



## 聯合分析法於醫療領域之運用 Application of Conjoint Analysis in Health Care

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### Outlines

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- Evolution of conjoint analysis
- Recent studies using discrete choice experiments (DCEs)
- Steps in conducting DCEs
- Strength & limitation of CA
- Q & A

## Brief history of conjoint analysis

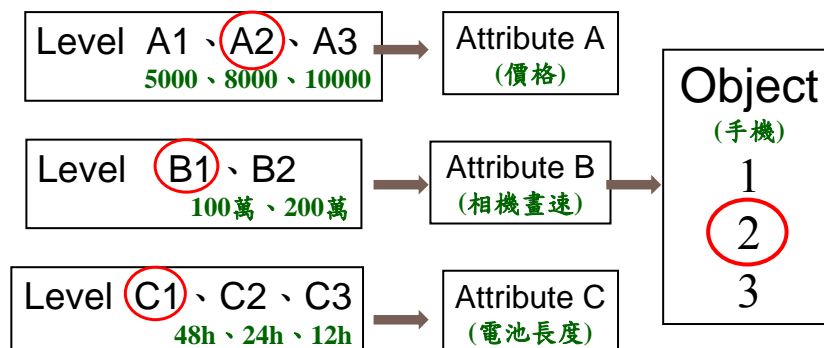
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- The origin of conjoint measurement was introduced in **1964** by the mathematical psychologist RD Luce and the statistician JW Tukey in the USA.
- Following the theoretical work of Luce & Tukey, conjoint analysis (CA) was introduced to the marketing research community in the early 1970s (Green and Rao, 1971).

## Concept of conjoint analysis (cont'd)

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- Object, attribute and level



## Concept of conjoint analysis

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- CA is based on three inter-related concepts:
  - ▣ Each product or service is a bundle of attributes
  - ▣ Each individual has unique values that reflect the desirability of different product features (attributes) and can be expressed numerically as a part-worth
  - ▣ Combining utilities for different attributes measures the individuals overall preference for a product or service (utility)

Mele, 2008, *Nursing Research*

## Concept of conjoint analysis (cont'd)

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- Humans make decision about the overall value of a product based on the value of its multiple, combined features (attributes).

*The features are **considered jointly!***

- Consumers must make difficult trade-offs when making their purchase decisions.
- The conjoint analysis is a trade-off measurement technique for analyzing **preferences** and **intentions-to-buy** responses.

## What can conjoint analysis do?

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- To show individuals are willing to trade between the attributes of product
- To understand the relative value of product features
- To define product with the optimal combination of features
- Isolate groups of customers who place differing importance on different features
- To make predictions and run simulations
  - ▣ To predict the demand for a product with given attribute
  - ▣ to compute overall desirability for each product concept
  - ▣ To create 'what-if' scenarios

Mele, 2008, *Nursing Research*  
Drummond et al. 2005

## Decisions on product purchasing

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- Consumer's choice vs. provider's choice:
  - ▣ In the business community
    - spends enormous sums of money each year **seeking consumer input** about the design and desirability of their product.
  - ▣ In the healthcare industry
    - providers traditionally have made treatment decisions (their product) on behalf of their patients, with little or **no consumer input**.

Mele, 2008, *Nursing Research*

## Why preferences for valuation in Health ?

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- Increasing recognition of patient choice as a key factor in uptake
- New technologies are more likely to be adopted if valued by patients & providers
- Accounts for multiple characteristics that may yield utility including 'process' factors
- Permits estimation of trade-offs between attributes, including monetary valuation if desired



Preferences can be used to reflect value and predict utilization

Marshall, Phillips & Johnson, iHEA, July 13, 2009

## When are preferences most relevant in health care?

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- When the evidence about **benefit** is unclear
- Tradeoffs between **risks** and **benefits**
- Patients' values for **process** or **outcome** vary widely

Marshall, Phillips & Johnson, iHEA, July 13, 2009

## Methodology of conjoint approaches

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- Ranking and rating conjoint analysis
  - Trade-off matrix
  - Full profile
  - Hybrid
  - ...
- **Discrete choice experiments (DCEs)**
  - Assume that
    - A given healthcare intervention can be described by its features (attributes) and
    - Any patient's preferences for an intervention are determined by levels of the attributes.

