality and external challenges. In this study, we suggest using serious health scares, also known as *near-misses*[1], as measures of events where external challenges were strong enough to almost kill the individual. We see this as a step towards a reconceptualization of ageing, not as the process of successfully surviving to another birthday, but as the repeated overcoming of near-miss events.

Using data collected on ca. 3000 old-age participants in Switzerland, we aim at answering the following question: how does the number of near-miss events progress with age, and how is it influenced by social, economic and psychological individual resources? This extended abstract gives a succinct (and still incomplete) overview of the theoretical framework, data and methods that we intend to use to answer this question and provides a few descriptive statistics that support the feasibility of our approach. We would like to stress that this draft reflects a work in progress. We welcome all constructive comments and suggestions and kindly ask the readers not to cite it.

[1] It is important to note that the concept of *near-miss* is a little ambiguous in health, because it can not only refer to a near-fatal health event, but also to a care event in which the patient narrowly escapes. The two ideas are similar, but in the latter the event is seen from the perspective of the quality of care and not the patient. We mean here the former definition, as found for example in the literature of maternal mortality, see e.g. Ueda, A., Chigusa, Y., Mogami, H., Nakita, B., Ohtera, S., Kato, G., Horie, A., Mandai, M., Kondoh, E., 2021. Maternal near-miss attributable to haemorrhagic stroke in patients with hypertensive disorders of pregnancy in Japan: A national cohort study. Pregnancy Hypertens 25, 240-243.

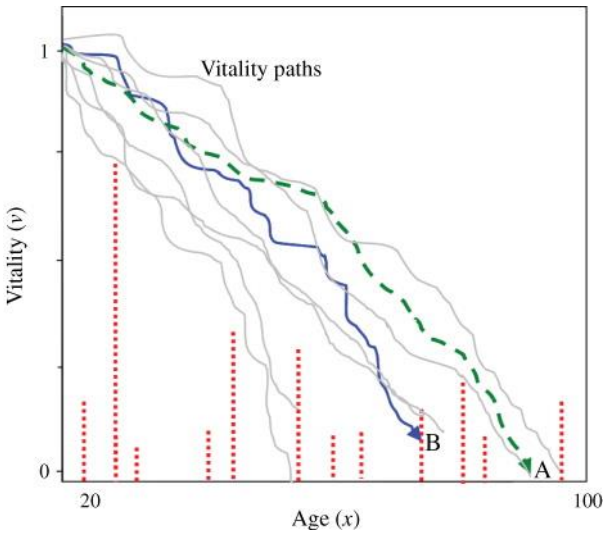
Theoretical framework

Strehler and Mildvan's (SM) theory of ageing can be summarized in two postulates (Strehler and Mildvan, 1960). The first postulate states that an organism is composed of multiple subsystems, each with a specific capacity to restore their initial conditions following a disturbance (such as changes in conditions caused by internal or external energy fluctuations). This capacity is expressed under the term *vitality*, defined as the organism's ability to remain alive, and is quantified by taking a weighted average of the highest achievable rate of work output (power output), subtracting the baseline power output from all functional aspects contributing to survival in the typical environment. This concept of vitality bears similarity to the one presented by Medawar (Medawar, 1957).

The second postulate states that death happens when the organism's ability to perform work to restore its original state falls below the energy required to counter the effects of a given external challenge. The sizes of challenges (or the responses needed to overcome these challenges) follow an energetic distribution similar to the Maxwell-Boltzmann distribution of energies among molecules.

More recently, this theory was reformulated as a vitality model (Anderson, 2000), and further elaborated as a two-process framework that takes into account mortality caused by two factors: the exhaustion of an organism's intrinsic vitality and external challenges that surpass an organism's vitality level (Li and Anderson, 2013). Figure 1 illustrates this process through the cases of two fictitious individuals A and B. In this example, both individuals first avoid eight external challenges, after which B's vitality decreases to the point where he/she cannot overcome the ninth challenge and dies at the age of roughly 70 years. Individual A, on the other hand, manages to avoid another three challenges but eventually dies around 90 years of age, when his/her vitality is completely exhausted.

