

**STATED-PREFERENCE STUDY TO EXAMINE THE ECONOMIC  
VALUE OF BENEFITS OF AVOIDING SELECTED ADVERSE  
HUMAN HEALTH OUTCOMES DUE TO EXPOSURE TO  
CHEMICALS IN THE EUROPEAN UNION**

**PART I - SENSITIZATION & DOSE TOXICITY**

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# general outline

- WHAT:
  - estimate willingness-to-pay for priority health outcomes
  - sensitization: acute and chronic dermatitis
  - dose toxicity: acute kidney injury and chronic kidney disease
- HOW: contingent valuation + chained standard gamble
- WHERE: in CZ + UK + IT + NL
- RESULTS: EU-wide economic values for priority health outcomes

# methods

## contingent valuation

- stated preferences valuation method eliciting willingness to pay directly („*What is the amount you would definitely pay for ..?*“)
- five contingent scenarios per respondent:
  - 4x skin sensitization (variants of acute mild dermatitis)
  - 1x acute dose toxicity



## „chained“ standard gamble

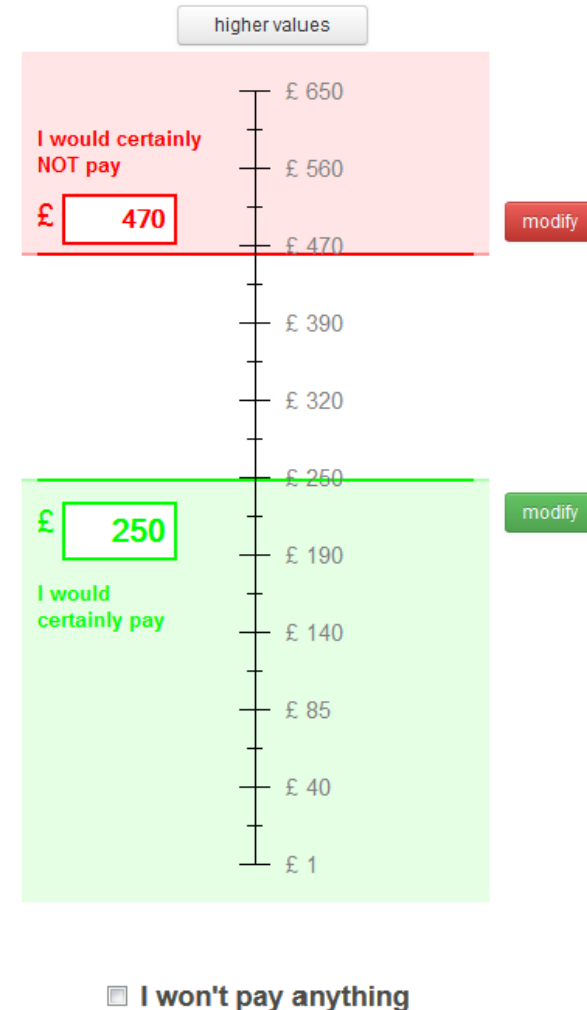
- combines modified standard gambles (*i.e. trading between certainty of less severe outcome and chance of cure and risk of more severe outcome*):
  - chronic severe dermatitis
  - chronic kidney disease



complemented with elicitation of quality of life rating (→ QALYs)

# Questionnaire

- introduction of illnesses
- health quality assessment using VAS
- CV: WTP elicited using two-way payment ladder (i.e. two questions – (1) highest amount certainly would pay, and (2) lowest amount certainly would not pay – taken as an interval range of true WTP)
- „I won't pay anything“ option followed by probe questions (true zeros/protests)
- monetary values in national currencies (EUR, GBP, CZK), converted to „generic“ euros by PPP
- both chronic outcomes valued using chained standard gamble

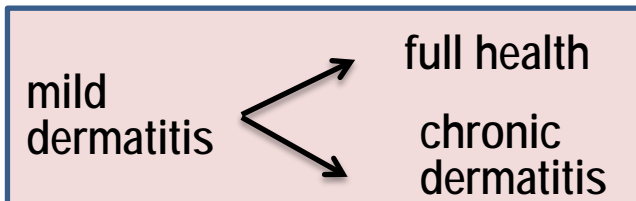


# Questionnaire – chained SG

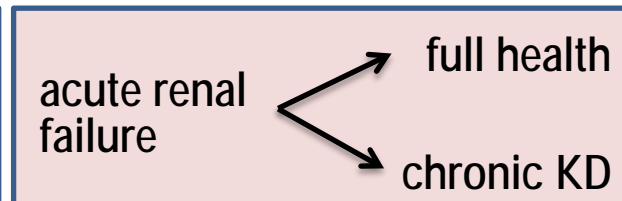
- 2 chronic outcomes: chronic dermatitis and chronic kidney disease
  - chaining of WTP for less severe health state (here health state A) to derive risk trade-off for more severe health state (health state B) vs complete cure
- 3 standard gambles per respondent:

TREATMENT 1	TREATMENT 2
health state A (with certainty)	(1- $p_B$ )% chance of full health  $p_B$ % chance of health state B

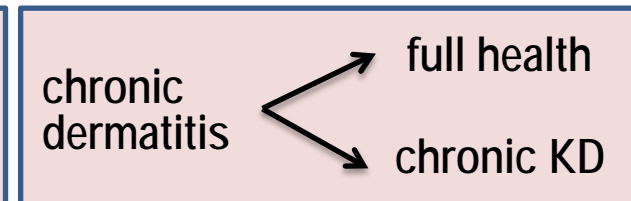
## SKIN SENSITIZATION



## DOSE TOXICITY



## COMBINED



# illnesses

## Illness A (acute dermatitis)

<b>Symptoms of illness</b>	<ul style="list-style-type: none"> <li>• itchy, burning skin</li> <li>• red rashes, small blisters</li> <li>• blisters burst open, forming scabs and scales</li> </ul>
<b>Area</b>	<ul style="list-style-type: none"> <li>• less than <u>10% of your body</u></li> </ul>
<b>How long?</b>	<ul style="list-style-type: none"> <li>• 2 weeks</li> </ul>
<b>How often?</b>	<ul style="list-style-type: none"> <li>• once</li> </ul>
<b>Treatment</b>	<ul style="list-style-type: none"> <li>• applying skin creams frequently throughout the day</li> <li>• treatment with <u>antihistamines</u> and local <u>corticosteroids</u></li> </ul>
<b>Quality of life impact</b>	<ul style="list-style-type: none"> <li>• skin soreness from scratching</li> <li>• sleep disturbance</li> <li>• medical side effects such as drowsiness</li> </ul>