## Key steps in undertaking a discrete choice conjoint analysis

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- **Step I.** Identify the attributes of the treatment or service
- **Step II.** Assign levels to the attributes
- **Step III.** Draw up scenarios that describe all possible configurations of the attributes and levels chosen
- **Step IV.** Elicit preferences for the scenarios using discrete choices
- **Step V.** Analyze the data

Drummond et al. 2005

## Recent studies as illustrative examples

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- Criteria for selecting these 5 studies
  - Type of intervention: treatment for a certain disease
  - Study design: DCEs

## Recent studies using conjoint analysis

| Type of Services                         | Diseases                                    | Authors               | Country        | Year |
|--|---|-----------------------|----------------|------|
| Drug treatment                           | Osteoporosis                                | de Bekker-Grob et al. | The Netherland | 2008 |
| Coagulation factor concentrate treatment | Haemophilia with inhibitors                 | Lee et al.            | USA            | 2008 |
| Drug treatment                           | Children with asthma or wheezing conditions | Walzer & Zweifel      | Switzerland    | 2007 |
| Conservative treatment                   | Non-metastatic prostate cancer              | Sculpher et al.       | U.K.           | 2004 |
| Chemotherapy                             | Colorectal cancer                           | Aristides et al.      | Australia      | 2002 |

## Step I: Identify the attributes of the treatment or service

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- Attributes describing the product concept can be defined through the use of
  - Literature reviews
  - Focus group discussions with health professionals or patients
  - Direct questioning
- In case of treatment, the attributes are likely to relate to the main dimensions of **efficacy** and the major **adverse events**, or may be predefined by a **policy question** (Ryan, 1999).
- 4-6 attributes acceptable (Ryan & Gerard, 2003)

### Attributes and levels considered in recent CA studies

| Study   | Attributes  | Levels   |
|---|---|--|
| Osteoporosis drug treatment   | 1. Route of drug administration                                 | Tablet monthly; Tablet weekly; Injection four months; Injection monthly (4)                                    |
|   | 2. 10-year-risk reduction of a hip fracture (%)                 | 5; 10; 25; 50 (4)  |
|   | 3. Nausea   | No; Yes (2)  |
|   | 4. Total treatment duration                                     | 1; 2; 5; 10 (4)  |
|   | 5. Total cost to you  | 0; 120; 240; 720 (4)   |
| Coagulation factor concentrates in treatment of Haemophilia with inhibitors | 1. Risk of human viral infection                                | Recombinant concentrate; Very pure concentrate; Extracted from human plasma (3)                                |
|   | 2. Possibility that the titre of inhibitor may rise             | No ; Yes (2)   |
|   | 3. Reduces the likelihood of dose-related thromboembolic events | No ; Yes (2)   |
|   | 4. # of infusions required to stop a haemorrhage                | One; Two; Three infusions (3)  |
|   | 5. Time required to prepare the infusion                        | ≤5; 6-10; 11-30; >30 min (4)   |
|   | 6. Infusion time  | ≤5; 6-10; 11-30; >30 min (4)   |
|   | 7. Infusion volume  | ≤15ml; 16-40ml; 41-80ml; 81-120ml (4)  |
|   | 8. Time required to stop bleeding                               | ≤6; 7-12; 13-24; >24h (4)  |
|   | 9. Time required to alleviate pain                              | ≤2; 3-6; 7-9; 10-12h (4)   |
|   | 10. Use in prophylaxis  | One infusion every 2 days; One infusion every day (2)  |
|   | 11. Ability to undergo major surgery                            | Yes; No (2)  |
|   | 12. <u>Costs of medications</u>                                 | Cost is not really a consideration; Cost is somewhat of a consideration; Cost in very much a consideration (3) |