Figure 1: Illustration of the two-process vitality model inspired by the SM model of ageing

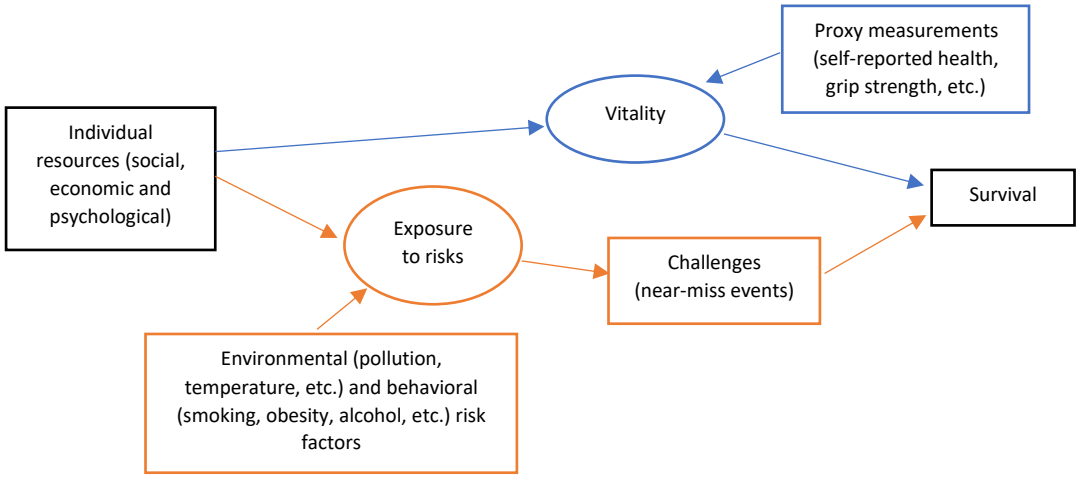


Source: Li and Anderson (2015)

The SM model of ageing and its variants are often used as conceptual framework to deduce aggregate measures, but, to the best of our knowledge, it was not used to study individual trajectories. The main reason for this lack of empirical application at the individual level is that the components of the SM model are hard to observe. In fact, the only thing that can be directly observed is whether someone is dead or alive, and possibly what was the cause of death. We try however to consider unobserved states as latent variables, alongside observed proxies. In order to make a first attempt at filling this gap, we

design a conceptual model that includes observable and unobservable dimensions[2] to operationalize the SM model with empirical micro data (Figure 2).

Figure 2: A possible conceptual model for the operationalization of the SM model of ageing at the individual level



Our conceptual model includes the two processes driving survival described in Li and Anderson (2013): in blue at the top the 'intrinsic' vitality, and in orange at the bottom the 'extrinsic' challenges. It however also includes individual characteristics, which are expected to affect both dimensions. This hypothesis marks a slight change compared to the original framework, since we assume here that both 'intrinsic' vitality and 'extrinsic' challenges are affected by the amount of resources (social, economic and psychologic) of each individual. This hypothesis might be easier to accept for vitality than challenges, which are assume to be the expression of random variables that are external to the individuals. We should however acknowledge that all individuals do not share the same environment (professional, familial, etc.) and thus are not exposed to the same risks, which affects in turn the probability (or frequency) of occurrence of challenges. Using the dataset present below, we will attempt to model the lower part of the conceptual framework, and if possible also estimate a complete model including individual resources, challenges, vitality and survival (or age at death) as the main outcome.

Data

The Vivre-Leben-Vivere survey (hereafter VLV) focuses on the health and living conditions of older adults born between 1911 and 1946, living in Switzerland (Oris et al., 2016). The first wave of VLV, conducted in 2011-12, was specifically constructed to promote a fair inclusion of vulnerable individuals – those living in poverty, social isolation, depression or those physically dependent on external care – who are usually underrepresented in such surveys. 3'068 individuals, without major cognitive impairments and aged 65-102, were included in this data collection via a two-step procedure: they first completed a self-administered questionnaire that included a retrospective life calendar covering their family, work, residential and health trajectories from their birth until the date of the survey (Morselli et al., 2016). Following this, they participated in a computer assisted personal interview where the interviewer checked the life calendar (Oris et al., 2016). A second wave of VLV was carried out in 2016-17 among a subsample or survivors, with a short life calendar covering the period between the two waves (see Ihle et al., 2020).

