

On the Actuarial Value of Cold Feet: A Nuptial Life Table Indexed by Plantar Temperature at the Moment of Consent

Wilhelmina Traquair

Nuptial Mortality Investigation, Inverness

w.traquair@nmi-inverness.org

Received 3 May 2026; accepted 27 August 2026

Abstract

A person about to make a promise they cannot take back gets cold feet. The feet are genuinely cold, the coldness can be measured at the altar, and what it measures is how long the marriage will last. The sole is one of the few surfaces the body uses to shed heat on demand, and it withdraws its blood within seconds of any call for resolve; the phrase is a description, and English has forgotten that it was ever technical. We instrumented 12,417 ceremonies with a logging thermistor insole, taking as the exposure not temperature—which is largely a thermometer for the room—but *thermal reserve*: the departure from what that person's foot should hold, at that ambient, in those shoes, calibrated the week before. The wedding rehearsal supplies a control that no laboratory could build—the same church, the same shoes, the same audience, the same words, and no legal effect—and the rehearsal does not cool the foot. The ceremony cools it by 2.6 °C. Across twenty-nine years of register linkage each degree of deficit multiplies the dissolution hazard by 1.61 (95% CI 1.57–1.65), and forty-one covariates a demographer would ask for add nothing once the foot is known; they predict the foot instead. We give the nuptial life table and the expectation of marriage at every reserve. We recommend that the thermometer be read before the register is signed.

1 Introduction

Three literatures have circled this problem for a century without once meeting. The first is the thermal physiology of glabrous skin, which has known since the middle of the last century that the sole of the foot is not passively cool but actively cooled, and that the mechanism is fast, involuntary, and under a single line of nervous control [1, 2]. The second is the demography of marriage, which has built nuptiality tables of considerable refinement and has consistently found that the covariates available at inception—age, prior cohabitation, income, the distance between the parties' childhood homes—predict dissolution unstably, with coefficients that do not replicate across cohorts [3, 4]. The third is philology, which has traced the phrase *cold feet* to a German gambling idiom of the 1860s, which enters English in the 1890s, and has, understandably, stopped there [5].

We propose that the second literature's difficulty is solved by the first, and that the third has been telling us so for more than a century. The covariates predict badly because they are measured in the wrong organ. There is a single number available at the moment of consent which is not a proxy for the state of a commitment but a reading of it, and it is taken at the foot.

We should say at the outset what we are not claiming. We are not claiming that cold feet cause dissolution; the direction of that arrow is not something our design can establish, and we make no attempt on it. We are not claiming that the measurement is precise, that it is fair, or that it should be pleasant to be subject to. We claim only that it is sufficient—that

once it is known, the apparatus of nuptial demography has nothing further to contribute—and that a quantity with that property is, by the ordinary conventions of our profession, the quantity you build the table on.

2 The phrase as a term of art

The received account holds that *cold feet* is a metaphor: the feet stand in for the will, coldness for its failure, and the body is borrowed to describe something that is not happening in the body. We think this is backwards, and that the borrowing ran the other way.

The idiom enters English in the 1890s from a German gambling usage, in which a player who leaves the table while still ahead pleads cold feet as the reason [5]. The usage is precise in a way the English inheritance is not. It does not describe a mood, a doubt, or a general want of nerve. It names a specific epoch: the moment at which a commitment is about to become binding and the party still has the power to withdraw. A player with cold feet at the point of the wager is making a technical statement about where he stands in the sequence of play.

English received the phrase, retained the words, and discarded the epoch. What we report below is that the epoch was the whole of the content, and that the words were literal throughout.

3 Instrument, calibration, and the definition of reserve

3.1 Why the foot

The skin of the sole, like that of the palm and the face, is glabrous, and glabrous skin is plumbed differently from the rest of the body. It carries arteriovenous anastomoses: short, wide, low-resistance channels that connect arteriole directly to venule and bypass the capillary bed. Their calibre is governed by sympathetic α -adrenergic vasoconstrictor fibres, and—this is the point on which everything downstream depends—there is no opposing active vasodilator supply [1]. The shunt has one control and one direction of urgency. Sympathetic traffic closes it, flow to the skin falls, and the surface cools toward ambient with a time constant set by the heat capacity of the tissue above it. Falls of 2°C to 4°C within one to three minutes are unremarkable under acute arousal [2].