## Attributes and levels considered in recent CA studies (cont'd)

| Study   | Attributes  | Levels   |
|---|---|--|
| Drug treatment for children with asthma   | 1. Episode-free-days (EFDs)   | Increase from 180 to 200 EFDs per year; Increase from 180 to 220 EFDs per year; Decrease from 180 to 160 EFDs per year; Decrease from 180 to 140 EFDs per year (4) |
|   | 2. Risk of a mild to severe exacerbation  | 6%; 10%; 16% (3)   |
|   | 3. Information availability on long-term effects in children 4-14 years of age            | Yes; No (2)  |
|   | 4. Out-of-pocket expenses   | \$10; \$30; \$50; per month (3)  |
| Management of non-metastatic prostate cancer  | Part 1-1 Loss of sex drive or libido  | No; Diminished (2)   |
|   | Part 2-1 Diarrhoea  | Absent; Mild; Moderate (3)   |
|   | Part 1-2 Ability to get or maintain erection  | No problems; Occasional problems; Unable (3)   |
|   | Part 2-2 Hot flushes  | Absent; Mild; Moderate (3)   |
|   | Part 1-3 Lack of physical energy or "pep"   | No problems; Lacking (2)   |
|   | Part 2-3 Breast swelling  | Absent; Present (3)  |
|   | 4. <u>Treatment cost to you personally</u>  | Range €0-€400 (16 levels used)   |
| 5. Life expectancy  | Both options equal; One option better by two months; One option better by four months (3) |  |
| Chemotherapy in advanced colorectal cancer: Raltitrexed vs. fluorouracil plus low dose calcium folinate (FU-LV) | 1. Risk of mucositis  |  |
|   | (1) All grades  | 75; 63; 45; 19 (4)   |
|   | (2) Grade III / IV  | 30; 19; 10; 2 (4)  |
|   | 2. Administration   |  |
| (1) Consecutive days of treatment/ weeks, per chemotherapy cycle  | 8/4; 5/4; 2/3; 1/3 (4)  |  |
| (2) <u>Costs</u>  | 0; 100; 200; 300; 400; 600; 800 (7)   |  |

## Step II: Assign levels to the attributes

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- Each attribute is assigned at least two mutually exclusive levels that are both concrete and unambiguous.
- The number of levels with the usual number ranging from 3-5 levels per attribute should be balanced across attributes (Mele, 2008).
- **May include hypothetical levels**
- Attributes can be cardinal, ordinal or categorical

## Step III: Draw up scenarios

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- *Scenario* is used interchangeable with *task*, *choice set*, *product profile*, or *concept...*
- Scenario is defined as a collection of product alternatives from which the respondent must choose (Orme, 2006)
- The # of scenarios increases with the # of attributes and levels

## Orthogonal design

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- To avoid interviews of excessive length, the number of treatment scenarios can be reduced.
- A fractional factorial design algorithm is used to omit redundant alternatives and provided an orthogonal design (Hahn & Shapiro, 1966).
  - ▣ To reduce the number of treatment concepts
  - ▣ To minimize the correlation between the remaining cards
  - ▣ To allow the estimation of utilities in a statistically coherent way

## Issues regarding survey design

| Study   | Number of treatment alternative      | Orthogonal design         | Opt-out choice | Regression model   | Number of choice tasks  | Number of scenarios in a choice task |
|---|--------------------------------------|---------------------------|----------------|--|---|--------------------------------------|
| Drug treatment of Osteoporosis  | $4^2 \times 2^1 = 512$               | 16                        | Yes            | Conditional logit  | 16 (A dominant choice set is included)  | 3                                    |
| Coagulation factor concentrate treatment of Haemophilia with inhibitors | $2^5 \times 3^2 \times 4^5 = 294912$ | 36 by D-optimal design    | Yes            | Multinomial logit  | 12  | 3                                    |
| Drug treatment of children with asthma                                  | $4^1 \times 3^2 \times 2^1 = 72$     | 16                        | No             | Random effect Probit model                                     | 16 (compared with a fixed status quo)   | Pair-wise options 2                  |
| Conservative treatment of non-metastatic prostate cancer                | —                                    | Part 1: 8<br>Part 2: 8    | No             | Random effect Probit model                                     | Two-parts exercise<br>Each contained 8 options  | Pair-wise options 2                  |
| Chemotherapy of Colorectal cancer                                       | $4^2 \times 7^1 = 112$               | 39 (no orthogonal design) | No             | Robust cluster logistic regression to allow for cluster effect | 10 or 15 to test cognitive problem; two dominant pair-wise choices were included; compared with a fixed scenario. | Pair-wise options 2                  |

