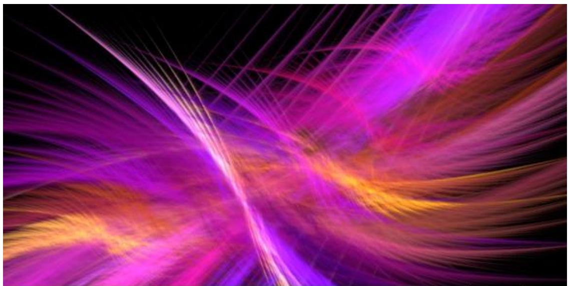

# Healthcare Technology Engineering

WARWICK

Early HTA
Dr Leandro Pecchia

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INTRO

## …BME peculiar contribution?

- It is important to start thinking new inventions from the “HTA-prospective” **during the R&D** (early stage HTA, premarket evaluation…), when **a small change may have a big impact**…
- The HTA is perceived as a barrier to the introduction of new technologies in the health care systems (80% r SME in EU)
- A reason is that: “*the "problem" of the assessments is considered only when the technology is close to its placing on the market and not during R&D process*” (WHO*)
- Research question: ***may we support R&D of new MDs with early stage HTA methods?***

*WHO web site (last access 15.09.2012): http://www.who.int/medical_devices/assessment/en/



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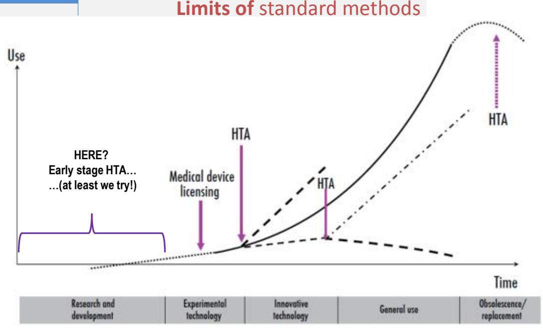
HTA

## HTA
## Limits of standard methods




*WHO web site (last access 15.09.2012): http://www.who.int/medical_devices/assessment/en/

GOALS

## GOALS OF THIS LECTURE

- **"Standard" methods of HTA limitation for Med. Dev. and early HTA**
- Methods and tools for early stage HTA:
  - **Headroom Analysis (HA):**
    - Assuming such a benefit for the patient, above the existing funded treatment…
    - …what is the maximum cost that the new device may have, to be cost-effective?
    - Is this worth of investing my resources? It there a reasonable ROI?
  - **Markov Models (MM):**
    - Assuming that my device will have this benefit (i.e. reduce ΔX% mortality)…
    - …will it be cost-effective, with a reasonable certainty?
    - May I simulate the scenario and infer, with statistical significance, its cost-effectiveness?
  - **Predictive statistical methods to** designing a new home monitoring telemedicine interventions basing on the best available evidence
    - How often to collect data?
    - Which data?
    - Which target population?
  - **Analytic Hierarchy Process (AHP)** :
    - Are there more important user needs to be satisfied? (users: patients, nurses, MD…)
    - May we quantify their relative importance?
    - May we measure the fitting of our solution with these needs?