4 variants of acute mild sensitization per respondent:

illness A(x) sub-variant	frequency (per year)	duration (years)
A	1	1
A1	2 or 4	1
A2	1	2, 5 or 10
A3	2 or 4	2, 5 or 10

# illnesses

## Illness B (chronic dermatitis)

<b>Symptoms of illness</b>	<ul style="list-style-type: none"><li>• permanently:</li><li>• itchy, burning skin</li><li>• red rashes, small blisters</li><li>• massive swelling, skin lesions, scabs and scales during flare-up</li></ul>
<b>Area</b>	<ul style="list-style-type: none"><li>• permanently: less than <u>10% of your body</u></li><li>• more than <u>10% of your body</u> during flare-up</li></ul>
<b>How long?</b>	<ul style="list-style-type: none"><li>• for the rest of your life</li><li>• flare-up lasting about 2 weeks</li></ul>
<b>How often?</b>	<ul style="list-style-type: none"><li>• flare-up twice a year for the rest of your life</li></ul>
<b>Treatment</b>	<ul style="list-style-type: none"><li>• permanently: daily application of skin creams and local <u>corticosteroids</u></li><li>• one-week hospitalisation during flare-up with oral or injectable <u>corticosteroids</u> and <u>phototherapy</u></li></ul>
<b>Quality of life impact</b>	<ul style="list-style-type: none"><li>• permanently:</li><li>• skin soreness from scratching</li><li>• sleep disturbance</li><li>• medical side effects such as drowsiness</li><li>• inability to work in certain types of occupation</li><li>• during flare-ups:</li><li>• unpleasant and unsightly appearance</li><li>• limits to leisure activities</li></ul>



# illnesses

## Illness C (acute renal failure)

<b>Symptoms of illness</b>	less urination (leading to swelling) or excessive urination reduced appetite nausea, vomiting shortness of breath, bad breath weight increase or loss itching and dry skin fatigue, sleep disturbance
<b>How long?</b>	4 weeks: 2 weeks in hospital and 2 weeks recovery at home
<b>How often?</b>	once
<b>Treatment</b>	two-week hospitalisation (dialysis) to improve kidney function symptoms disappear after successful treatment
<b>Quality of life impact</b>	permanent dietary changes required no occupational impacts after 4 weeks of treatment



## Illness D (chronic renal failure)

<b>Symptoms of illness</b>	your kidneys stop working properly
<b>How long?</b>	for the rest of your life
<b>Treatment</b>	dialysis in hospital 3 times a week for 4-5 hours each time
<b>Quality of life impact</b>	dialysis limits ability to work and carry out everyday activities your state of mind may be influenced by the illness, e.g. you may feel depressed or frustrated





# Sampling & data collection

- target population - general population in 4 countries (18-65 years) recruited from internet panels maintained by IPSOS
- quotas on region, age, education, gender and household income

## **data collection**

- pilot: August 2013: 64 questionnaires in CZ
- main wave: October 2013 - February 2014
- 3634 completed questionnaires collected in total

## **identification of potential speeders**

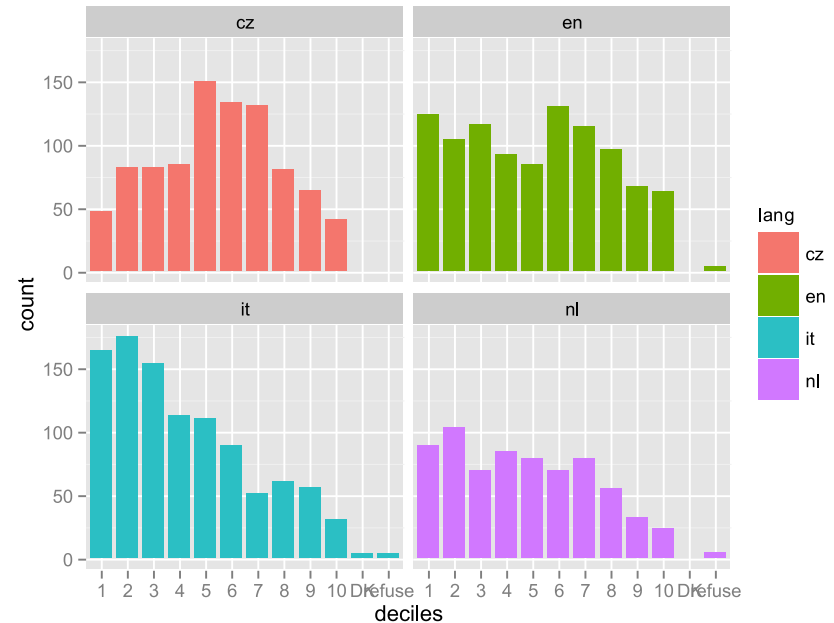
- those who completed the whole survey and its three parts (VAS, CVM, SG) in 48% of the median time or less (median time was ~25 min.)
- 135 respondents in total (i.e. 3.6%)

# Descriptive statistics

## Sample and population statistics

	Czech	United Kingdom	Netherlands	Italy
female – sample	51.5%	49.4%	49.7%	50.2%
female – population	51.2%	51.5%	50.9%	51.5%
age (mean) – sample	40.1	41.2	42.6	42.3
age (mean) – population	40.0	42.5	38.5	39.4
tertiary education - sample	15.7%	36.9%	22.3%	12.1%
tertiary education - population	17.0%	34.7%	28.6%	13.8%
9 <sup>th</sup> household income decile	7.2%	6.8%	4.7%	5.6%
10 <sup>th</sup> household income decile	4.6%	6.4%	3.6%	3.1%