[2] Observed dimensions are noted in rectangles, latent ones in ellipses.

If retrospective life calendars are increasingly used in life course studies, they rarely cover health, which is quite a broad concept, moreover over the long-life course of older adults. A critical analysis has been done to see how respondents have appropriated this tool and what they answered, using their own words. A codification, distinguishing accidents, diseases (using ICD 10 for the latter) and (usually long-term) disabilities, has been realized (Fioretta, 2015). On that basis, the various memory biases have been discussed. The conclusion is that serious threats (ex. breast cancer), in other words the near misses, have been well-declared by the respondents, although some traumatized experiences like aggressions are likely to be under-reported (Fioretta, 2015; Morselli et al., 2016).

Methods

We envisage the following stages in our analysis of the data. We apologize for the roughness of the writing, which is due to a lack of time before the submission deadline. A cleaner version will be made available before the conference.

1. Coding of near-miss events, ideally using ICD-10 and survival probabilities of the diagnostics at the time of the event, which would lead to a score from 0 to 1 estimating the probability that the event would have resulted in the death of the individual
2. Descriptive analysis: number of near-miss events by age, disaggregated by individual characteristics
3. Multilevel modelling: Poisson model with number of near-miss events as dependent
4. Structural Equation Modelling: Try to estimate the whole conceptual model

Preliminary results

At this stage of our analysis, we only have basic descriptive statistics of our dataset provided by previous publications. They however confirm that the dataset is robust and offers a valid and reliable measure of near-miss events, as well as a large-enough sample size (1804 women, 1855 men, to which 307 and 284 proxy interviews need to be deducted, respectively, because they do not contain all variables) that guarantees sufficient statistical power.

Table 1: Complete interviews by stratum, VLV, five cantons, 2011

		Women													
	Complete interviews							In percent of the persons solicited							
	65-69	70-74	75-79	80-84	85-89	>90	Total		65-69	70-74	75-79	80-84	85-89	>90	Total
Geneva	59	58	61	57	55	61	351		37.3	32.2	33.9	31.8	30.7	34.3	33.3
Valais	58	61	58	59	60	61	357		32.0	31.4	27.6	31.6	36.4	38.6	32.6
Bern	63	65	64	62	62	61	377		37.5	34.0	29.6	24.5	29.0	24.5	29.2
Basel	68	59	59	60	58	60	364		35.1	24.5	24.3	22.5	22.4	17.8	23.6
Ticino	60	57	61	53	62	63	356		33.0	24.3	22.0	21.9	26.4	25.0	25.0
Total	308	299	303	291	297	306	1804		34.9	28.7	26.9	25.8	28.2	26.0	28.2
		Men													
	Complete interviews							In percent of the persons solicited							
Geneva	58	56	62	58	61	60	355		36.7	31.8	41.1	36.5	39.6	35.3	36.7
Valais	60	60	64	61	61	59	365		40.5	34.3	38.3	34.9	37.7	36.6	36.9
Bern	72	62	66	67	66	64	397		41.9	39.7	34.2	36.8	31.4	29.6	35.2
Basel	67	62	61	59	53	71	373		37.2	38.5	31.4	30.7	24.3	31.8	31.9
Ticino	58	72	56	59	59	61	365		36.9	39.8	27.1	27.6	28.5	26.4	30.5

Total	315	312	309	304	300	315	1855		38.7	36.7	33.9	33.0	31.5	31.5	34.0

Source: (Oris et al., 2016)

Table 2:Number of proxy interviews by age and gender of ego, VLV, five cantons, 2011

Age	Women	Men	Total
65–69	4	3	7
70–74	8	9	17
75–79	17	15	32
80–84	45	45	90
85–89	75	63	138
90+	158	113	271
Total	307	248	555