HTA limits

## HTA
## Limits of standard methods

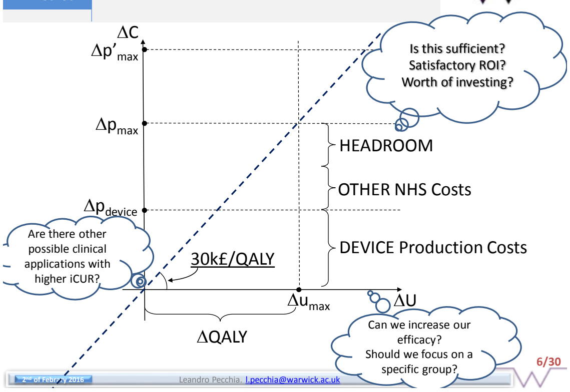
| Devices | VS | Drug |
|---|---|---|
| ***Principal action*** | | |
| Other than principally drugs | | Pharmaco./Immunologic/Metabolic |
| Mechanical/Electromagnetic/Materials | | Chemical based |
| ***Product life cycle*** | | |
| Short life cycle | | Long life cycle |
| Constantly evolving components/parts | | Unchanging compound |
| ***Clinical evaluation*** | | |
| Difficult to blind (no placebo) | | Easy to blind |
| Multiple end users | | Usually one end users |
| Long learning curve | | Short learning curve |
| Strongly dependent by settings/users | | Less dependent by settings/users |
| Complex to standardize for RCT | | Easy to standardize for RCT |
| ***Use issues*** | | |
| User-dependent efficacy | | Efficacy is less user-dependent |
| Often require intensive training | | Usually do not require training |
| Complication decrease with use | | Complication increase with use |
| ***Diversity*** | | |
| Mainly small companies/few large co. | | Mainly large multinationals |
| Diagnostic or therapeutic | | Therapeutic |
| ***Costs*** | | |
| Varying overheads/slow return | | High overheads with quicker return |
| Higher distribution costs | | Lower distribution costs |
| Higher maintenance/installation costs | | No maintenance/installation |

**L Pecchia**, MP Craven, *"Early stage Health Technology Assessment (HTA) of biomedical devices. The MATCH experience"*. World Congress on Medical Physics and Biomedical 2012, 26-31 May 2012, Beijing, China.



Method 1

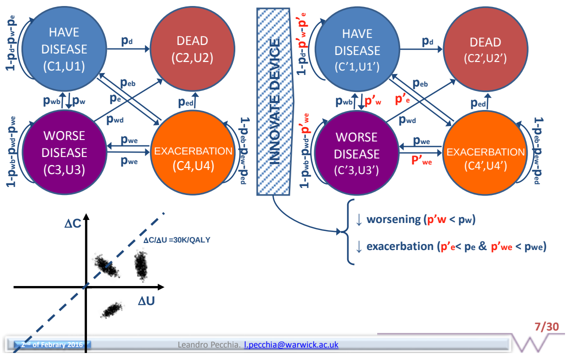
## Headroom Analysis



MM

# 4 states Markov Models

disease/worsening/exacerbation/dead






MM&AHP

**Designing a new home monitoring telemedicine interventions for CHF basing on the best available evidence**

- How often to collect data?
- Which data?
- Which target population?



METHODS

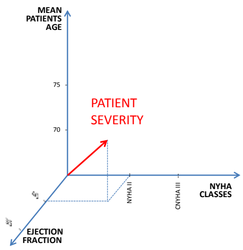
# METHODS 1/2

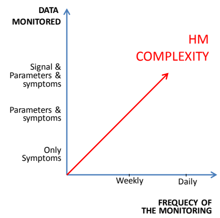
1. A meta-analysis Home Monitoring (HM) vs Usual Care (UC)
2. Only well designed RCT were included
3. Outcome considered:
   - mortality for CHF,
   - mortality for all causes,
   - bed days for CHF,
   - bed days for all causes,
   - readmissions for CHF and
   - readmissions for all causes
4. RCT were classified according to: **patients' severity** and **HM complexity**
5. Correlation between the 6 outcomes and **patients' severity/HM complexity** were studied

METHODS

## METHODS 2/2

- HM RCT were classified according to **patients' severity** and **HM complexity**




- Correlations **effectiveness-severity** and **effectiveness-complexity** were computed



RESULTS

## RESULTS

- Study selection:

314 papers

Title/abstract selection:
- 8 Not heart failure
- 18 Invasive hemodynamic monitoring
- 43 Editorial or review
- 70 not an RCT
- 41 Other heart failure intervention or research
- 19 Study design

115 papers

Full paper selection:
- 1 Not heart failure
- 7 Editorial or review
- 16 not an RCT
- 40 Other heart failure intervention or research
- 10 Study design
- 4 Other languages
- 5Short Follow-up