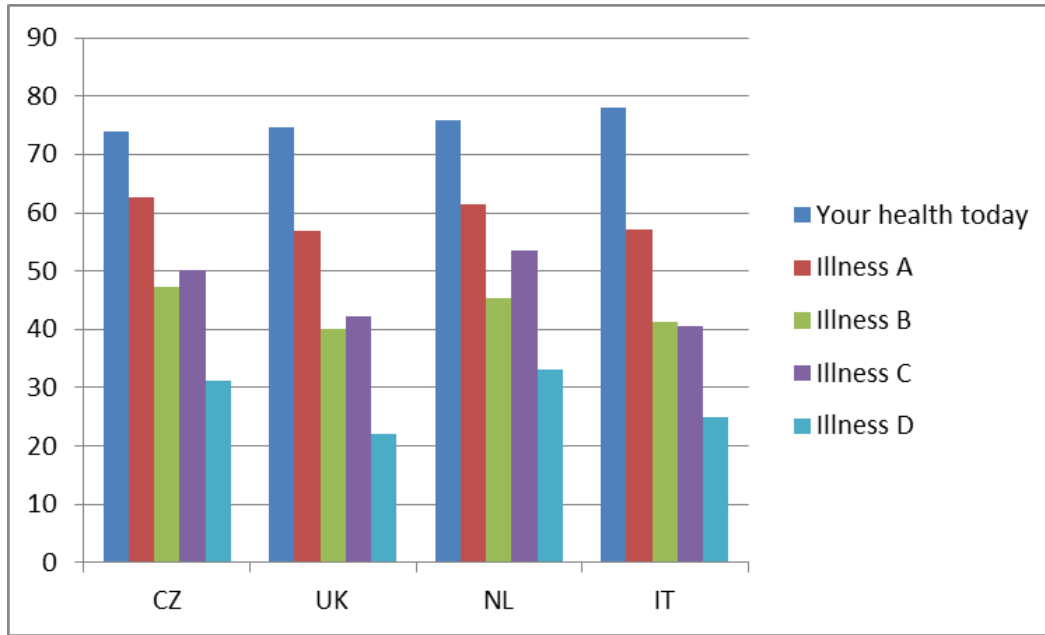
## Household income



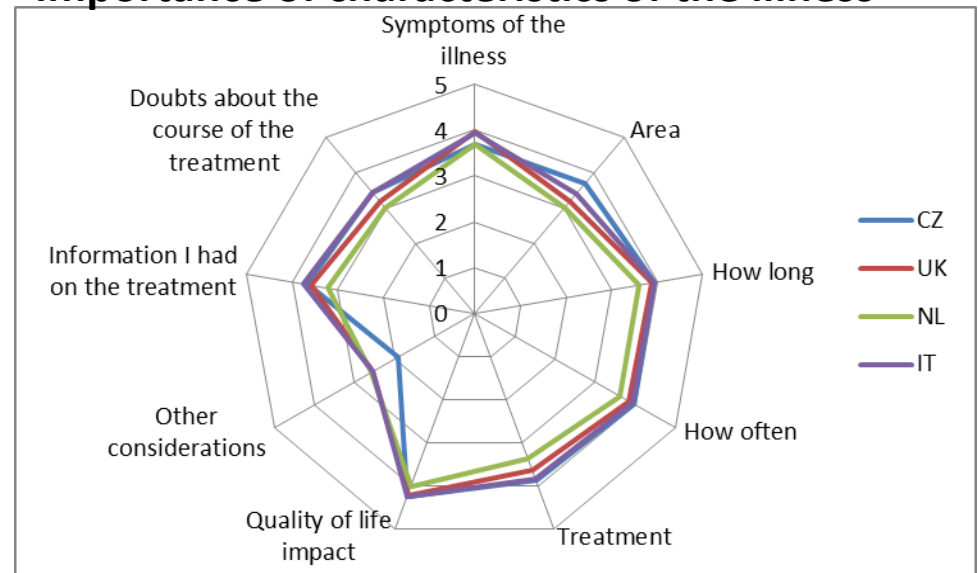
## Respondent's health

	CZ	UK	NL	IT
Eczema	26.9%	21.5%	22.9%	19.0%
Allergy	42.1%	28.2%	36.3%	46.5%
Acute kidney disease	9.8%	1.5%	1.3%	6.0%
Chronic kidney disease	3.1%	1.2%	0.9%	3.4%

## Self-assessment on Visual Analogue Scales

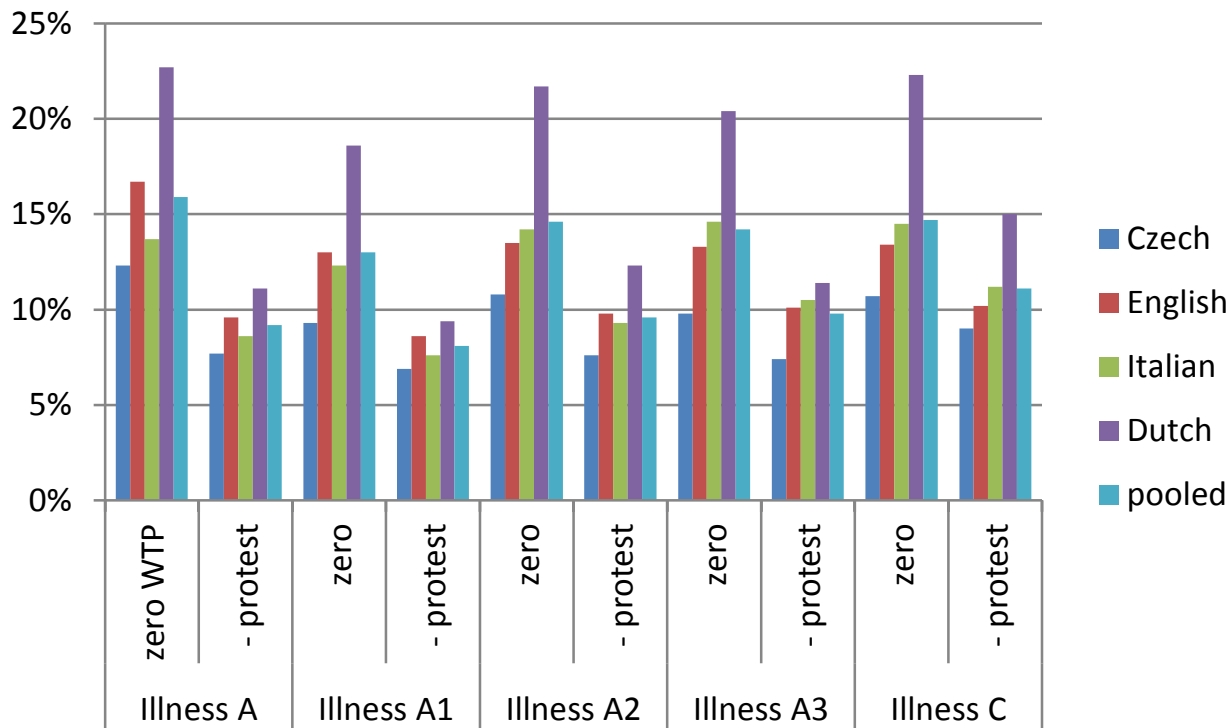


## Importance of characteristics of the illness



# zero and protest WTP

- those who tick „I won't pay anything“ option
  - protesters identified from subsequent question asking for main reason of zero WTP („NHS should pay“ most frequent)