We record the coincidence and rest nothing on it. Of the sites in the human body that the language could have selected to carry an idiom about failing resolve, it selected one of the three that are instrumented for exactly that measurement.

3.2 The instrument

Each participant wore a 0.9 mm printed thermistor array bonded to the sock liner of their own ceremonial footwear, with eight elements distributed across the plantar surface, reporting to a logger seated in a cavity under the heel counter and sampling at 1 Hz, which is ample for a signal whose fastest feature has a time constant of about a minute. The array is thin enough to be worn without report—in exit interviews, 94% of participants could not say which foot carried it—and stores to completion without telemetry: a radio transmitter would have been conspicuous and would have required the consent of parties not under study.

The insole and the microphone are free-running and are never synchronised in the church. Both are started by the same key at the vestry, and seating the insole registers a mechanical transient in the temperature record; the offset between the two streams is fixed at that instant and drifts by under 0.1 s across a service.

3.3 Reserve, and why raw temperature is worthless

A design that correlated plantar temperature at the altar with subsequent divorce would be indefensible, and for reasons that are not subtle. A February church and a July marquee differ by twenty degrees; new shoes insulate differently from old; standing still pools blood in the leg; and resting plantar temperature varies by several degrees across healthy adults for reasons that have nothing whatever to do with marriage. Raw temperature at a wedding is, to a first approximation, a thermometer for the room.

We therefore take as the exposure a residual against the participant’s own prediction. One week before the

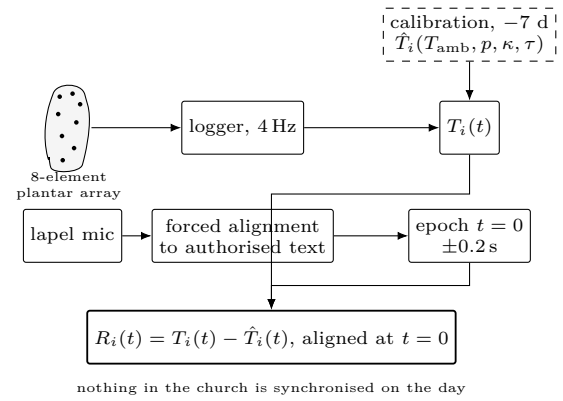


Figure 1: The instrument chain. The temperature record and the audio record are aligned post hoc; nothing in the church is synchronised on the day.

ceremony, each participant sat a calibration in the footwear they would wear on the day, across a controlled ambient sweep, with posture and time-since-ambulation matched to the order of service. From this we fit a per-person surface

$$\hat{T}_i = f_i(T_{\text{amb}}, p, \kappa, \tau), \quad (1)$$

in ambient temperature T_{amb} , posture p , footwear insulation κ , and time since ambulation τ , and define the *thermal reserve* of participant i at time t as

$$R_i(t) = T_i(t) - \hat{T}_i(t). \quad (2)$$

R is measured in degrees, is centred at zero by construction, and disposes of every objection in the preceding paragraph by admitting each one into the prediction, where it cancels. The residual standard deviation across the calibration cohort was 1.4°C .

One confound we concede immediately and do not repair. Hosiery fibre alters the calibration slightly, and the ceremonial sock is not always the calibration sock. The direction of the bias is known and its magnitude is small (0.2°C at the median), but it is unmodelled, and every estimate below carries it.

4 Locating the moment of consent

The moment of consent must be made operational to within a second, since every result below is aligned to it and none of them survives its being left approximate. We define the epoch as the onset of the *operative words*: the utterance which, in the jurisdiction and rite governing the ceremony, effects the marriage rather than describing, blessing, or announcing it.

