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Determining the cost of new technologies such as the linear accelerator under consideration.

Yolande Lievens, MD, PhD

Chair Radiation Oncology Department, Ghent University Hospital

Co-Chair HERO (Health Economics in Radiation Oncology) project

ESTRO president

ESTRO European Society for RADIOTHERAPY & ONCOLOGY

"The biggest problem with health care isn't with insurance or politics.

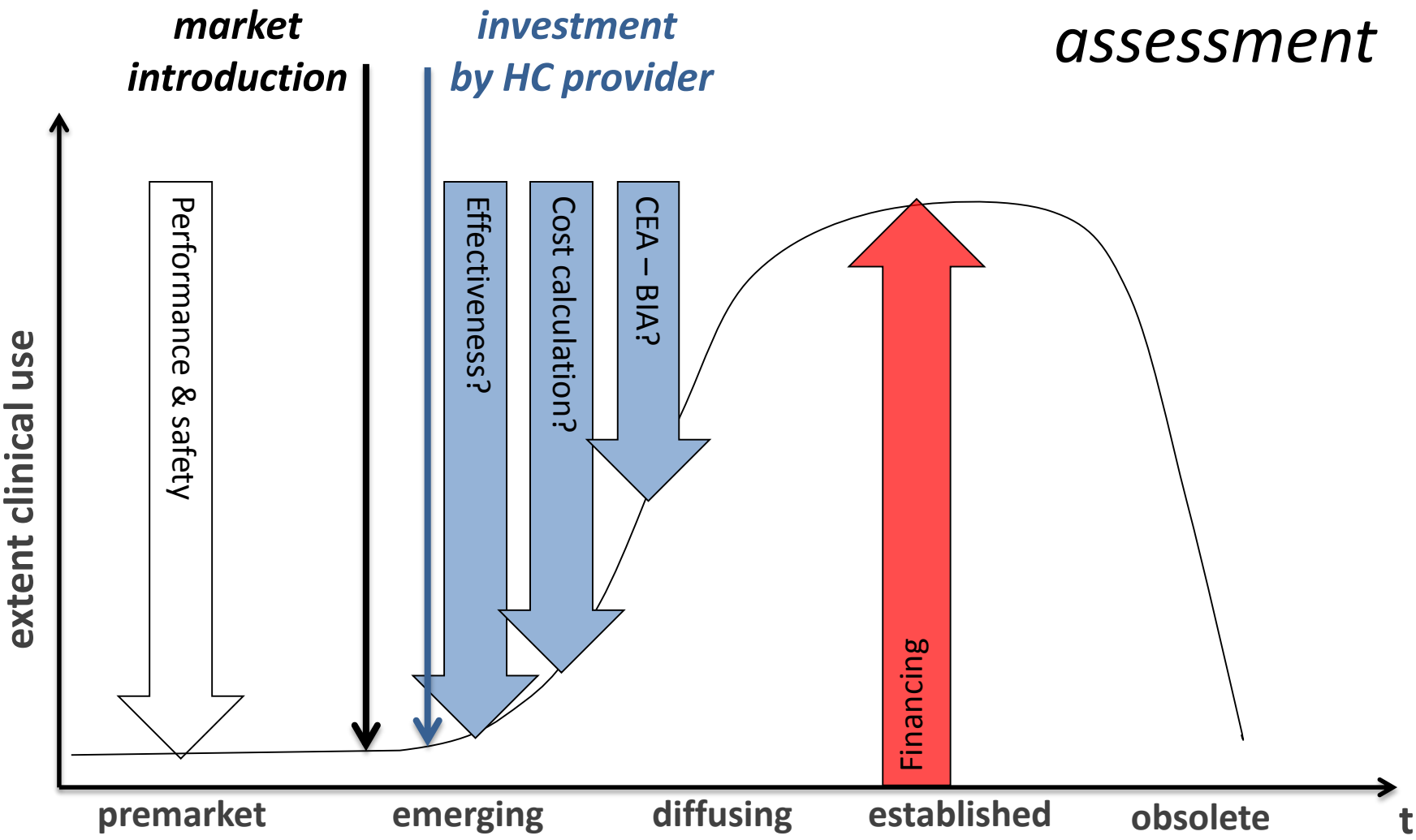
It's that we're measuring the wrong things the wrong way."