# outliers

- large WTP amounts stated by respondents – some may represent true WTP some not
- one test of reasonableness is to compare the WTP amount with the respondent's income and internal consistency („truncation strategy I“)
- as alternative regression diagnostics (Smith and Desvousges 1986) used – identification of observations that exert an undue influence on a regression equation for WTP („truncation strategy II“)
- either of the two strategies lead to elimination of 3 to 5% of the sample
- estimated WTPs quite similar – only strategy I result presented here

# WTP estimation

- non-parametric model – Kaplan-Meier estimator
  - *distribution-free WTP estimation*
- parametric model
  - two part model – probit on participation (i.e. accounting for „true zeros“)

$$f(WTP|x) = \begin{cases} Pr[d = 0|x] & \text{if } WTP = 0 \\ Pr[d = 1|x] f(WTP|d = 1, x) & \text{if } WTP > 0 \end{cases}$$

- log-normal on positive WTP (slightly better AIC than Weibull)

# willingness to pay estimates (in PPP euros)

- non-parametric and parametric estimates generally quite close to each other
- means are about 60% higher than medians (*not unusual in CVM*)
- several inconsistent values (*mostly in non-parametric mean estimates in individual countries*)

	illness A	illness A1		illness A2			illness A3						illness C
frequency		2	4				2			4			
length				2	5	10	2	5	10	2	5	10	
N	3095	1548	1595	1071	1022	995	561	519	540	532	531	536	3180
	non-parametric estimates												
mean	220.9	278.8	319.6	298.3	341.7	328.6	261.5	377.7	432.1	322.5	369.9	593.5	511.1
median	148	212	225	189	245	252	196	265	276	212	265	315	315
	parametric estimates												
mean	226.2	292	321.5	301	326.4	373.5	303.8	352.4	441.5	347.6	396.4	505	492.2
median	145	186	204.9	183.8	201.4	228.7	182.8	210.7	260.6	205.6	239.9	303.6	312.2

# regression analyses (two-part models)

- **country** variables have significant effects (*CZ as base*)
  - NL: sig. negative in participation
  - IT: sig. positive in non-zero WTP
  - UK: sig. negative in non-zero WTP
- **age** - negative (ns) in participation, positive (sig.) in non-zero WTP
- **higher education** – positive in participation (sig., excl. A2), positive in non-zero WTP (but mostly n.s.)
- **gender** (female) - negative in participation (but n.s.) and in non-zero WTP (sig. for A, A1 and A2)
- **frequency** and **length** of illness A episodes (A1-A3)
  - frequency – positive in participation (sig.) for but negative (n.s.) for A3, positive in non-zero WTP for A1 and A3 (both sig.)
  - length – participation - positive for A2 (n.s.), negative for A3 (n.s.), non-zero WTP - positive for A2 and A3 (both sig.)
- **perceived health impact** ( $\Delta$ VAS) – sig. positive in non-zero WTP



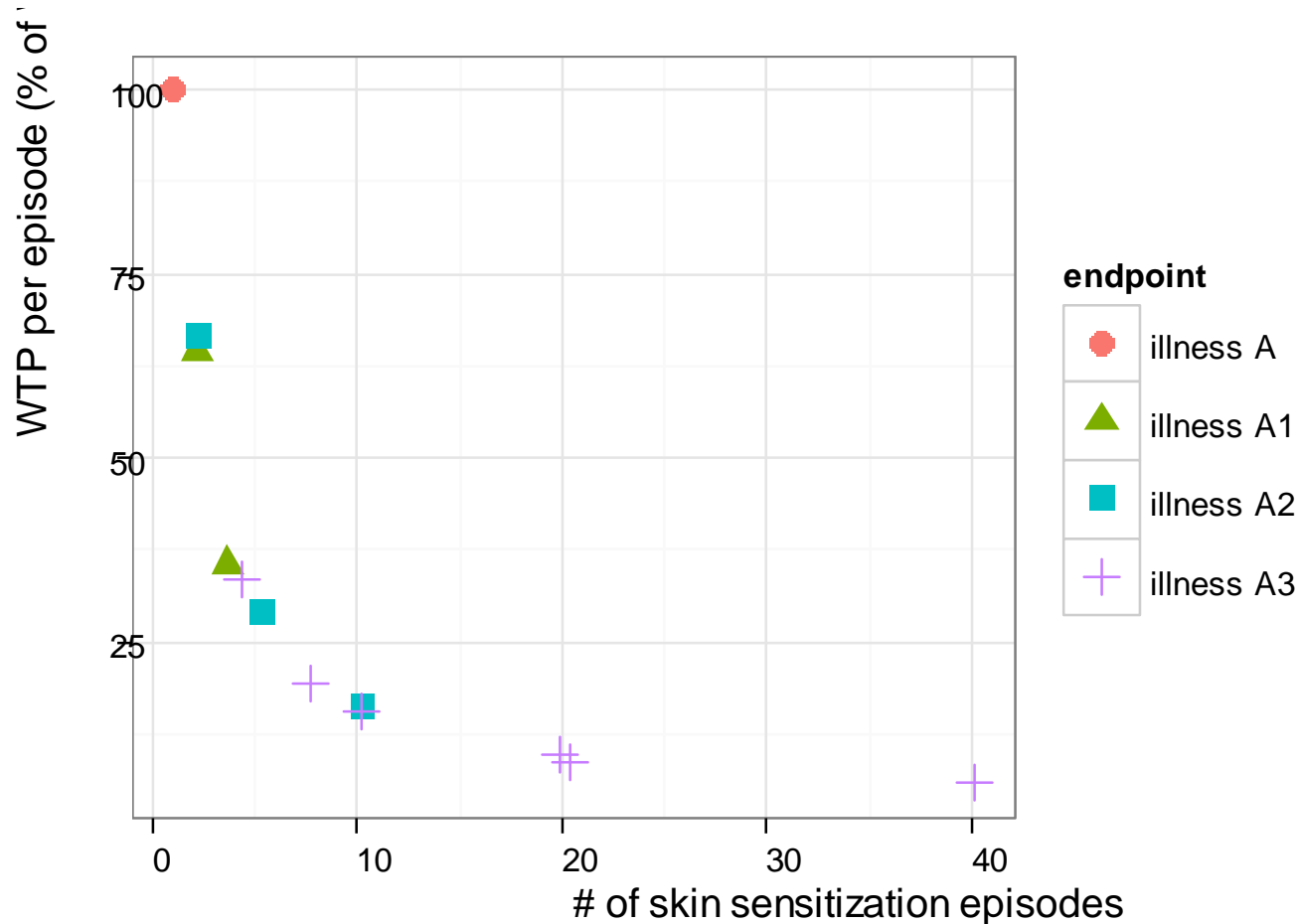
# repeated sensitization episodes - scope (in)sensitivity

