Discrete Choice Experiments (DCEs): Theory and Applications

Seminar RIVM, Bilthoven, the Netherlands

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Content

- What is a Discrete Choice Experiment (DCE)?
- How to conduct a DCE?
- How are DCEs applied and reported in health care?
- Future research

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DCEs: What are they?

- Quantitative method to measure benefit/preferences
- Origins in mathematical psychology
- Main practice in marketing, environmental, transport economics

DCEs – What are they?

- Introduced in health care early 1990s
- as an economic technique to measure benefit beyond health outcomes.

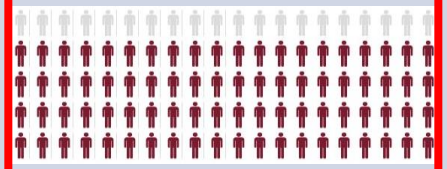
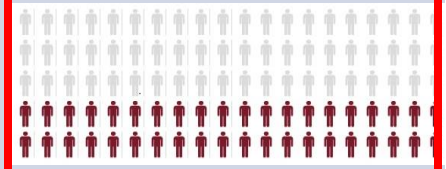
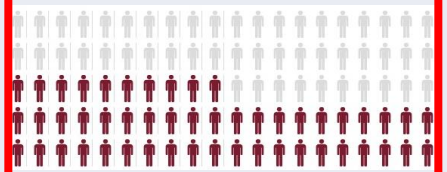
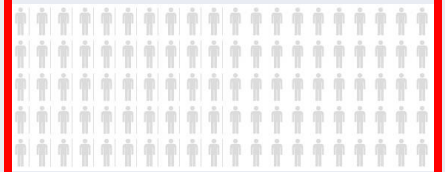
See e.g. Ryan M, Farrar S. Eliciting preference for healthcare using conjoint analysis. BMJ 2000;320: 1530-3.

DCE – Attribute based survey

- DCE is an attribute based survey (economic technique)

A DCE typically consists of:

  - numerous respondents
  - being asked to complete a number of choice tasks

	Program 1	Program 2	No screening
Deaths prostate cancer	 18 out of 1000	 25 out of 1000	 35 out of 1000
Freq blood test	every 3 years	every 4 years	n.a.
Risk unnecessary biopsy	 800 out of 1000	 400 out of 1000	n.a.
Risk unnecessary treatment	 500 out of 1000	 0 out of 1000	n.a.
Out-of-pocket costs annually	€ 50	€ 100	€ 0
I prefer:	O	O	O

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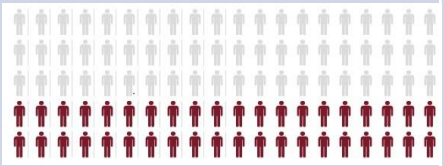
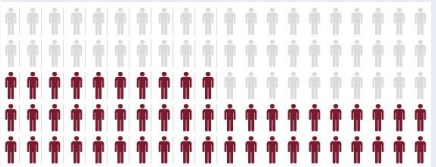
Risk unnecessary biopsy	 800 out of 1000	 400 out of 1000	n.a.
Risk unnecessary treatment	 500 out of 1000	0 out of 1000	n.a.
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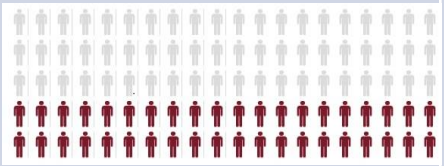
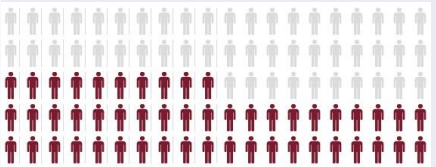
Risk unnecessary biopsy	 800 out of 1000	 400 out of 1000	n.a.
Risk unnecessary treatment	 500 out of 1000	0 out of 1000	n.a.
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I prefer:	O	O	O

DCE – advantage

- Reasonably straightforward task (ordinal instead of cardinal)
- Closely resembles a real world decision
- Many output possibilities (OR, WTP, MRS, utility scores, probs)

Research question (some examples)

- What is the willingness to pay to receive a more comprehensive prenatal testing?
- How willing are patients to wait for a treatment in a hospital they prefer?
- How much risk reduction is required to consider treatment X as acceptable?
- How to implement an intervention in an effective way?
- How do individuals weigh the harms and benefits of treatment X?
- How is screening participation affected by the type of screening test?
- What outcomes are important to patients with long term conditions?
- Which uptake can be expected for vaccination against disease X?
- What do the people in this room value about their jobs?

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Content

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- How to conduct a DCE?
- How are DCEs applied and reported in health care?
- Future research

Note: this part contains several slides that are based on the course slides of "Bliemer & Rose. 2011. Course in Stated Choice Methods, Maastricht, the Netherlands" (i.e. slides 13-15, 17, 20, 27, 28, 32 and 34; agreement was received).