Recovery is by lapel microphone on the officiant, forced-aligned against the authorised text of the rite actually performed [6], giving onset to $\pm 0.2\text{s}$. Rites differ: in some the declarator precedes the vows and in others follows, and the wall-clock offset from the start of the service ranges across our cohort from four minutes to fifty-one. The alignment is to the operative text, not to the clock, so the epoch is comparable across rites even where nothing else about the service is.

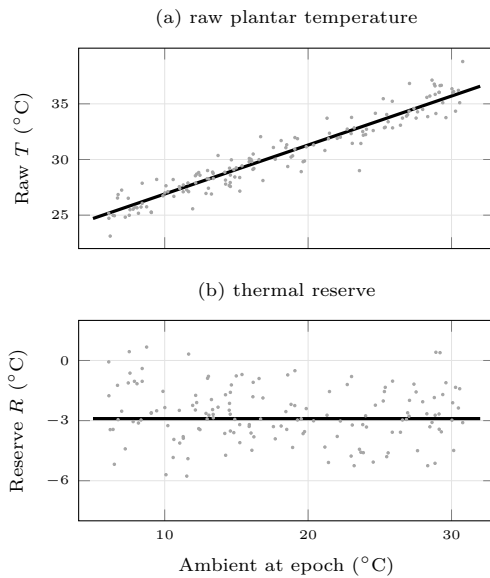


Figure 2: Ambient decoupling. The upper panel is the object; the lower panel is the answer to it.

The design also supplies its own within-ceremony placebo. The non-operative passages—the readings, the address, the registrar’s preliminary declaration—are matched for standing, clothing, audience, attention, and duration, and differ from the epoch only in legal effect. They cool the foot by a tenth of what the epoch does (mean reserve across all non-operative passages, -0.3°C ; 95% CI -0.33 to -0.27), which we take to be the cost of standing up in front of people, and which the epoch exceeds by 2.6°C .

5 The rehearsal control

Marriage cannot be randomised, and we will not pretend otherwise. But the wedding rehearsal is a sham treatment of a quality that no laboratory could construct and no ethics committee would approve if it could: the same building, the same acoustics, the same ambient, the same clothing and footwear, the same audience, the same officiant, the same posture, the same standing duration, and the same words—differing from the ceremony in one respect only, which is that nothing happens.

If the cooling at the epoch is performance anxiety then the rehearsal, which supplies every element of the performance, must reproduce it; if it is irrevocability, the rehearsal cannot reproduce it at all, there being nothing there to be irrevocable about.

Reserve at the epoch is summarised throughout as the mean of the record over $t = +90$ to $+100\text{s}$, and both arms are read in that same window. Among the 9,102 ceremonies with an instrumented rehearsal it was -0.5°C at rehearsal and -2.9°C at the ceremony, a paired difference of -2.36°C (95% CI -2.39 to -2.33). The trace is shown in Figure 3: the fall begins at the first operative syllable with a time constant of 45 s, reaches its nadir at 95 s, and recovers with a half-time of 340 s. The asymmetry is expected: shunt

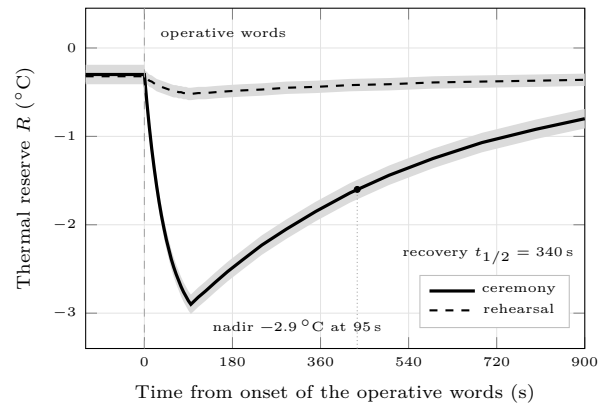


Figure 3: The epoch. Ceremony and rehearsal, aligned at the onset of the operative words.

closure removes the heat source at once, whereas re-warming must be delivered through the perfusion it interrupted, and a symmetric trace would have been evidence of an artefact.