32 papers

- 23 DMP vs UC
- **8 HM vs UC**
- 1DMP & HM vs UC



RESULTS

## RESULTS

| MORTALITY | DMP vs UC RR (95% CI;p) | HM vs UC RR (95% CI;p) |
|---|---|---|
| All-causes | **0.826 (0.691 ; 0.987; 0.043)** | 0.723 (0.402; 1.302; 0.223) |
| HF-related | 0.848 (0.518; 1.389; 0.322) | 0.602 (0.362; 1.001; 0.059) |

RR < 1 <=> DMP/HM better than UC; p < 0.05 <=> resalt statistically significant (**bold**)

| READMISSION | DMP vs UC RR (95% CI;p) | HM vs UC RR (95% CI;p) |
|---|---|---|
| All-causes | **0.835 (0.710; 0.982; 0.037)** | 0.970 (0.811; 1.159; 0.377) |
| HF-related | **0.797 (0.689; 0.923; 0.004)** | 0.816 (0.559; 1.192; 0.230) |

RR < 1 <=> DMP/HM better than UC; p < 0.05 <=> resalt statistically significant (**bold**)

| BED DAYS | DMP vs UC MD (95% CI;p) | HM vs UC MD (95% CI;p) |
|---|---|---|
| All-causes | 0.094 ( -2.680; 2.868; 0.112) | 1.109 (-1.100; 3.317; 0.311) |
| HF-related | 0.637 (-2.236; 3.510; 0.000) | 1.937 (-0.792; 4.666; 0.124) |

MD <0 <=> DMP/HM better than UC; p < 0.05 <=> resalt statistically significant (**bold**)

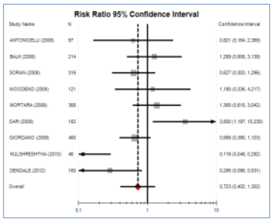
- **There is evidence that DMP are more effective that UC**
  - Reducing All-causes mortality
  - Reducing readmission (All-causes and HF-related)
- **It seems, but there is not evidence that DMPs reduce bed-days**