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Discrete choice experiment process

Determining, what:

1. Alternatives
2. Attributes
3. Attribute levels
4. Utility function
5. Model
6. Statistical design
7. Number choice tasks

	A	B	C	D	E	A	B	C	D	E
1	0	0	0	0	0	1	1	1	1	1
2	0	1	1	1	1	1	2	2	2	2
3	0	2	2	2	2	1	3	3	3	3
4	0	3	3	3	3	1	0	0	0	0
5	1	0	1	2	3	2	1	2	3	0
6	1	1	0	3	2	2	2	1	0	3
7	1	2	3	0	1	2	3	0	1	2
8	1	3	2	1	0	2	0	3	2	1
9	2	0	2	3	1	3	1	3	0	2
10	2	1	3	2	0	3	2	0	3	1
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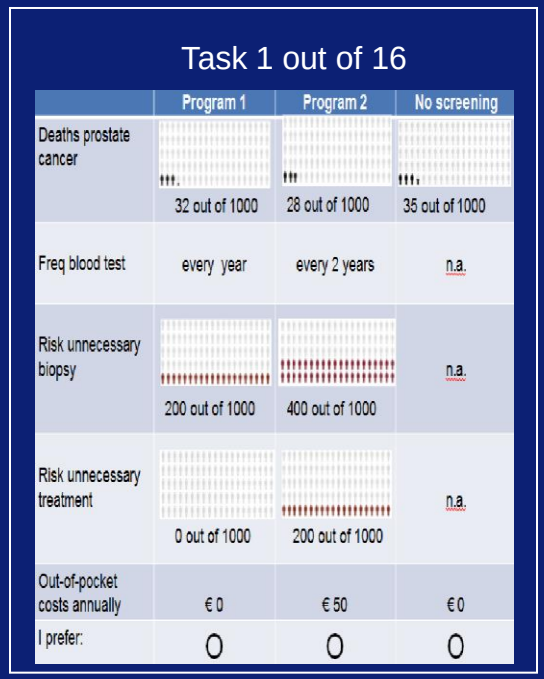

respondents

pre-experimental design decisions

experimental design

combi of attribute levels

questionnaire

data

0	1	0
0	0	1
0	0	1
1	0	0
0	1	0
0	1	0
1	0	0
0	0	1
1	0	0

data analysis

$U_{in} = V(X_{in}, \beta) + \varepsilon_{in}$

results:

OR, MRS, utility scores, WTP, probabilities,….

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Discrete choice experiment process

Determining, what:	
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pre-experimental design decisions

→ Decisions before we get to the DCE design

For more details, see e.g. Hensher DA, Rose JM, Greene WH. Applied choice analysis: a primer. Cambridge: Cambridge University Press, 2005.

Pre-experimental design decisions

1. What and how many alternatives?

Attributes	Program A	Program B	No vaccination
Protection against cervical cancer	70%	90%	0%
Protection duration	Lifetime	6 years	n.a.
Serious side effects	very small	very small	No risk
Mild side effects	10 out of 100	2 out of 100	No risk
Age at vaccination	14 years	9 years	n.a.
Which vaccination program do you prefer?	☐ **A**	☐ **B**	☐ **None**

Opt-out?

Attributes	Program A	Program B
Protection against cervical cancer	70%	90%
Protection duration	Lifetime	6 years
Serious side effects	very small	very small
Mild side effects	10 out of 100	2 out of 100
Age at vaccination	14 years	9 years
Which vaccination program do you prefer?	☐ **A**	☐ **B**

No opt-out?

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Pre-experimental design decisions

1. What and how many alternatives?

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Mild side effects	10 out of 100	2 out of 100	No risk
Age at vaccination	14 years	9 years	n.a.
Which vaccination program do you prefer?	☐ **A**	☐ **B**	☐ **None**

Unlabelled?

Attributes	Gardasil	Cervarix	No vaccination
Protection against cervical cancer	70%	90%	0%
Protection duration	Lifetime	6 years	n.a.
Serious side effects	very small	very small	No risk
Mild side effects	10 out of 100	2 out of 100	No risk
Age at vaccination	14 years	9 years	n.a.
Which vaccination program do you prefer?	☐ **A**	☐ **B**	☐ **None**

Labelled?

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Pre-experimental design decisions

2. What and how many attributes?

Driven by research question

→ Literature, focus groups, expert interviews crucial! ←

Number of attributes

too many?

Increased error variance

Lexicographic behaviour

Always pre-test and pilot your survey!!

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Pre-experimental design decisions

3. What and how many attribute levels?

Driven by research question

e.g. Do individuals prefer every year, every 2 years or every 5 years screening?