## Step IV: Elicit preferences for the scenarios using discrete choices

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- Pre-test; pilot test
- Face-to-face interviews
- Choice set: Pair-wise?
- The non option (the opt-out alternative) – decline the hypothetical purchase – can be included as a choice
- Test for rationality: a dominant choice set is included

## Issues regarding data collection

| Study   | Way of administer the questionnaire  | Pre-test (sample size)  | Sources of study sample   | Sample size  |
|---|--|---|---|--|
| Drug treatment of Osteoporosis  | Questionnaire sent by post and telephone interview was administered a week later | Five experts and 15 women for developing the attributes; 10 women for answering the questionnaire | Community-dwelling elderly women aged >60 from 34 general practices in Rotterdam, the Netherlands | 181 invited; 120 responded; 117 passed the dominant question |
| Coagulation factor concentrate treatment of Haemophilia with inhibitors | Self-administered  | —   | Haematologists attending a key scientific meeting   | 30   |
| Drug treatment of children with asthma                                  | On-line  | Face-to-face interview (n=6)  | On-line   | 42   |
| Conservative treatment of non-metastatic prostate cancer                | Face-to-face interview   | Two-phase: 14 men to determine attributes; 9 men to answer the questionnaire                      | Patients with non-metastatic prostate cancer at the Middlesex Hospital, London                    | 180 invited; 129 interviewed                                 |
| Chemotherapy of colorectal cancer                                       | Self-administered  | face-to-face interview (n=10) of oncology nurses  | Nurses worked at 4 oncology clinics in Sydney teaching hospitals.                                 | 71   |

## Sample size?

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- A rule of thumb for power calculator (Mele, 2008)

$$n \times t \times a / c \geq 500$$

- $n = \#$  of respondents
- $t = \#$  of tasks
- $a =$  the  $\#$  of alternatives per task (excluding the non option)
- $c =$  the largest  $\#$  of levels in any one attribute when considering the main effect

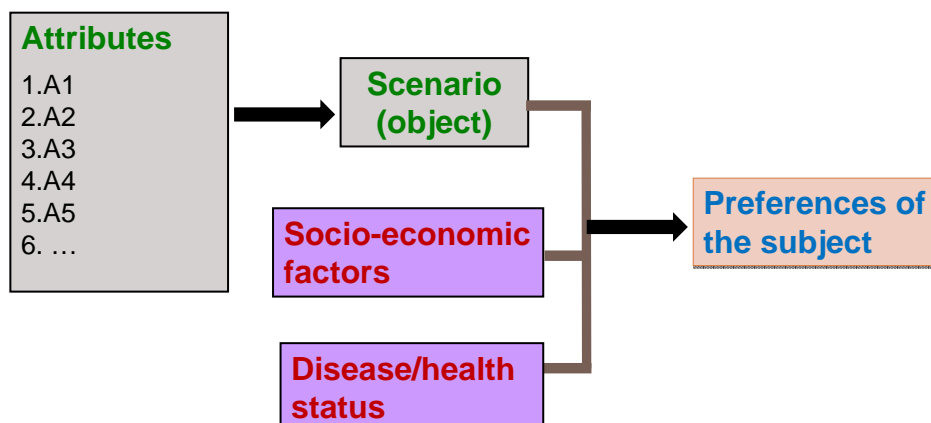
## Step V: Analyze the data

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- To estimate part-worth utilities and relate them to probability that the estimated part-worths would have produced the observed choices.
- Discrete choice analysis: provide one utility estimate for each attribute level for the entire sample
  - Conditional logit
  - Multinomial logit
  - Latent class analysis
  - Hierarchical Bayes estimation
  - ....