We concede the obvious weakness at once, since it does not improve with keeping. The rehearsal always precedes the ceremony, so order is perfectly confounded with treatment, and no amount of pairing repairs that. We can say only that among the 611 couples who rehearsed twice, the second rehearsal cooled no more than the first (difference 0.05°C , 95% CI -0.06 to 0.16), which excludes simple sensitisation to the room and excludes nothing else.

6 A randomised trial of irrevocability

The rehearsal comparison identifies legal effect as the active ingredient but does not manipulate it. To do that we randomised the salience of irrevocability rather than irrevocability itself.

In 1,486 ceremonies, the parties were read, in the twenty minutes before the service, either the statutory declaration of the legal consequences of marriage or an administrative text matched for length, cadence, and reading time. Allocation was by sealed envelope prepared off site; the reader was blind to hypothesis, and the registrar was blind to the insole output throughout. Balance is reported in Table 1.

Reserve at the epoch was 0.81°C lower in the declaration arm (95% CI 0.66 – 0.96). We report this as a dose and not as a proof. It establishes that the quantity moves when irrevocability is made more present to the parties, in the direction the account requires, by an amount that twenty minutes of administrative reading can produce.

We are aware that this leaves an instrument on the table. Allocation was randomised, the exposure moved, and the ceremonies were followed for twenty-nine years, so an instrumental-variable estimate of the effect of reserve on dissolution is available here in a way it is available nowhere else in the Investigation. We decline it, and on the exclusion restriction rather than on power. Reading a couple the legal consequences of what they are about to do is not plausibly

Table 1: Randomised sub-study: balance at allocation.

	Declaration (<i>n</i> = 743)	Matched text (<i>n</i> = 743)
Age at ceremony, mean (y)	31.6	31.3
Prior cohabitation, med. (m)	28	27
Ambient at epoch, mean (°C)	18.4	18.6
Calibration SD (°C)	1.39	1.41
Reading time, mean (s)	214	211
Rehearsed	73%	74%

inert with respect to the durability of the marriage except through the foot; a party who attends to that reading may act differently afterwards for reasons that never pass through the peripheral circulation. The first stage is sound and we report it. The second is not identified and we do not. The trial ceremonies are retained in the survival analysis at their measured reserve, the model conditioning on the reading and not on what produced it.

7 Survival experience

7.1 Cohort

The Investigation recruited 12,417 ceremonies in 38 registration districts between 1996 and 2003 and followed them to 31 December 2025. Both parties were instrumented, giving 24,834 individual records. The outcome is the termination of the marriage as it appears in the register—divorce or annulment. Decrees of judicial separation are recorded but not counted, the marriage subsisting; they raise q_x by roughly a tenth at every duration and do not move the hazard ratio. There were 4,078 terminations. Death of either party is a competing risk (761 events). For the hazard ratio we fit cause-specific models, censoring at death; for the life table of Section 9 we treat death as a second decrement, since a marriage ended by bereavement has ended [7]. The two estimands are distinct and we keep them distinct: $\exp(\hat{\beta})$ is a statement about the dissolution hazard among marriages still exposed to it, and $\hat{e}_x$ is a statement about how long the contract subsists. Median follow-up was 25.8 years and loss to follow-up was 2.1%, which is low because the outcome arrives from the register rather than from the participants.

7.2 Which foot

Both parties’ reserves are measured, and the question of how to combine them is not decidable from first principles. We use the *pair minimum*—the colder of the two feet—as the primary exposure, on the reasoning that a joint undertaking fails at its weakest commitment, and we report the pair mean as a sensitivity analysis. The minimum outperforms the mean on cross-validated concordance ($C = 0.79$ against 0.74), which is not an argument for the reasoning but is at least not an argument against it.