- to test for (non-)linearity, at least 3 levels needed

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Pre-experimental design decisions

4. What will the utility functions of the model look like?

Attributes	Program A	Program B	No vaccination
Protection against cervical cancer	70%	90%	0%
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Which vaccination program do you prefer?	☐ **A**	☐ **B**	☐ **None**

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Pre-experimental design decisions

4. What will the utility functions of the model look like?

Write out the utility functions you expect to estimate:

$V^{\text{program A}} = \beta_0 + \beta_1 \textit{Effect} + \beta_2 \textit{Duration\_25y} + \beta_3 \textit{Duration\_lifetime} + \beta_4 \textit{Serious} + \beta_5 \textit{Mild} + \beta_6 \textit{Age\_12y} + \beta_7 \textit{Age\_14y}$

$V^{\text{program B}} = \beta_8 + \beta_1 \textit{Effect} + \beta_2 \textit{Duration\_25y} + \beta_3 \textit{Duration\_lifetime} + \beta_4 \textit{Serious} + \beta_5 \textit{Mild} + \beta_6 \textit{Age\_12y} + \beta_7 \textit{Age\_14y}$

$V^{\text{No vaccination}} = 0$

→ to have an overview of:

- how many parameters has to be estimated
- which attributes are linear/categorical and/or alternative specific

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Pre-experimental design decisions

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$V^{\text{No vaccination}} = 0$

→ to have an overview of:

- how many parameters has to be estimated
- which attributes are linear/categorical and/or alternative specific

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Pre-experimental design decisions