RESULTS

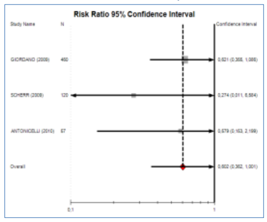
## RESULTS

- **Mortality**: HM vs UC

All causes




HF mortality




**The HM RCT seems (no statistically significant result) more effective than UC**

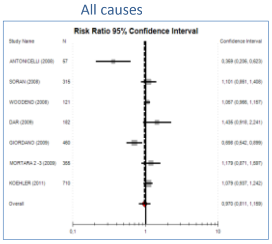


RESULTS

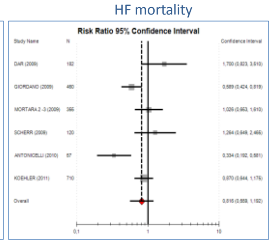
## RESULTS

- **Readmission**: HM vs UC

All causes




HF mortality




**The HM RCT seems (no statistically significant result) more effective than UC**

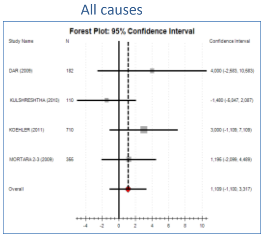


RESULTS

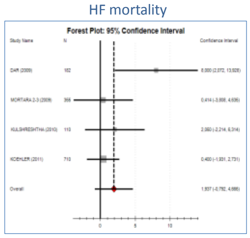
## RESULTS

- **Bad days**: HM vs UC

All causes




HF mortality




**The HM RCT seems (no statistically significant result) more effective than UC**

RESULTS

# RESULTS

- HM RCT classification: **Patients' severity**

| | NYHA | Ejection Fraction | Mean Age | Patient Severity |
|---|---|---|---|---|
| Sherr 2008 | 3 | <40 | 73 | 8 |
| Dendale, 2011 | 3 | <40 | 76 | 7 |
| Dar, 2009 | 3 | >40 | 72 | 6 |
| Koehler,2011 | 2&3 | <35 | 67 | 5 |
| Antonicelli, 2010 | 2&3 | <40 | 78 | 4 |
| Soran, 2008 | 2&3 | <40 | 76 | 4 |
| Kulshreshtha, 2010 | 2&3 | <40 | 68 | 3 |
| Giordano, 2010 | 2 | <40 | 70 | 2 |
| Mortara, 2009 | 2 | <40 | 60 | 1 |



RESULTS

# RESULTS

- HM RCT classification: **HM protocol complexity**

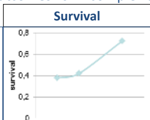
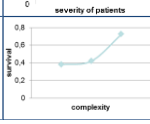
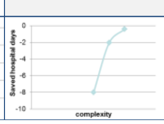
| | Simptomps | Parameters | Signals | Frequency | Complexity |
|---|---|---|---|---|---|
| KOEHLER, 2011 | | x | ECG | Daily | 6 |
| KULSHRESHTHA, 2010 | | X | | Daily | 5 |
| DAR, 2009 | X | X | | Daily | 4 |
| SORAN, 2008 | X | X | | | 4 |
| GELLIS, 2012 | | X | | Daily | 4 |
| SHERR, 2008 | | X | | Daily | 3 |
| DENDALE, 2011 | | X | | Daily | 3 |
| ANTONICELLI, 2010 | X | X | ECG | Weekly | 2 |
| MORTARA, 2009 | X | X | ECG | Weekly | 2 |
| GIORDANO, 2010 | | X | ECG | Each 15 days | 1 |



RESULTS

# RESULTS

- HM outcomes vs Pz complexity and HM complexity:

| | Survival | Saved Bed days | Reospedalization |
|---|---|---|---|
| PATIENT SEVERITY |  | No significant correlation | No significant correlation |
| HM COMPLEXITY |  |  | No significant correlation |



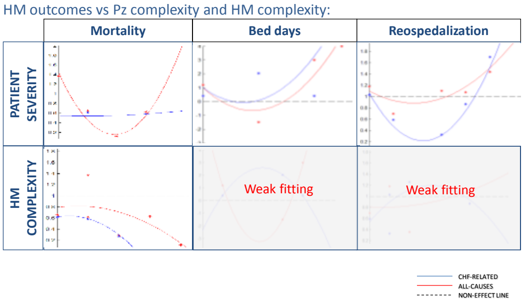


- Evidence:
  - HM is more effective for more severe patients
  - More complex HM are more effective in reducing mortality and bed-days

RESULTS

## RESULTS

- HM outcomes vs Pz complexity and HM complexity:






MM&AHP

**Measure user needs to design most appropriate technology**

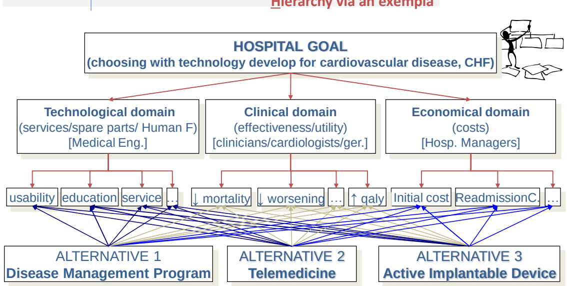
- What are the most important needs?
- How your innovative idea meet these needs?
- And the other?