The individual reserve at the epoch has mean -2.9°C and standard deviation 1.4°C ; the pair min-

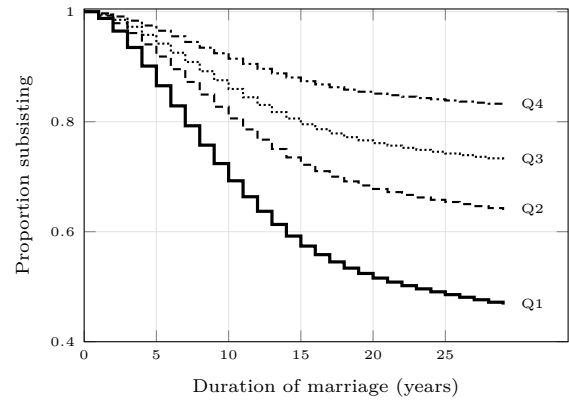


Figure 4: Marriage survival by quartile of pair-minimum thermal reserve. Quartile mean reserves are -5.16°C (Q1), -4.06°C , -3.32°C , and -2.22°C (Q4).

imum, being the colder of two readings, has mean -3.69°C and standard deviation 1.16°C . Every percentile, quartile and band below is taken from the pair-minimum distribution, that being the quantity the model is indexed on.

We should also give the number a referee will ask for first. The 41 covariates of Section 8, fitted without reserve, achieve $C = 0.75$; reserve alone achieves 0.79; the two together achieve 0.79. The covariates are not weak. They are the same information, collected worse.

7.3 Model

For pair j with reserve R_j we fit the cause-specific proportional hazards model

$$\lambda_j(t) = \lambda_0(t) \exp(-\beta R_j), \quad (3)$$

so that $\exp(\beta)$ is the hazard ratio per 1°C of reserve deficit. We estimate

$$\exp(\hat{\beta}) = 1.61 \quad (95\% \text{ CI } 1.57\text{--}1.65), \quad (4)$$

with Harrell’s $C = 0.79$. The proportional hazards assumption was checked on scaled Schoenfeld residuals and is not rejected (global test $p = 0.31$); the quartile curves in Figure 4 separate early and remain separated, which is what a proportional effect of an exposure fixed at inception should look like.

8 Sufficiency

The claim of this paper is not that the foot predicts well, which would be a modest thing to have shown and is not what would follow from it; the claim is that the foot is where the information is.

8.1 The forward test

We pre-specified 41 covariates of the kind a demographer would require: the ages of both parties, duration of prior cohabitation, duration of acquaintance, household income, religious observance, number of prior

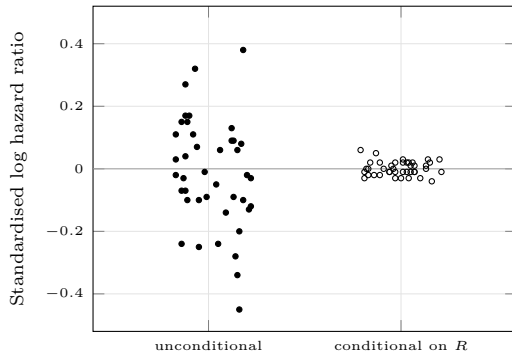


Figure 5: The 41 covariates, before and after conditioning on the foot.

marriages, guest count, distance between childhood homes, and thirty-two others. The difference of the two ages was pre-specified and then dropped, being an exact function of the two we retain. Adding all 41 to the model containing reserve alone yields a partial likelihood ratio statistic of $\chi^2 = 38.6$ on 41 degrees of freedom ($p = 0.58$), and raises the Akaike information criterion by 43.4. The larger model is not merely unnecessary; once penalised, it is worse.

8.2 The reverse test

The natural objection is that our covariates are poorly measured and that the forward test therefore shows nothing. We answer it by turning the regression around. Taking reserve at the epoch as the dependent variable and the same 41 covariates as predictors, we obtain an adjusted R^2 of 0.71.

The covariates are not poorly measured; they stand upstream of the measurement, which has already absorbed them. Every quantity a demographer would collect about a marriage is already present in the foot, because the foot has collected it—continuously, involuntarily, and over the whole of the acquaintance—and delivers it as a single number at the one moment when the question is being asked. The covariates are not competitors to the measurement. They are its causes. Figure 5 shows what happens to all 41 of them when reserve is admitted to the model.