5. What model will most likely to be estimated after data collection?

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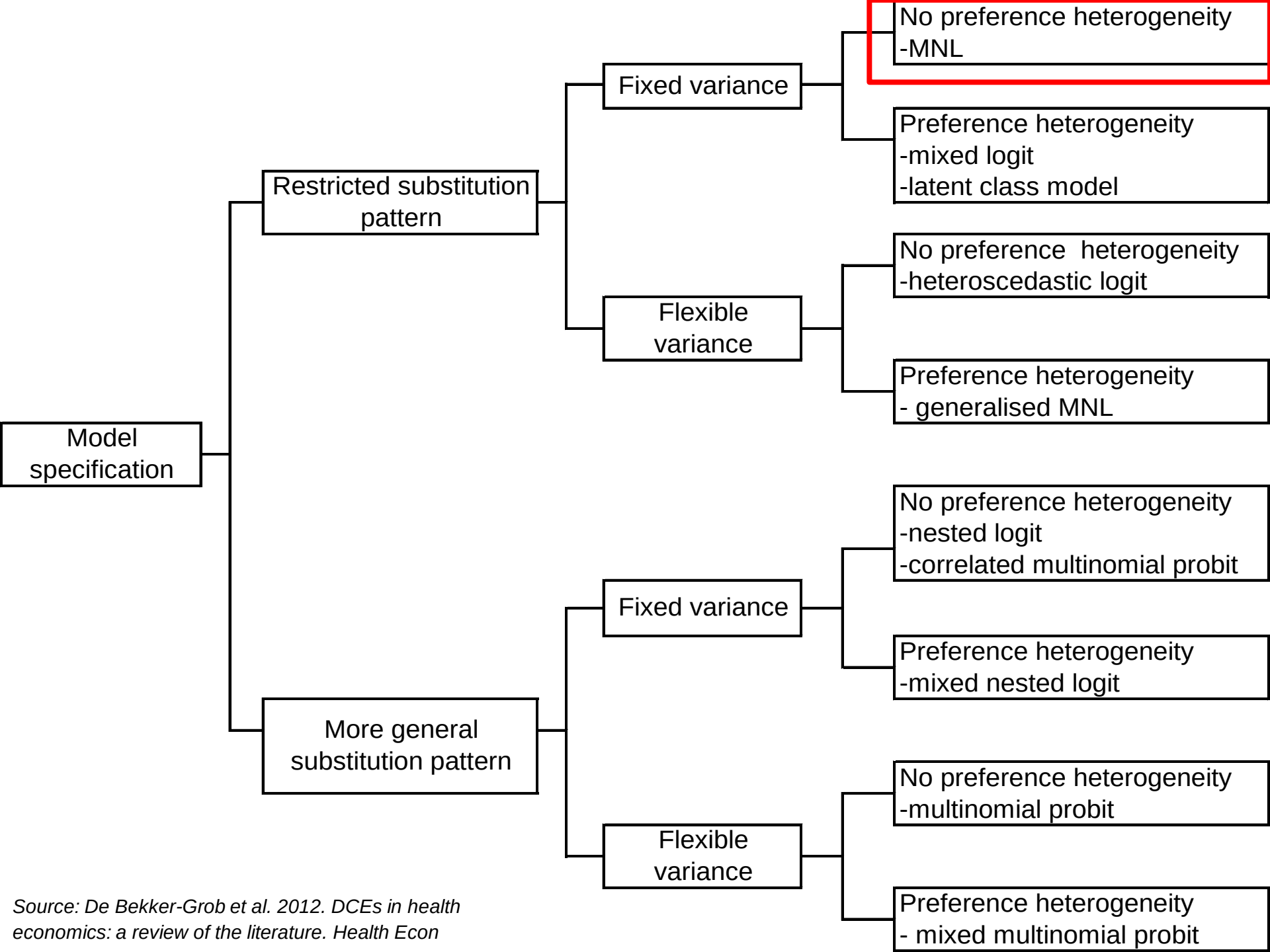
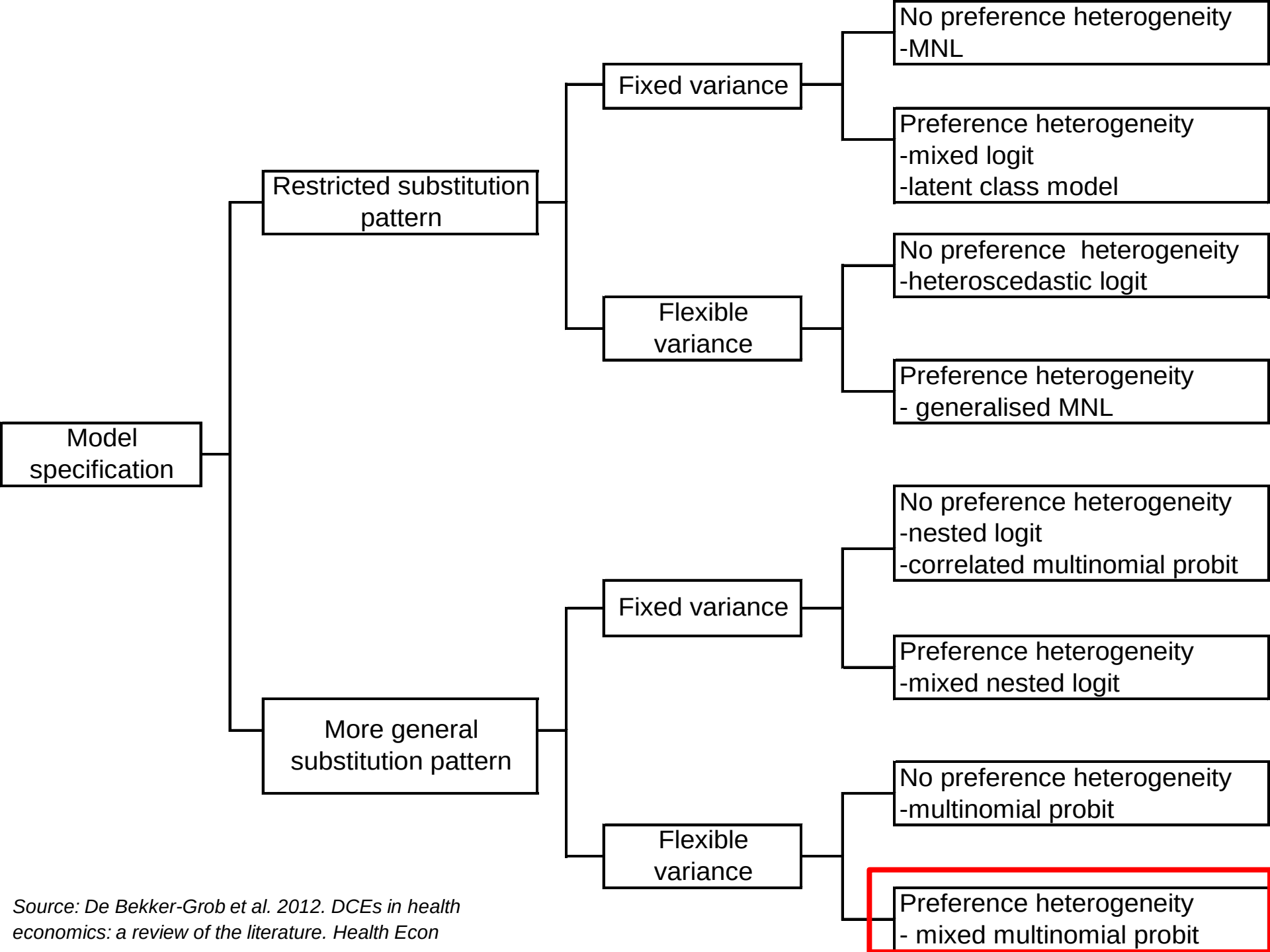


Source: De Bekker-Grob et al. 2012. DCEs in health economics: a review of the literature. Health Econ



Source: De Bekker-Grob et al. 2012. DCEs in health economics: a review of the literature. Health Econ

Pre-experimental design decisions

6. What statistical properties should the design display?

There are a lot of different designs one can choose

Full factorial designs

Non-full factorial designs

- Orthogonal designs
- Efficient designs
- Bayesian efficient designs
- ….