## Research framework

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## Coding the data collected

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| Variables | Attribute                           | Levels   | Coding               |
|-----------|-------------------------------------|--|----------------------|
| 1         | Loss of sex drive or libido         | No(reference)<br>Diminished  | D1=0<br>D1=1         |
| 2         | Ability to get or maintain erection | No problems(reference)<br>Occasional problem<br>Unable                                     | D2=0<br>D2=1<br>D2=2 |
| 3         | Lack of physical energy or "pep"    | No problems(reference)<br>Lacking  | D3=0<br>D3=1         |
| 4         | Treatment cost to you personally    | Range €0-€400<br>(16 levels used)  | D4                   |
| 5         | Life expectancy                     | Both options equal<br>One option better by two months;<br>One option better by four months | D5                   |

Sculpher et al. (2004), *BMJ*

## Creating variable values from the results of a choice set

Sculpher et al. (2004), *BMJ*

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**Table 1** Example of show card used in discrete choice experiment

|                                     | <input type="checkbox"/> Option A | <input checked="" type="checkbox"/> Option B |
|-------------------------------------|-----------------------------------|--|
| <b>Part 1</b>                       |                                   |  |
| Sex drive or libido                 | Diminished                        | Diminished                                   |
| Ability to get or maintain erection | No problems                       | No problems                                  |
| Physical energy                     | Lacking "pep"                     | No problems                                  |
| Treatment cost to you personally    | £400                              | £275   |
| Life expectancy                     | Option A better by two months     |  |

**Option A:** D1= 1; D2= 0; D3= 1; D4= \$400; D5= 2

**Option B:** D1= 1; D2= 0; D3= 0; D4= \$275; D5= 0

**Modeling:**

Independent var. X1= 0; X2= 0; X3= -1; X4= -\$125; X5=-2

Dependent var. Y=1

## Model specification

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- The utility function is in additive form
- The change in utility in moving from option A to option B depend upon the differences in attribute levels A and B.
- $\beta_1, \beta_2, \dots, \beta_K$  are the coefficients of the model to be estimated.

$$\Delta U_j = \beta_0 + \beta_1 X_{1,j} + \beta_2 X_{2,j} + \dots + \beta_K X_{K,j} + \gamma_{k+1} X_{k+1,j} + \gamma_{k+2,j} X_{k+2,j} + \dots + \gamma_m X_{m,j} + \varepsilon_j$$

$\Delta U_j$  = changes in utility from A to B;

$X_{1j}, \dots, X_{Kj}$  = levels of the various attribute of the  $j^{\text{th}}$  scenario; mostly dummy variables and can be sometimes continuous variables.

$X_{k+1,j}, \dots, X_{m,j}$  = other controls such as socio-economic and health status variables.

**Table 3** Results of first part of discrete choice exercise

| Variable   | Coefficient (95% CI)            | SE     | P value |
|--|---------------------------------|--------|---------|
| Libido   | -0.3089<br>(-0.5719 to -0.0460) | 0.1342 | 0.021   |
| Ability to maintain erection                             | -0.4243<br>(-0.5321 to -0.3165) | 0.0550 | <0.001  |
| <u>Physical energy</u>                                   | -0.7032<br>(-0.8219 to -0.5845) | 0.0606 | <0.001  |
| Out of pocket expenses                                   | -0.0007<br>(-0.0014 to -0.0001) | 0.0003 | 0.017   |
| Life expectancy  | 0.2336 (0.1707 to 0.2966)       | 0.0321 | <0.001  |
| Interaction between ability to maintain erection and age | 0.2184 (0.0934 to 0.3433)       | 0.0637 | 0.001   |
| Constant   | -0.0541<br>(-0.1459 to 0.0376)  | 0.0468 | 0.248   |
| No of observations                                       | 1000; 194.92; P<0.0001*         |        |         |

\* $\chi^2$  test.