AHP

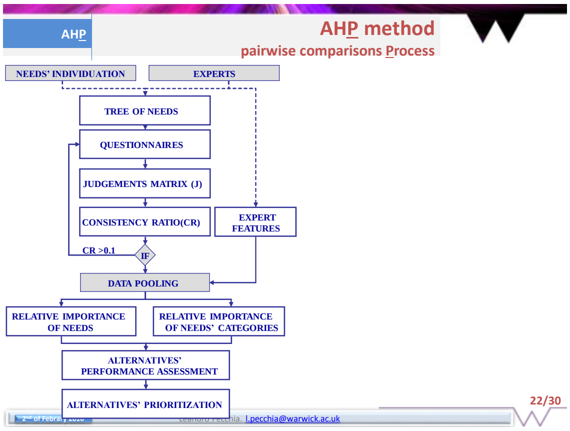
## AHP for HTA

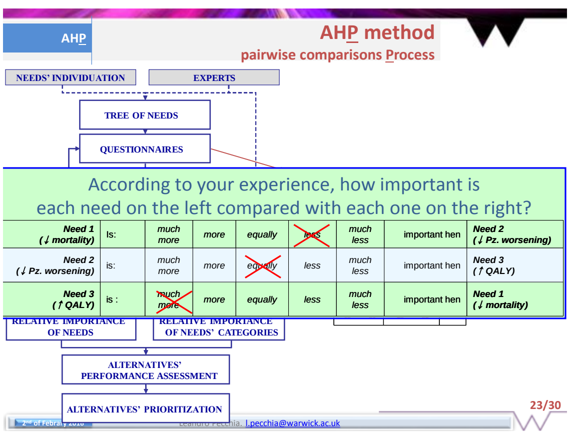
### Hierarchy via an exempla

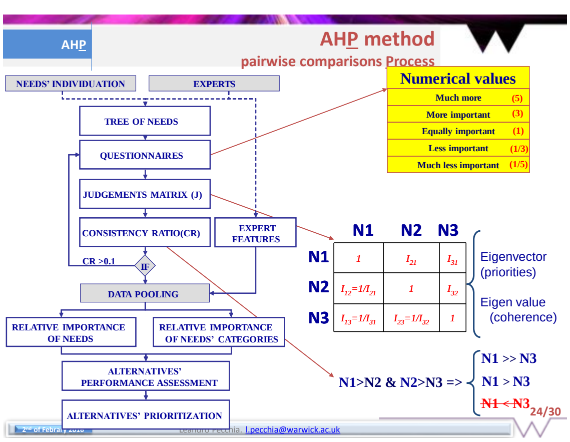


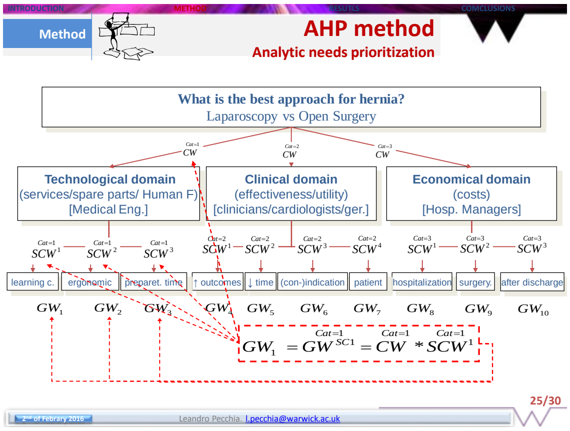

**How important is each factor (outcome/output/need) for the assessment?**

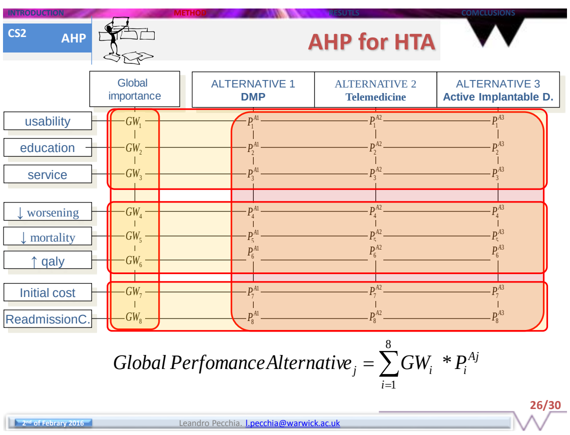
**How each alternative satisfy each factor?**