Depends on preferred statistical properties, the information available, and the preferred size of the design

For more details: see e.g. Reed Johnson F et al. Constructing experimental designs for discrete-choice experiments: report of the ISPOR Conjoint Analysis Experimental Design Good Research Practices Task Force. Value Health. 2013 Jan-Feb;16(1):3-13.

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Pre-experimental design decisions

7. How many choice tasks should be included in the design?

Respondent perspective

	A	B	C	D	E	A	B	C	D	E
1	0	0	0	0	0	1	1	1	1	1
2	0	1	1	1	1	1	2	2	2	2
3	0	2	2	2	2	1	3	3	3	3
4	0	3	3	3	3	1	0	0	0	0
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8	1	3	2	1	0	2	0	3	2	1
9	2	0	2	3	1	3	1	3	0	2
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14	3	1	2	0	3	0	2	3	1	0
15	3	2	1	3	0	0	3	2	0	1
16	3	3	0	2	1	0	0	1	3	2

Statistical design perspective

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Pre-experimental design decisions

7. How many choice tasks should be included in the design?

Respondent perspective

Burden and fatigue

Learning effect

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Pre-experimental design decisions

7. How many choice tasks should be included in the design?

	A	B	C	D	E	A	B	C	D	E
1	0	0	0	0	0	1	1	1	1	1
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3	0	2	2	2	2	1	3	3	3	3
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15	3	2	1	3	0	0	3	2	0	1
16	3	3	0	2	1	0	0	1	3	2

Statistical design perspective

Each parameter requires a degree of freedom:

- alternative specific constant(s)
- main effects
- interaction effects

etc.

That's why writing out the expected utility functions is important!

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Discrete choice experiment process

Determining, what:	
1	Alternatives
2	Attributes
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7	Number choice tasks

pre-experimental design decisions

	A	B	C	D	E	A	B	C	D	E
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8	1	3	2	1	0	2	0	3	2	1
9	2	0	2	3	1	3	1	3	0	2
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16	3	3	0	2	1	0	0	1	3	2

experimental design

combi of attribute levels

Full factorial designs

- Designs in which all possible choice situations are included

For example:

Assuming an unlabelled design (2 options per choice set)

- 2 attributes with 3 levels → 3^2 = 9 alternatives (choice situations)
  → 9*((9-1)/2) = 36 choice sets

- 3 attributes with 3 levels → 3^3 = 27 alternatives (choice situations)
  → 27*((27-1)/2) = 351 choice sets

- 4 attributes with 3 levels → 3^4 = 81 (choice situations)
  → 81*((81-1)/2) = 3,240 choice sets

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Full factorial designs

How to reduce the number of choice situations?

- Reduce the number of attributes
- Reduce the number of attribute levels
- Create a non-full factorial design …

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Non-full factorial designs

Designs that use a subset of choice situations

Advantage

Reduction of the number of choice situations shown to each respondent

Disadvantage

Because only a fraction of the choice situations is used, not all effects can be measured

Note

Remember there is a lower bound on the number of choice situations.

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Non-full factorial designs

	Orthogonal designs	Optimal orthogonal designs	(Bayesian) efficient designs	Optimal choice prob designs
Widely used	+	-	+	-
Ease of generation	-	-	-/+	+
Efficiency of design	-	-/+	+	+
Prior parameter info needed	+	+	-	-
Model flexibility	-/+	-	+	-

Adapted from Bliemer & Rose. 2011. Course in Stated Choice Methods, Maastricht

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Discrete choice experiment process

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pre-experimental design decisions

	A	B	C	D	E	A	B	C	D	E
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3	0	2	2	2	2	1	3	3	3	3
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8	1	3	2	1	0	2	0	3	2	1
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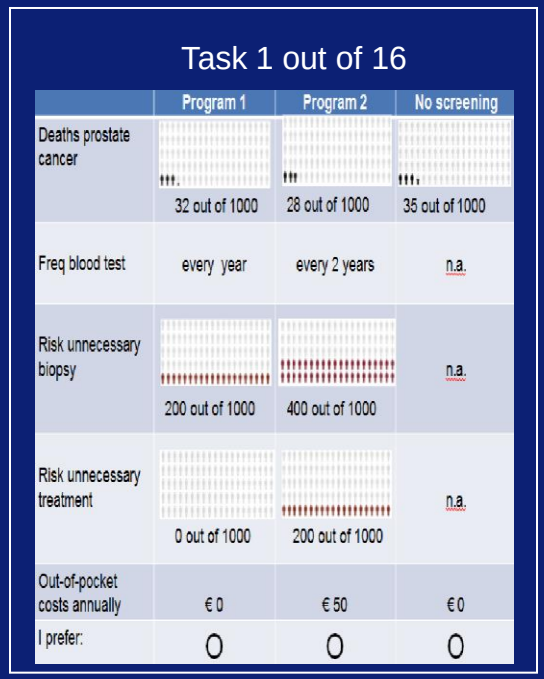
experimental design