**Q: does the value of avoiding a single episode of ill health depends on how many episodes of a particular illness an individual will avoid?**

- limited evidence from the literature - declining marginal disutility of ill health more common than declining marginal utility of good health (Baker et al., 2010; Navrud, 2001; Johnson et al., 2000; Tolley et al., 1986)
  - e.g. Navrud (2001): WTP for avoiding 1 day with shortness of breath € 32 vs. WTP for avoiding 14 days € 92
- Bateman et al. (2005) „*sensitivity of WTP to changes in scope is an empirical question - as long as it remains positive total WTP should increase as the scope of the good increases*“ (but marginal WTP often declines with increases in scope)

# WTP for various skin sensitization profiles

- ratio of implied WTP for a single sensitization episode in illness descriptions A1, A2 and A3 vs WTP for illness A
- strictly declining with increasing no. of episodes (almost perfectly fits to a power function)



# Insensitive respondents

- number of respondents (n) with the same WTP for avoiding illness A and any another illness
- in addition 66 respondents stated the same WTP for all CV questions
  - out of these, 50 respondents stated (valid) zero WTPs

		Illness A		
length (yrs.) / frequency (per year)		n (incl. zero WTP)	n (excl. zero WTP)	
Illness A1	2x	215	155	
	4x	131	93	
Illness A2	2yrs	87	87	
	5yrs	71	71	
	10yrs	54	54	
Illness A3	2yrs	2x	46	27
	5yrs	2x	37	22
	10yrs	2x	36	19
	2yrs	4x	34	20
	5yrs	4x	39	28
	10yrs	4x	45	31
all (A1, A2, A3)		66	16	

# Insensitive respondents

## effect of excluding insensitive respondents on WTP

- changes in WTP relatively small; between -0.4% and 3.4%
- generally the longer and/or more frequent the illness is the higher is the increase  
*(it could be that „insensitives“ are constrained by budget)*

	length (yrs.) / frequency (per year)	n	effect on WTP [illness]	effect on WTP (A)
Illness A1	2x	357	1.7%	0.3%
	4x		1.5%	
Illness A2	2y	316	1.9%	1.6%
	5y		2.2%	
	10y		2.6%	
Illness A3	2x/yr.,2yrs.	237	0.4%	-0.4%
	2x/yr.,5yrs.		0.7%	
	2x/yr.,10yrs.		1.1%	
	4x/yr.,2yrs.		2.7%	
	4x/yr.,5yrs.		3.0%	
	4x/yr.,10yrs.		3.4%	

# internal scope tests (within-subject)

- out of 47 tests, we could not reject the null hypothesis of equal distributions in 26 cases (at 0.05 level of statistical significance)

	A		A1 (2x/yr.)		A1 (4x/yr.)		A2 (2 yrs.)		A2 (5 yrs.)		A2 (10 yrs.)	
	Z score	n	Z score	n	Z score	n	Z score	n	Z score	n	Z score	n
A1 (2x/yr.)	4.77 ***	1571										
A1 (4x/yr.)	8.44 ***	1593										
A2 (2 yrs.)	3.62 ***	1095	-0.05	550	-1.95	554						
A2 (5 yrs.)	5.78 ***	1063	1.69	522	-0.03	537						
A2 (10 yrs.)	7.03 ***	1057	3.01 **	518	1.27	533						
A3 (2x/yr., 2 yrs.)	3.82 ***	544	0.10	283	-0.84	275	0.69	198	-0.67	184	-1.03	178
A3 (2x/yr., 5 yrs.)	5.63 ***	506	2.06 *	258	0.79	255	1.71	169	0.77	174	-0.61	173
A3 (2x/yr., 10 yrs.)	5.80 ***	533	2.93 **	262	0.97	276	1.99 *	193	0.97	166	0.71	185
A3 (4x/yr., 2 yrs.)	5.53 ***	521	1.58	255	0.53	268	1.75	181	-0.12	170	-0.17	177
A3 (4x/yr., 5 yrs.)	6.64 ***	521	2.85 **	264	2.39 *	265	2.32 *	170	1.65	183	0.35	173
A3 (4x/yr., 10 yrs.)	7.66 ***	528	3.82 ***	251	2.55 *	281	2.85 **	186	2.05 *	181	1.54	166

(Wilcoxon paired tests, alternative hypothesis: the two distributions are not equal)

# external scope tests within respective illness' descriptions (between-subject)

- comparison of WTPs from sub-variants of illness' A1, A2 and A3 profiles
- most tests pass the external scope test (at 0.05 level of statistical significance)

	A1 (2x/yr.)		A2 (2 yrs.)		A2 (5 yrs.)	
	Z score	n	Z score	n	Z score	n
A1 (4x/yr.)	-2.42 *	1595				
A2 (5 yrs.)			3.43 ***	1071		
A2 (10 yrs.)			-4.52 ***	1071	-1.22	1022

	A3 (2x/yr., 2 yrs.)		A3 (2x/yr., 5 yrs.)		A3 (2x/yr., 10 yrs.)		A3 (4x/yr., 2 yrs.)		A3 (4x/yr., 5 yrs.)	
	Z score	n	Z score	n	Z score	n	Z score	n	Z score	n
A3 (2x/yr., 5 yrs.)	4.27 ***	561								
A3 (2x/yr., 10 yrs.)	-4.59 ***	561	-0.65	540						
A3 (4x/yr., 2 yrs.)	-2.63 **	561	1.64	532	2.15 *	540				
A3 (4x/yr., 5 yrs.)	-4.98 ***	561	-0.68	531	0.09	540	2.34 *	532		
A3 (4x/yr., 10 yrs.)	-8.23 ***	561	-4.27 ***	536	-3.33 ***	540	5.83 ***	536	-3.70 ***	536

(Wilcoxon two-sample/trend tests, alternative hypothesis: distributions are not equal)

# External scope tests between respective illness' descriptions

- comparison of WTPs from sub-variants with same/similar profiles (i.e. total no. of episodes)
- frequency and length seems interchangeable (i.e. effectively no discounting...)