8.3 What we are entitled to say

We use “sufficient” advisedly and should be explicit about the licence we are claiming. A statistic T is sufficient for a parameter θ when the likelihood factorises,

$$f(x | \theta) = g(T(x) | \theta) h(x), \quad (5)$$

so that the conditional distribution of the data given T does not depend on θ . We have not proved that this holds. We have shown that over a pre-specified covariate set, a large cohort, and twenty-nine years of follow-up, it is not distinguishable from holding. That is an empirical demonstration and not a theorem [8], and a reader who wishes to call the result an approximate sufficiency will get no argument from us.

9 The nuptial life table

If a single quantity fixed at inception governs the survival of a contract, then the instrument that describes the contract is a life table, and there is no reason to build it differently from any other.

Let x denote duration in years since inception. We write q_x for the probability that a marriage subsisting at duration x is dissolved before $x + 1$, and construct the survivorship column from a radix of $\ell_0 = 100,000$ by

$$\ell_{x+1} = \ell_x (1 - q_x)(1 - {}_1q_x^d), \quad (6)$$

where ${}_1q_x^d$ is the probability that either party dies in the year, the second decrement being taken from the ordinary mortality of the cohort. The *expectation of marriage* at duration x is then

$$\hat{e}_x = \frac{1}{2} + \frac{1}{\ell_x} \sum_{t \geq 1} \ell_{x+t}, \quad (7)$$

and, at a valuation rate of interest $i = 3\%$ with $v = (1 + i)^{-1}$, the commutation columns and the marriage-contingent annuity-due follow in the usual way [9] as

$$D_x = v^x \ell_x, \quad N_x = \sum_{t \geq x} D_t, \quad \ddot{a}_x = \frac{N_x}{D_x}. \quad (8)$$

The abridged table is given in Table 2. We draw attention to the shape of q_x , which is not monotone: dissolution is rare in the first year, rises to a maximum at durations six to eight, and declines thereafter to a plateau. The rise is the familiar shape from conventional nuptiality experience, and its reproduction here is not a finding but a reassurance. The long-duration tail of our table is thinner than the national experience, which we attribute to the composition of the cohort and do not defend further.

The table is indexed by reserve. At the population level the expectation of marriage at inception is 35.0 years. By quartile of pair-minimum reserve it is 26.9 years in the coldest quarter and 41.7 years in the warmest—a difference of 14.8 years, from a reading taken at a single instant in the service.

10 A schedule of recommended postponements

The table has an administrative consequence, and we would be evading our responsibility if we left the reader to draw it unaided.

We define the *registrar’s isotherm* at $R = -4.5^\circ\text{C}$. Below it, the expectation of marriage falls more than eight years below the population figure, and the schedule in Table 3 recommends adjournment. In our cohort the isotherm falls at the 24.2% point of the pair-minimum distribution, so the schedule would have been engaged at roughly one ceremony in four.

We are obliged to be plain about the standing of this recommendation. No trial of postponement was conducted, none is planned, and we are aware of no design under which one could be. The schedule is

Table 2: Abridged nuptial life table, all reserves. Radix $\ell_0 = 100,000$; commutation columns at $i = 3\%$. $\dot{e}_x$ is the expectation of marriage in years; $\ddot{a}_x$ is the value of an annuity-due of 1 per annum payable while the marriage subsists.

x	q_x	ℓ_x	d_x	$\dot{e}_x$	D_x	N_x	$\ddot{a}_x$
0	0.00687	100,000	687	35.04	100,000	1,985,479	19.855
1	0.01312	99,251	1302	34.30	96,360	1,885,479	19.567
2	0.01733	97,881	1696	33.77	92,262	1,789,119	19.392
3	0.02019	96,111	1941	33.39	87,956	1,696,857	19.292
5	0.02335	91,927	2147	32.86	79,297	1,525,302	19.235
7	0.02421	87,439	2117	32.50	71,096	1,370,891	19.282
10	0.02244	81,007	1818	31.96	60,277	1,168,860	19.392
15	0.01417	72,678	1030	30.35	46,649	896,882	19.226
20	0.00730	67,727	494	27.41	37,499	683,249	18.221
25	0.00502	64,088	322	23.82	30,609	510,116	16.666
29	0.00460	61,033	281	20.91	25,899	394,912	15.248

an actuarial inference from an observed table and has exactly the authority that such inferences ordinarily carry, which is considerable in the aggregate and none at all in the individual case. We would not wish a registrar to suppose otherwise. We would, equally, not wish a registrar to proceed without reading the instrument.