combi of attribute levels



questionnaire

Always pre-test and pilot your survey!!

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Discrete choice experiment process

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pre-experimental design decisions

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5	1	0	1	2	3	2	1	2	3	0
6	1	1	0	3	2	2	2	1	0	3
7	1	2	3	0	1	2	3	0	1	2
8	1	3	2	1	0	2	0	3	2	1
9	2	0	2	3	1	3	1	3	0	2
10	2	1	3	2	0	3	2	0	3	1
11	2	2	0	1	3	3	3	2	2	0
12	2	3	1	0	2	3	0	2	1	3
13	3	0	3	1	2	0	1	0	2	3
14	3	1	2	0	3	0	2	3	1	0
15	3	2	1	3	0	0	3	2	0	1
16	3	3	0	2	1	0	0	1	3	2

experimental design

combi of attribute levels

Task 1 out of 16

	Program 1	Program 2	No screening
Deaths prostate cancer	32 out of 1000	28 out of 1000	35 out of 1000
Freq blood test	every year	every 2 years	n.a.
Risk unnecessary biopsy	200 out of 1000	400 out of 1000	n.a.
Risk unnecessary treatment	0 out of 1000	200 out of 1000	n.a.
Out-of-pocket costs annually	€ 0	€ 50	€ 0
I prefer:	O	O	O

questionnaire

respondents

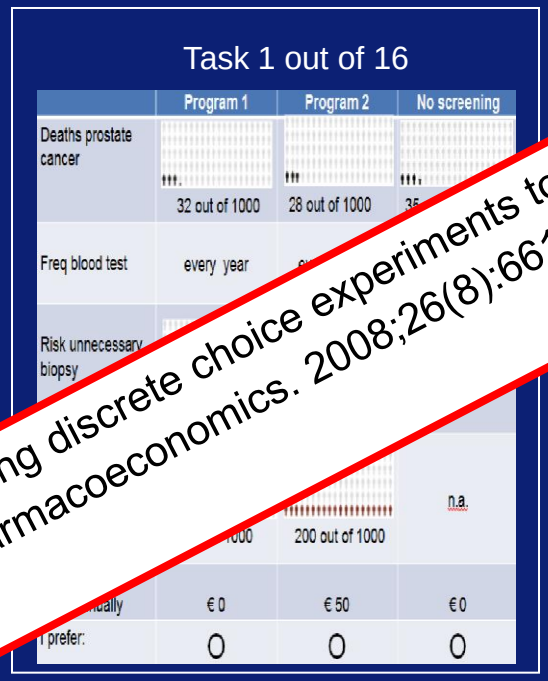
- Paper & pencil, panel data, interviewer based,..
- Sample size *(for more information, see De Bekker-Grob et al. 2015. Sample size requirements for discrete choice experiments in health care: a practical guide. Patient.)*

Discrete choice experiment process

Determining, what:

1. Alternatives
2. Attributes
3. Attribute levels
4. Utility function
5. Model
6. Statistical design
7. Number choice tasks

	A	B	C	D	E	A	B	C	D	E
1	0	0	0	0	0	1	1	1	1	1
2	0	1	1	1	1	1	2	2	2	2
3	0	2	2	2	2	1	3	3	3	3
4	0	3	3	3	3	1	0	0	0	0
5	1	0	1	2	3	2	1	2	3	0
6	1	1	0	3	2	2	2	1	0	3
7	1	2	3	0	1	2	3	0	1	2
8	1	3	2	1	0	2	0	3	2	1
9	2	0	2	3	1	3	1	3	0	2
10	2	1	3	2	0	3	2	0	3	1
11	2	2	0	1	3	3	3	2		
12	2	3	1	0	2					
13	3	0	3							
14										



respondents

See for example Lancsar E, Louviere J. Conducting discrete choice experiments to inform healthcare decision making: a user's guide. Pharmacoeconomics. 2008;26(8):661-77 .