	A2 (2 yrs.)		A2 (5 yrs.)		A3 (2x/yr., 2 yrs.)		A3 (2x/yr., 5 yrs.)	
	Z score	n	Z score	n	Z score	n	Z score	n
A1 (2x/yr.)	-1.04	1037/554						
A1 (4x/yr.)			0.34	1085/522	-2.45 *	1342/283		
A2 (5 yrs.)					-3.14 **	873/375		
A2 (10 yrs.)							0.84	880/343

# joint estimation of WTP over all A (x) subvariants

- linear model with panel-level random effects, i.e.

$$y = \beta x_i + v_i + \varepsilon_i$$

- coefficients of illness' length, frequency and interaction

$$WTP = \alpha + \beta_1 length + \beta_2 frequency + \beta_3 (length \times frequency)$$

- panel interval regression (*xtintreg*)



# joint estimation of WTP over all A(x) subvariants

- coefficients of length and frequency are significant and positive
- coefficient of interaction term is negative → implicit “discount”

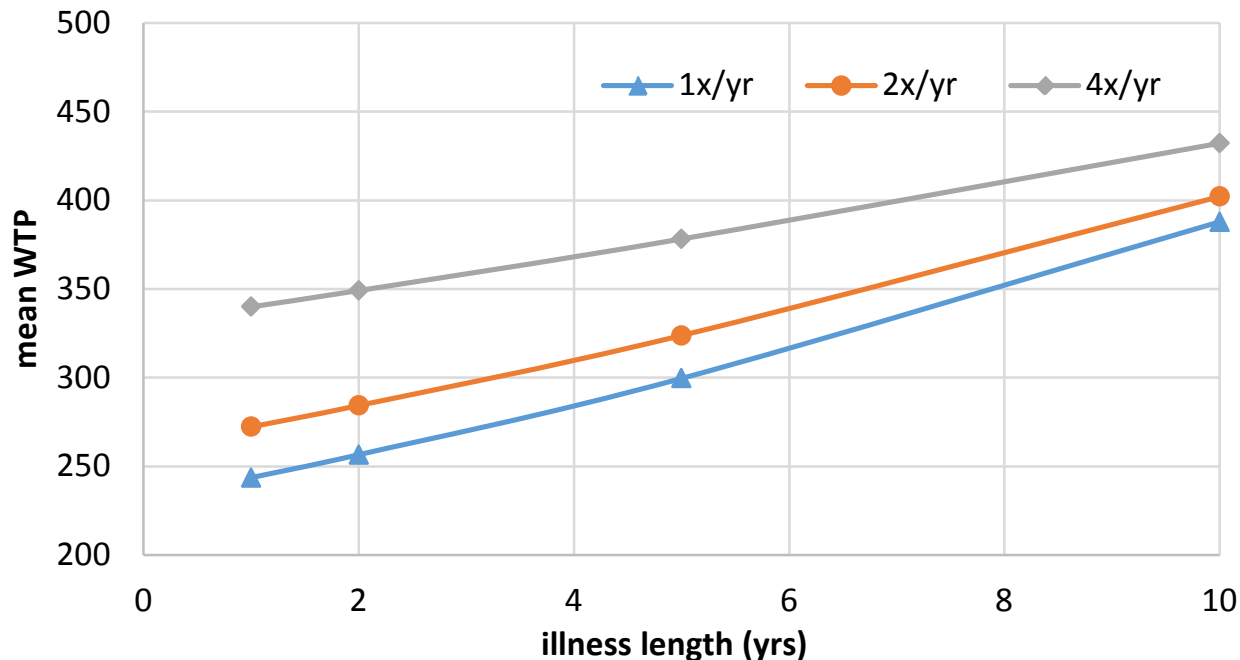
*(not shown – more variables:*

- *coefficients of income and age significant and positive*
- *country coefficients – UK(-), IT(+)*
- *perceived health impact ( $\Delta$ VAS)(+ sig.)*

	model 1			model 2		
	Coef.		Std. Error	Coef.		Std. Error
constant	4.984	***	0.0199	4.883	***	0.0219
length of illness				0.060	***	0.0027
2y	0.216	***	0.0185			
5y	0.385	***	0.0185			
10y	0.451	***	0.0187			
frequency of illness				0.119	***	0.0054
2x/yr	0.231	***	0.0159			
4x/yr	0.369	***	0.0157			
frequency*length				-0.008	***	0.0012
2_2	-0.183	***	0.0319			
2_4	-0.181	***	0.0324			
5_2	-0.159	***	0.0330			
5_4	-0.199	***	0.0321			
10_2	-0.154	***	0.0325			
10_4	-0.206	***	0.0322			
$\sigma_v$	0.940	***	0.0134	0.941	***	0.0134
$\sigma_\varepsilon$	0.377	***	0.0028	0.383	***	0.0029
$\rho$	0.862		0.0039	0.858		0.0040
Log-likelihood	-15312.1			-15417.2		

# predicted changes in WTP relative to duration of sensitization episodes

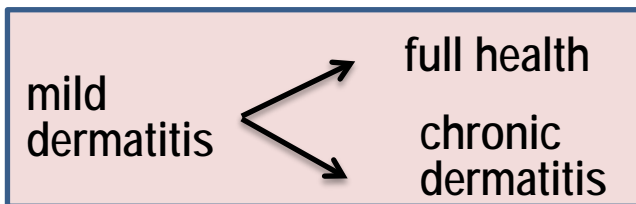
- **average marginal effects** - amount of change in WTP with one unit change in length of the illness episode while holding frequency constant at predefined values



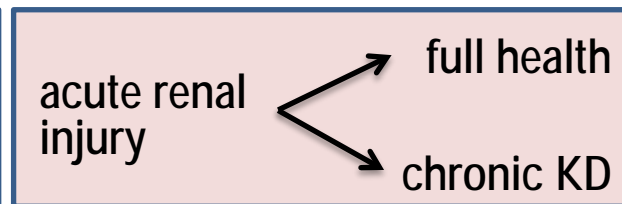
- the 3 lines converge → **declining marginal disutility of ill health**
- in theory one would expect (rather) the opposite ...
- budget constraint may play role (or adaptation/experience?)