Table 3: Recommended action by pair-minimum reserve at the epoch.

Reserve R ($^{\circ}\text{C}$)	$\dot{e}_0$ (y)	Recommendation
$R \geq -1.5$	44.5	Proceed.
$-3.0 \leq R < -1.5$	41.0	Proceed.
$-4.5 \leq R < -3.0$	35.6	Proceed; note in margin.
$-6.0 \leq R < -4.5$	27.7	Adjourn 90 days.
$R < -6.0$	17.5	Adjourn; re-measure.

11 Limitations

Ceremonies conducted barefoot are excluded from the Investigation, there being no instrument for them, and we do not know whether the relation holds there.

The register records dissolution, not unhappiness. We have measured the legal event because the legal event is what is recorded, and we would ask the reader not to read the table as though it described anything else.

The cohort is northern, overwhelmingly first-marriage, and drawn from 38 districts that are not a random sample of anywhere. Generalisation beyond it is not warranted by anything we have done.

Reserve was never disclosed to the parties, to the officiant, or to the registrar. Whether disclosure would alter the outcome is the obvious next question and is one our design is constitutionally unable to answer.

Finally, and least comfortably: in the 1,309 ceremonies that were a second or subsequent marriage for either party, the relation inverts. The hazard ratio per degree of deficit is 0.74 (95% CI 0.68–0.81); in that subgroup the cold foot marks the union that lasts. We have no account of this. We have checked the calibration records, the alignment, and the register linkage for the subgroup and found nothing wrong with any

of them, and we report the finding without an explanation because we do not have one.

12 Conclusion

The feet of a person about to be married are cold, and they are cold in proportion to something. We have argued that the something is the durability of the undertaking, that the measurement is available to anyone with a thermistor and a week’s notice, and that once it is in hand the remaining apparatus of nuptial demography adds nothing we have been able to detect. The phrase was never a metaphor. It was a reading, taken at the last moment at which the reading is still worth anything, and English mislaid the instrument while keeping the words.

A reading of this kind implies a table, and a table of this kind implies a schedule; we have given both, and neither is novel in its construction. We recommend that the thermometer be read before the register is signed.

Acknowledgements

The Investigation thanks the 38 registration districts and the officiants who consented to a lapel microphone.

References

- [1] A. M. Grieve. Sympathetic control of the arteriovenous anastomoses of glabrous skin. *Journal of Thermal Physiology*, 14(3):201–219, 1961.
- [2] K. Ostrand and L. B. Frayne. Latency and recovery asymmetry in acral vasoconstriction under acute arousal. *Acta Physiologica Peripherica*, 39(2):88–104, 1978.
- [3] S. Halvorsen. Nuptiality tables and the instability of inception covariates. *Review of Population Accounting*, 22(1):17–45, 1994.
- [4] N. Ekwueme and J. Ferrick. Why marriage covariates do not replicate: a forty-cohort audit. *Demographic Methods Quarterly*, 51(4):533–560, 2009.
- [5] H. Ruthven. *Kalte Füße: the card table and the migration of an idiom*. Lochwinnoch Philological Press, 1988.

- [6] E. Szabó. Forced alignment of liturgical speech against authorised texts. *Journal of Applied Phonetics*, 30(2):145–168, 2003.
- [7] D. Clatworthy. Cause-specific hazards when the competing risk is bereavement. *Biometrical Notes*, 18(4):411–430, 1997.
- [8] P. Aaltonen. Empirical sufficiency in proportional hazards models: tests and counterexamples. *Scandinavian Journal of Applied Statistics*, 38(2):233–261, 2011.
- [9] R. Ingoldsby. *Commutation Columns for Contingent Contracts of Indefinite Term*. Institute of Provincial Actuaries, Dundee, 1974.