pre-experimen… design d…

…tal design

…of attribute levels

questionnaire

data

0	1	0
0	0	1
0	0	1
1	0	0
0	1	0
0	1	0
1	0	0
0	0	1
1	0	0

data analysis

$U_{in} = V(X_{in}, \beta) + \varepsilon_{in}$

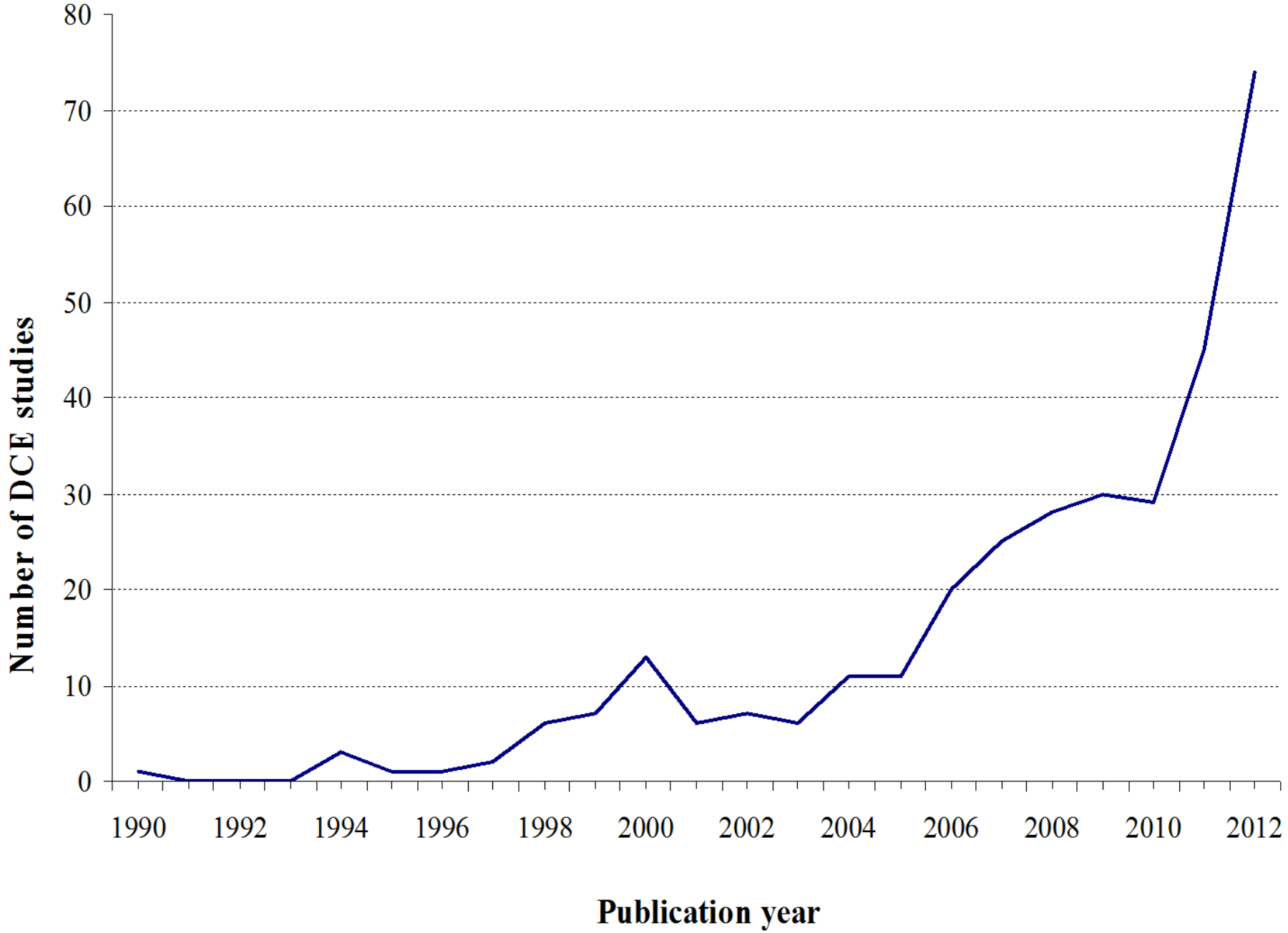
…sults:

OR, MRS, utility scores, WTP, probabilities,….