Sculpher et al. (2004), *BMJ*

**Table 5** Patients' marginal rates of substitution between life expectancy and other attributes

| Attribute                            | <u>Life expectancy willing to forgo (months)</u> | Single level improvement                     |
|--------------------------------------|--|--|
| Diarrhoea                            | 1.8  | From moderate to mild or from mild to absent |
| Hot flushes                          | 0.5  | From moderate to mild or from mild to absent |
| Breast swelling                      | 1.9  | From present to absent                       |
| Loss of libido                       | 1.3  | From present to absent                       |
| Problems in maintaining an erection: |  |  |
| Aged <70 years                       | 1.8  | From moderate to mild or from mild to absent |
| Aged >70 years                       | 0.9  | From moderate to mild or from mild to absent |
| Lack of energy or "pep"              | 3.0  | From present to absent                       |

Sculpher et al. (2004), *BMJ*

**Table 3** Women's preferences for preventive osteoporosis drug treatment

| Attribute   | Beta coefficient | P value | 95% CI |       |
|---|------------------|---------|--------|-------|
| Constant (drug treatment)                             | 1.23             | <0.001* | 0.81   | 1.66  |
| Drug administration (base level tablet once a month): |                  |         |        |       |
| Table once a week                                     | -0.31            | <0.001* | -0.45  | -0.17 |
| Injection every four months                           | -0.21            | 0.027*  | -0.41  | -0.02 |
| Injection once a month                                | -0.44            | <0.001* | -0.64  | -0.25 |
| Effectiveness (10% risk reduction)                    | 0.28             | <0.001* | 0.23   | 0.34  |
| Side effect nausea                                    | -1.10            | <0.001* | -1.30  | -0.89 |
| Treatment duration (1 year)                           | -0.04            | <0.001* | -0.06  | -0.02 |
| Cost (100)  | -0.15            | <0.001* | -0.18  | -0.11 |

\*Significant at the 5% level  
 Number of observations 5,589  
 (117 respondents × 16 choices × 3 options per choice, minus 27 missing values), pseudo-  
 $R^2 = 0.1847$ , log pseudo-likelihood = -1668.7

De Bekker-Grob et al. 2008

**Table 4** Women's time and monetary trade-offs for preventive osteoporosis drug treatment

| Attribute   | Willingness to adhere to the drug treatment longer (years) | WTP for total treatment (€) | Interpretation note   |
|---|--|-----------------------------|---|
| Constant (no drug treatment)                          | 32.7   | 847                         | For drug treatment vs. no drug treatment                        |
| Drug administration (base level tablet once a month): |  |                             |   |
| Tablet once a week                                    | 8.2  | 212                         | For change from tablet once a week to tablet once a month       |
| Injection every 4 months                              | 5.7  | 147                         | For change from injection every 4 months to tablet once a month |
| Injection once a month                                | 11.7   | 304                         | For change from injection once a month to tablet once a month   |
| Effectiveness   | 7.5  | 195                         | For 10% reduction in 10-year risk of a hip fracture             |
| Side effect nausea                                    | 29.0   | 752                         | For change from side effect to no side effect                   |
| Treatment duration                                    |  | 26                          | For 1-year decrease in total drug treatment duration            |
| Cost  | 3.9  |                             | For 100 euro decrease in drug treatment cost                    |

WTP = willingness to pay

De Bekker-Grob et al. 2008

## Predicting the value of an existing product: bisphosphonate

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- Bisphosphonate is the most frequently used preventive osteoporosis drug treatment.
- Attributes: taken as a weekly tablet; approximately 30% fracture risk reduction; nausea as a possible side effect; total treatment duration of 5 years; and no out-of-pocket payment
- $V(\text{utility level; preference})=0.46$ ;
- $WTP (\text{willingness to pay}) =338$