Source: (Oris et al., 2016)

Table 3:Descriptive statistics of the sample

Variable	Catégories d'origine	Catégories recodées	Fréquence relative en %	Nombre de cas valides	Missings en %
FACTEURS					
Facteurs sociodémographiques					
Canton	Genève		19.0	3317	0
	Valais		19.1		
	Berne		21.8		
	Bâle		20.6		
	Tessin		19.6		
Sexe	Femme		56.2	3317	0
	Homme		43.8		
Cohorte	1921 et avant		2.6	3317	0
	1922-1926		7.6		
	1927-1931		13.5		
	1932-1936		20.6		
	1937-1941		25.5		
	1942-1946		30.1		
Vivre en couple	Marie-Remarie-Pacse	En couple	40.2	3317	0
	Célibataire	Seul	59.8		
	Divorce-Sépare				
	Veuf				
Niveau d'éducation	Primaire		10.3	3316	0
	Secondaire inf.		7.8		
	Apprentissage		35.9		
	Secondaire sup.		17.3		
	Tertiaire		28.7		
Revenu mensuel individuel	<1200	Pauvreté	20.8	2870	13.5
	1200-2400				
	2400-3600	Précarité	34.2		
	3600-4800	Sécurité	18		
	4800-6000	Confort ou aisance	27.1		
	6000-7200				
	7200-10000				
	10000-15000				
	>15000				
Santé					
Statut de santé	Indépendant		68.7	3263	1.6
	Fragile		29.6		
	Dépendant		1.7		
Pourcentage d'années avec événement de santé	De 0 à 100%	<1%	28.7	3317	0
		2-6%	47.2		
		>7%	24.1		
Cancer	Pas de cancer		83.7	3317	0
	Cancer ancien		10.0		
	Cancer récent		6.3		
Problème cardiovasculaire grave	Pas de problème cardiovasc.		82.7	3317	0
	Problème cardiovasc. ancien		9.1		
	Problème cardiovasc. récent		8.2		
Problème ophtalmique	Pas de problème ophtalm.		90.8	3317	0
	Problème ophtalm. Ancien		4.1		
	Problème ophtalm. Récent		5.2		
Problème lié à la mobilité	Pas de problème mob.		55.3	3317	0
	Problème mob. Ancien		24.1		
	Problème mob. récent		20.5		
Vie sociale					
Fréquence des relations (directes ou téléphoniques) avec la famille	Presque jamais ou une fois par an		6.6	3267	1.5
	Une fois par mois		17.7		
	Une fois par semaine ou par jour		75.7		
Fréquence des relations (directes ou téléphoniques) avec les amis	Presque jamais ou une fois par an		10.8	3279	1.2
	Une fois par mois		29.1		
	Une fois par semaine ou par jour		60.1		
Personnalité					
Extraversion	Score de 2 à 10			2970	10.5
Agréabilité	Score de 2 à 10			3032	8.6
Etre consciencieux	Score de 2 à 10			3028	8.7
Neuroticisme	Score de 2 à 10			3034	8.5
Ouverture	Score de 2 à 10			3009	9.3
STRATEGIES					
Comparaison sociale et temporelle					
Estimation de son état de santé en comparaison des personnes du même âge	moins bon		6.7	3209	3.3
	identique		37.5		
	meilleur		55.8		
Estimation de son état de santé en comparaison d'il y a 10 ans	détérioré		59.1	3280	1.1
	identique		32.4		
	amélioré		8.5		
Coping					
Sentiment de n'avoir aucun contrôle sur les aspects important de sa vie	jamais	jamais	66.8	3249	2
	presque jamais				
	parfois	parfois	24		
	souvent	souvent	9.2		
	très souvent				
Sentiment d'avoir la capacité à surmonter les problèmes personnels	jamais	jamais	3.5	3245	2.2
	presque jamais				
	parfois	parfois	8.9		
	souvent	souvent	87.6		
	très souvent				

Source: (Fioretta, 2015)

Conclusions

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