AHP
AHP method
pairwise comparisons Process
NEEDS' INDIVIDUATION
EXPERTS
TREE OF NEEDS
QUESTIONNAIRES
JUDGEMENTS MATRIX (J)
CONSISTENCY RATIO(CR)
EXPERT FEATURES
CR >0.1
IF
DATA POOLING
RELATIVE IMPORTANCE OF NEEDS
RELATIVE IMPORTANCE OF NEEDS' CATEGORIES
ALTERNATIVES' PERFORMANCE ASSESSMENT
ALTERNATIVES' PRIORITIZATION
l.pecchia@warwick.ac.uk
22/30


AHP
AHP method
pairwise comparisons Process
NEEDS' INDIVIDUATION
EXPERTS
TREE OF NEEDS
QUESTIONNAIRES
According to your experience, how important is
each need on the left compared with each one on the right?
Need 1 (↓ mortality) | Is: | much more | more | equally | ~~less~~ | much less | important hen | Need 2 (↓ Pz. worsening)
Need 2 (↓ Pz. worsening) | is: | much more | more | ~~equally~~ | less | much less | important hen | Need 3 (↑ QALY)
Need 3 (↑ QALY) | is : | ~~much more~~ | more | equally | less | much less | important hen | Need 1 (↓ mortality)
RELATIVE IMPORTANCE OF NEEDS
RELATIVE IMPORTANCE OF NEEDS' CATEGORIES
ALTERNATIVES' PERFORMANCE ASSESSMENT
ALTERNATIVES' PRIORITIZATION
l.pecchia@warwick.ac.uk
23/30


AHP
AHP method
pairwise comparisons Process
NEEDS' INDIVIDUATION
EXPERTS
TREE OF NEEDS
QUESTIONNAIRES
JUDGEMENTS MATRIX (J)
CONSISTENCY RATIO(CR)
EXPERT FEATURES
CR >0.1
IF
DATA POOLING
RELATIVE IMPORTANCE OF NEEDS
RELATIVE IMPORTANCE OF NEEDS' CATEGORIES
ALTERNATIVES' PERFORMANCE ASSESSMENT
ALTERNATIVES' PRIORITIZATION
Numerical values
Much more (5)
More important (3)
Equally important (1)
Less important (1/3)
Much less important (1/5)
N1 N2 N3
N1 | 1 | $I_{21}$ | $I_{31}$
N2 | $I_{12}=1/I_{21}$ | 1 | $I_{32}$
N3 | $I_{13}=1/I_{31}$ | $I_{23}=1/I_{32}$ | 1
Eigenvector (priorities)
Eigen value (coherence)
N1>N2 & N2>N3 =>
N1 >> N3
N1 > N3
~~N1 < N3~~
l.pecchia@warwick.ac.uk
24/30


INTRODUCTION
METHOD
RESULTS
CONCLUSIONS
Method
AHP method
Analytic needs prioritization
What is the best approach for hernia?
Laparoscopy vs Open Surgery
Technological domain
(services/spare parts/ Human F)
[Medical Eng.]
Clinical domain
(effectiveness/utility)
[clinicians/cardiologists/ger.]
Economical domain
(costs)
[Hosp. Managers]
learning c.
ergonomic
preparet. time
↑ outcomes
↓ time
(con-)indication
patient
hospitalization
surgery.
after discharge
$GW_1 = GW^{SC1} = CW^{Cat=1} * SCW^{1}_{Cat=1}$
25/30
2nd of Febrary 2016
Leandro Pecchia, l.pecchia@warwick.ac.uk