**Table 5** Differences between low and high-risk patients' preferences for preventive osteoporosis drug treatment

| Attribute  | Beta coefficient of <u>low risk patients</u> | Beta coefficient of <u>high risk patients</u> | P value |
|--|--|---|---------|
| Constant (drug treatment)                              | 1.178  | 1.316   | 0.748   |
| Drug administration (basel level tablet once a month): |  |   |         |
| Table once a week                                      | -0.360                                       | -0.255  | 0.464   |
| Injection every 4 months                               | -0.125                                       | -0.317  | 0.323   |
| Injection once a month                                 | -0.445                                       | -0.454  | 0.966   |
| <u>Effectiveness (1% risk reduction)</u>               | 0.023  | 0.034   | 0.050*  |
| Side effect nausea                                     | -1.046                                       | -1.161  | 0.582   |
| Treatment duration (1 year)                            | -0.033                                       | -0.045  | 0.583   |
| Cost (1 euro)  | -0.002                                       | -0.001  | 0.435   |

\* Significant at the 5% level  
 Number of observations 5,589  
 (117 patients (i.e., 58 low-risk +59 high-risk patients) × 16 choices × 3 options per choice, minus 27 missing values),  
 pseudo R<sup>2</sup> = 0.1895, log pseudo-likelihood = -1658.8

De Bekker-Grob et al. 2008

## Strengths of CA

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### CA enables us to ....

- Describe the existing medical product as combinations of attributes & levels that are meaningful to customers/patients.
- Be aware of the trade-offs among various attributes and benefits offered to patients.
- Synthesize new product alternatives from those basic attribute levels.
- Allow cross patient group comparison and distinction of patient needs among various patient groups
- Incorporate patients' (or providers') preferences (or provider preference) into the existing HTA framework

# Limitations of CA

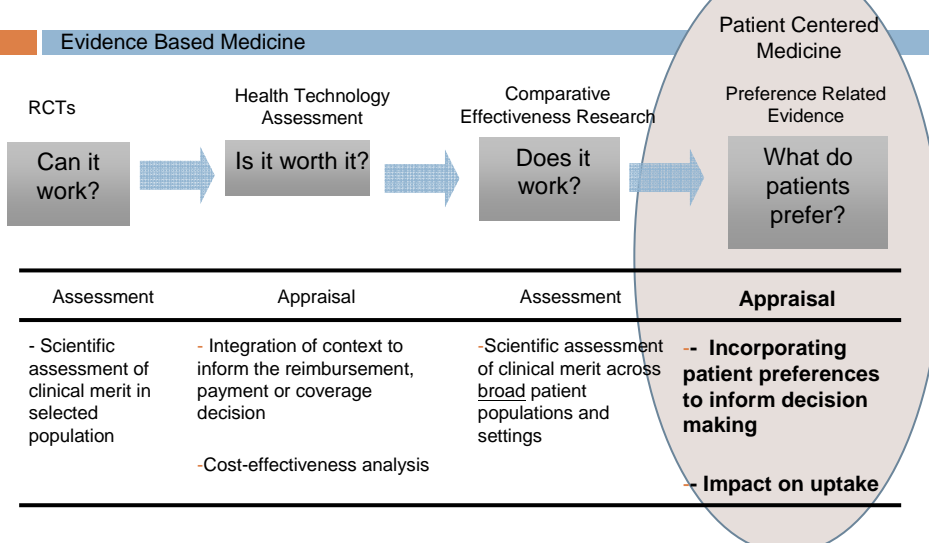
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## Limitations

- Internal validity and consistency
- Test-retest reliability
- The level at which the cost attribute is set can influence the WTP estimates for the level of the other attributes (Ratcliffe et al, 2000).
- The inclusion of the participation decision is crucial in obtaining accurate estimates

# The era of patient preferences

## Evidence Based Medicine



Marshall, Phillips & Johnson, iHEA, July 13, 2009

***Thank you very much!***