# chained SG approach

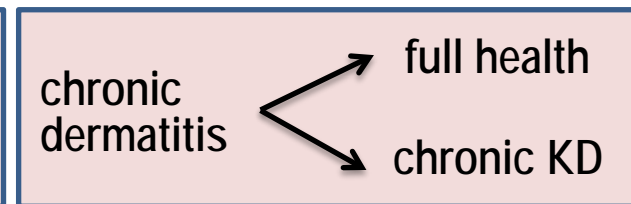
## SKIN SENSITIZATION



## DOSE TOXICITY



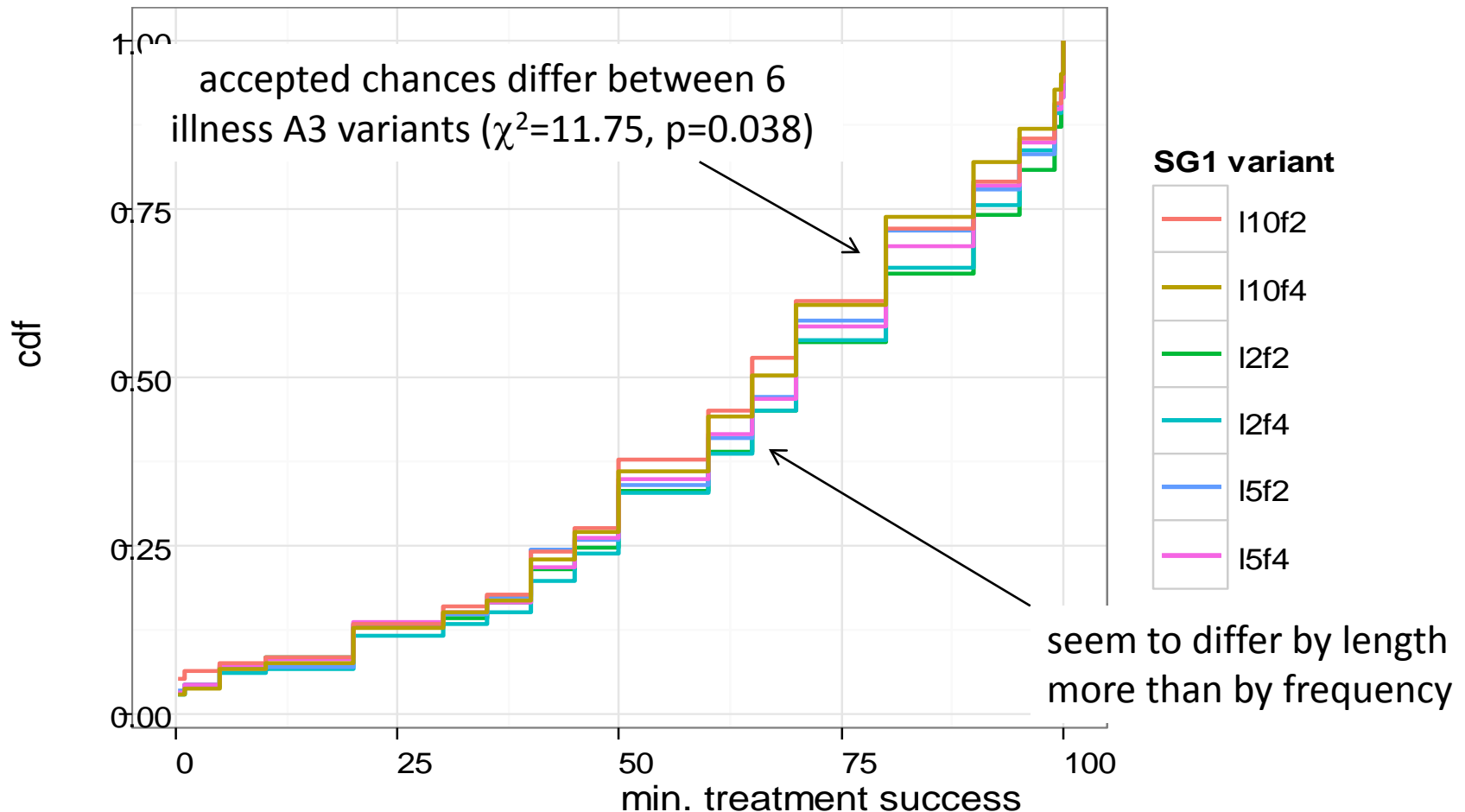
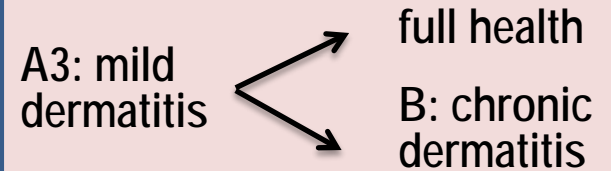
## COMBINED