INTRODUCTION
METHOD
RESULTS
CONCLUSIONS
CS2
AHP
AHP for HTA
Global importance
ALTERNATIVE 1
DMP
ALTERNATIVE 2
Telemedicine
ALTERNATIVE 3
Active Implantable D.
usability
education
service
↓ worsening
↓ mortality
↑ qaly
Initial cost
ReadmissionC.
$Global\ Perfomance Alternative_j = \sum_{i=1}^{8} GW_i * P_i^{Aj}$
26/30
2nd of Febrary 2016
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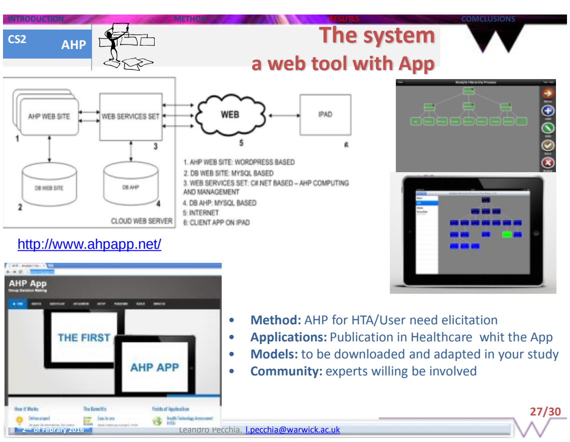
INTRODUCTION
METHOD
RESULTS
CONCLUSIONS
CS2
AHP
The system
a web tool with App
AHP WEB SITE
WEB SERVICES SET
WEB
IPAD
DB WEB SITE
DB AHP
CLOUD WEB SERVER
1. AHP WEB SITE: WORDPRESS BASED
2. DB WEB SITE: MYSQL BASED
3. WEB SERVICES SET: C#.NET BASED – AHP COMPUTING AND MANAGEMENT
4. DB AHP: MYSQL BASED
5. INTERNET
6. CLIENT APP ON IPAD
http://www.ahpapp.net/
AHP App
THE FIRST
AHP APP
Method: AHP for HTA/User need elicitation
Applications: Publication in Healthcare whit the App
Models: to be downloaded and adapted in your study
Community: experts willing be involved
27/30
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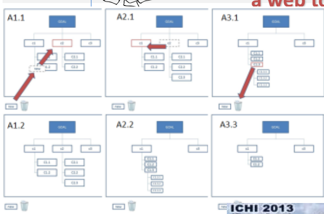
INTRODUCTION METHODS RESULTS CONCLUSIONS

CS2 AHP

## The system
### a web tool with App





A software tool to support the Health Technology Assessment (HTA) e the user need elicitation of medical devices via the Analytic Hierarchy Process (AHP)

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[2] Solution Engineering, Avellino, Italy
[3] Electrical Systems and Optics Research Division, University of Nottingham, Nottingham, UK

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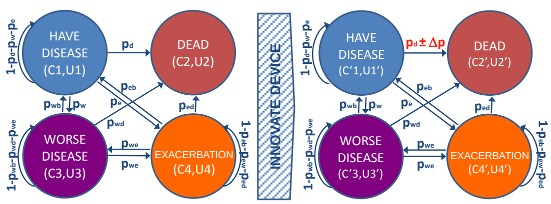
MM&AHP

## Markov Models & AHP

**What if some information are missing (eHTA)?**
**Missing data can be estimated using AHP…**




**…and using sensitivity analysisto estimate worst/best cases.**

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Concluding

## CONCLUSIONS

- The assessment of a new technology should be considered as soon as possible (R&D)
- **Standard methods of HTA are not sufficient for HTA of BME devices at early stage**
- **Headroom Analysis** may be used to evaluate in the ROI/max reimbursability cost of a new health technology in the best case
- **Analytic Hierarchy Process (AHP)** may be used to priorities needs, outcomes and outputs
- **4-state Markov Models (MM)** can be used to estimate cost-effectiveness at early stage (4 state can be used for many different cases) and update the R&D process
- **MM and AHP** can be combined to estimate unknown parameters when information are missing
- **Predictive statistical methods to** designing a new home monitoring telemedicine interventions basing on the best available evidence

30/30

2nd of Febrary 2016 Leandro Pecchia, l.pecchia@warwick.ac.uk