Erasmus MC

Content

- What is a Discrete Choice Experiment (DCE)?
- How to conduct a DCE?
- How are DCEs applied and reported in health care?
- Future research


80
70
60
50
40
30
20
10
0
Number of DCE studies
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
Publication year

Overview DCE practice (1)

Country of origin	1990-2000[1] (n=34)	2001-2008[2] (n=114)	2009-2012[3] (n=178)
	%	%	%
UK	59	48	22
US	21	12	16
Australia	18	11	7
Canada	3	5	11
Denmark	0	4	6
Netherlands	0	4	14
Germany	0	3	9
Other	0	11	25

Systematic reviews:

[1] Ryan, Gerard. Appl Health Econ Health Policy. 2003

[2] de Bekker-Grob**,** Ryan, Gerard. Health Econ. 2012

[3] Clark, Determann, Petrou, Moro, de Bekker-Grob. PharmaEcon. 2014

Overview DCE practice (2)

	Main study objective	1990-2000[1] (n=34)	2001-2008[2] (n=114)	2009-2012[3] (n=178)
		%	%	%
(A)	Valuing experience factors	35	35	12
(B)	Valuing health outcomes	9	7	6
(C)	Trade-offs health outcomes & experience factors	41	33	41
(D)	Utility weights within QALY framework	0	2	2
(E)	Job-choices	6	4	6
(F)	Developing priority setting frameworks	6	5	13
(G)	Health professional's preferences	3	15	12
(H)	Other	0	4	10

Note * Percentages do not add up to 100% as several studies had more than one main objective

Overview DCE practice (3)

		1990-2000 (n=34)	2001-2008 (n=114)	2009-2012 (n=178)
		%	%	%
Number of attributes	2-3	15	13	9
	4-5	29	44	33
	6	26	26	34
	7-9	12	13	22
	10	6	2	2
	>10	12	2	2
Attributes covered*	Monetary measure	56	54	56
	Time	74	51	66
	Risk	35	31	57
	Health status domain	56	54	61
	Health care	82	69	72
	Other	9	15	47

* Percentages do not add up to 100% as studies use many attributes

Overview DCE practice (4)

		1990-2000 (n=34)	2001-2008 (n=114)	2009-2012 (n=178)
		%	%	%
Number of choices per respondenent	8 or less choices	38	39	21
	9-16 choices	53	38	62
	More than 16 choices	6	18	15
	Not clearly reported	3	4	4
Administration of survey*	Self-complete questionnaire	79	67	48
	Interviewer administered	9	19	17
	Computerised interview	9	11	40
	Not reported	3	8	3

* Percentages do not add up to 100% as studies use multiple methods

		1990-2000 (n=34)	2001-2008 (n=114)	2009-2012 (n=178)
		%	%	%
Design source	Software package	56	52	53
	SPEED	38	19	4
	SPSS	6	12	6
	SAS	0	12	21
	SAWTOOTH	6	4	13
	Other	6	0	8
	No further details	0	4	4
	Catalogue	6	5	10
	Website	0	3	5
	Expert	12	4	6
	Not clearly reported	26	37	26
Method to create choice sets*	Orthogonal rays			
	Single profiles (i.e. binary choices)	9	11	1
	Random pairing	53	17	10
	Pairing with constant comparator	18	20	3
	Foldover - random pairing	0	1	2
	Foldover	0	10	17
	D-efficiency	0	12	30
	Other (pragmatically chosen)	12	2	5
	Not clearly reported	9	28	26
	Other	N / A	N / A	10

Overview DCE practice (6)

		1990-2000 (n=34)	2001-2008 (n=114)	2009-2012 (n=178)
		%	%	%
Estimation procedure*	Probit	18	7	2
	Random effects probit	53	41	10
	Logit	3	11	10
	Random effects logit	3	5	8
	MNL	18	22	43
	Nested logit (NL)	0	4	2
	Mixed logit (MXL)	3	5	10
	Latent class (LCM)	0	1	3
	Other	3	4	17
	Not clearly reported	6	4	1

Note: * Totals do not add up to 100% as some studies use multiple estimation procedures

Overview DCE practice (7)

		1990-2000 (n=34)	2001-2008 (n=114)	2009-2012 (n=178)
		%	%	%
Validity test*	External	0	1	<1
	Internal:			
	Theoretical	65	56	60
	Non-satiation	44	49	21
	Transitivity	9	4	1
	Sen's expansion and contraction	0	2	1
	Compensatory decision making	35	32	14

Note: * Totals do not add up to 100% as some studies use multiple validity tests

Conclusions DCE applications

- DCEs commonly used instrument in health care
- Covering wide range of policy questions
- Broad range of health-care systems
- A shift towards
  - Statistically more efficient designs
  - Flexible econometric models
- External validity tests are limited

Content

- What is a Discrete Choice Experiment (DCE)?
- How to conduct a DCE?
- How are DCEs applied and reported in health care?
- Future research

Future research

Among others…..

- External validity
- Incorporating DCE results into a decision-making framework
- Complexity (e.g. level overlap, colour coding, presenting risk)
- Eye-tracking
- Advanced choice models and utility functions
- Random regret minimization models
- DCE for QALY estimation
- …..

QUESTIONS?

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See also:

Erasmus Choice Modelling Centre

(www.erim.eur.nl/ecmc)