# Standard gamble I

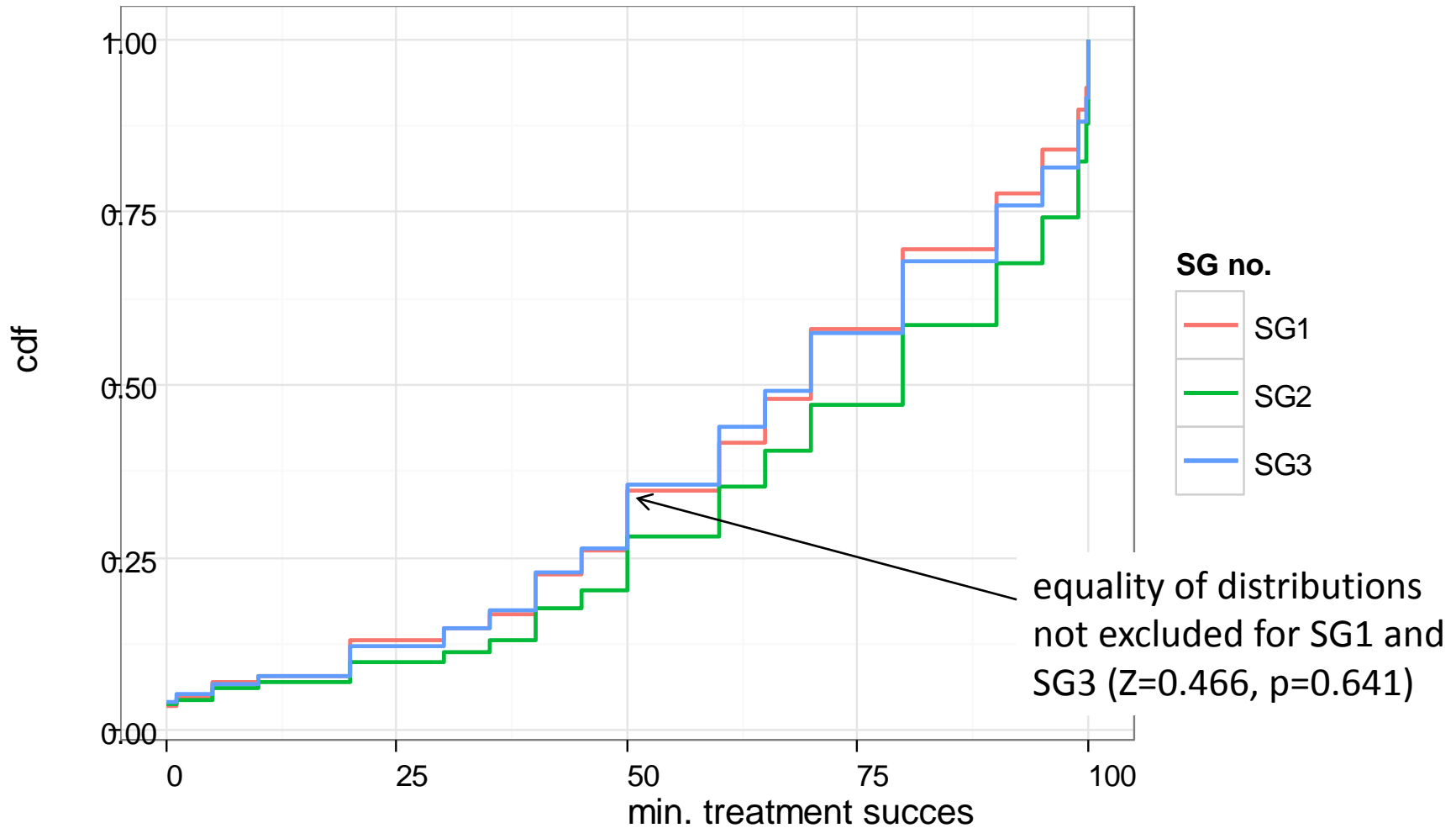
## Cum. distributions of SG1 variants

SKIN SENSITIZATION



# All 3 standard gambles

Cum. distributions of minimum  
new treatment success



# chaining of WTP from standard gambles

Conventional treatment				Novel treatment		min. desired treatment success	WTP "conventional treatment"	chained WTP	
	freq. (per yr.)	length (yrs.)	N	success	failure			B: severe chronic dermatitis	D: chronic kidney illness
A3: mild dermatitis	2	2	616	full health	Illness B	63.2%	261	<b>710</b>	
	2	5	599			61.3%	377	<b>975</b>	
	2	10	616			59.7%	432	<b>1071</b>	
	4	2	594			63.4%	322	<b>881</b>	
	4	5	601			61.5%	370	<b>960</b>	
	4	10	608			59.9%	594	<b>1482</b>	
C: acute kidney injury			3634		Illness D	67.6%	511		<b>1578</b>
B: severe chronic dermatitis			3634			61.2%			<b>2650</b>

# chaining of WTP from standard gambles

Conventional treatment			N	Novel treatment		min. desired treatment success	WTP "conventional treatment"	chained WTP	
	freq. (per yr.)	length (yrs.)		success	failure			B: severe chronic dermatitis	D: chronic kidney illness
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B: severe chronic dermatitis			3634		61.2%			2650	

lowest:highest - accepted mere 3% worsening

lowest:highest WTP 2.2x higher

# Health rating and QALY

- self-reported rating using VAS – *some respondents (likely) reported assessed illnesses compared to their current health rather to the best one they can imagine)*
- estimated annual QALY losses and WTP per QALY

	all respondents	$VAS_{\text{current\_health}} \geq VAS_{\text{illness[.]}}$	WTP/QALY (€)
illness A	0.00667 (0.00795)	0.00820 (0.00641)	25 028
illness B	0.3476 (0.2415)	0.3810 (0.2037)	2 579
illness C	0.0250 (0.0200)	0.0282 (0.0166)	17 500
illness D	0.5177 (0.2827)	0.5576 (0.2239)	4 656



# concluding remarks

- only few studies valuing chronic illnesses (*related to chemicals exposure*)
- our study looked at both acute and chronic (and transient) illnesses in risk-free (CVM) and risk-risk context (chained SG)
- SKIN SENSITIZATION:
  - most elicited valuations of acute sensitization profiles sensitive to scope
  - sensitivity analysis suggest diminishing marginal value of disutility
  - effect of prolongation and change in frequency very similar (time preferences..?)
  - WTP for chronic dermatitis too low (huge dif. VAS/QALY vs. SG/WTP)
- DOSE TOXICITY:
  - AKI: WTP 2.3x higher than for skin sensitization (by VAS/QALY 3.4x)
  - CKD: WTP too low (huge dif. VAS/QALY vs. SG/WTP)
  - again wide divergence between VAS and SG elicitations...

# comparison of implied „relative severities“

... by QALYs

	illness A	illness B	illness C	illness D
illness A	x	0.022	0.29	0.015
illness B	46.5	x	0.074	0.68
illness C	3.4	13.5	x	0.05
illness D	68	1.5	20	x

... by SG

	illness A3	illness B	illness C	illness D
illness A3	x	0.39		0.15
illness B	2.6	x		0.39
illness C			x	0.32
illness D	6.7	2.6	3.1	x

... by WTP

	illness A	illness B	illness C	illness D
illness A	x	0.218	0.43	0.083
illness B	4.6	x	0.505	0.38
illness C	2.3	2.0	x	0.19
illness D	12	2.6	5	x

Thank you for your attention!

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# payment ladder check

no. of WTP answers (lower&upper bound) same as midpoint and „maximum“ of TWPL and higher than „maximum“ (i.e. 650 EUR&GBP, 13000 CZK) and its position among respective WTP answers (decreasing order)

			<b>CZ (904)</b>	<b>UK (1006)</b>	<b>IT (1024)</b>	<b>NL (700)</b>
illness A	WTPIb=	TWPL_mid	75 (2.)	59 (4.)	91 (1.)	56 (1.)
		TWPL_max	2 (65.)	1 (94.)	4 (52.)	2 (70.)
	WTPub=	TWPL_mid	99 (1.)	59 (3.)	49 (1.)	47 (2.)
		TWPL_max	94 (2.)	88 (2.)	141 (3.)	58 (3.)
illness C	WTPIb=	TWPL_mid	100 (1.)	87 (1.)	76 (1.)	56 (2.)
		TWPL_max	3 (61.)	4 (60.)	5 (52.)	4 (48.)
	WTPub=	TWPL_mid	66 (3.)	34 (3.)	30 (3.)	29 (3.)
		TWPL_max	112 (1.)	111 (2.)	116 (2.)	62 (2.)
illness A	WTPIb>TWPL_max		8 (66.)	15 (72.)	25 (59.)	15 (41.)
	WTPub>TWPL_max		52 (31.)	71 (21.)	91 (15.)	56 (19.)
illness C	WTPIb>TWPL_max		41 (21.)	91 (12.)	131 (13.)	41 (20.)
	WTPub>TWPL_max		117 (4.)	198 (11.)	251 (6.)	107 (17.)