Kaplan and Porter, Harvard Business Review 2011

"It's always too early (to evaluate),
until, unfortunately it's suddenly too late!"

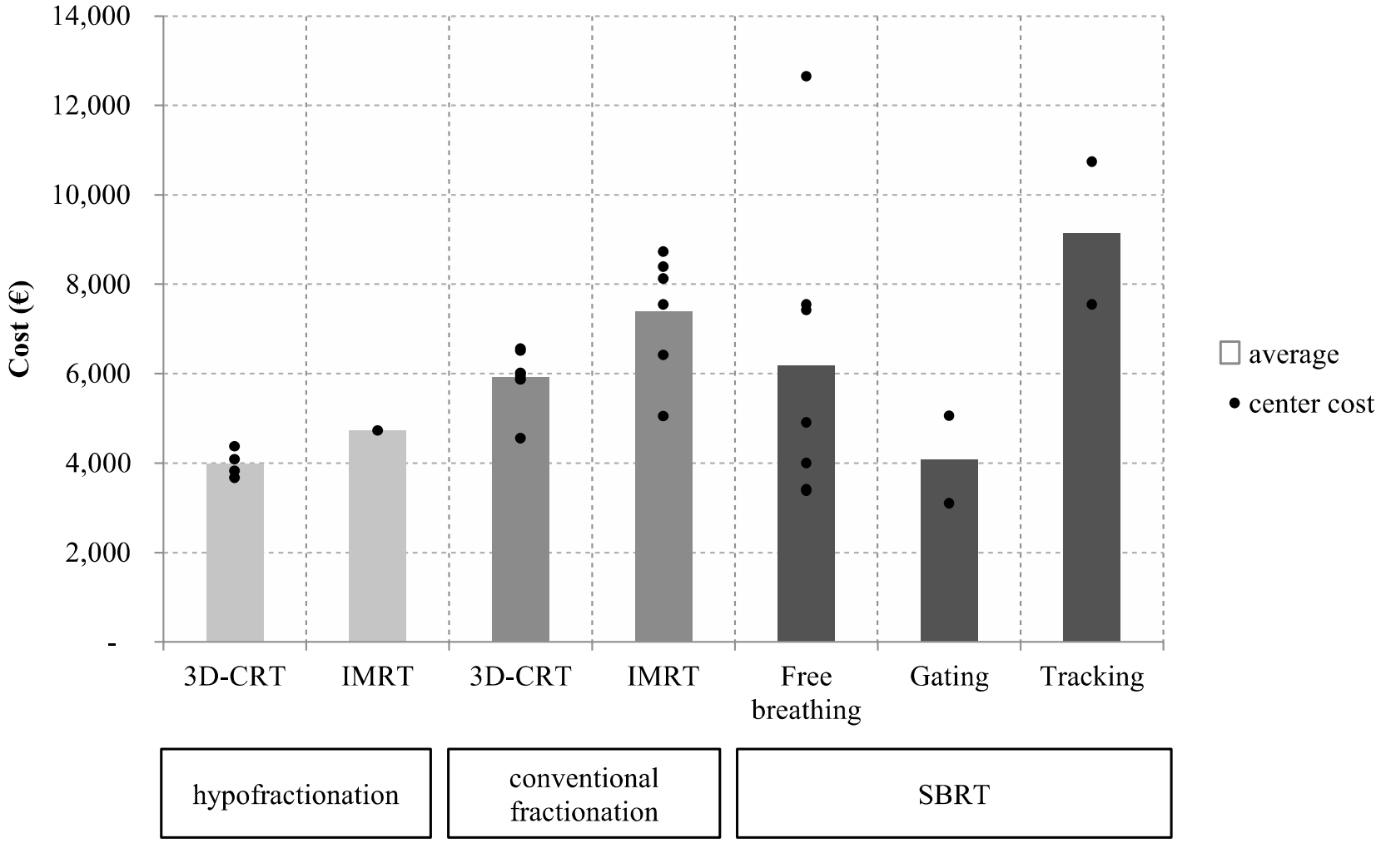
Buxton MJ. Economic appraisal of Health Technology in the European Community 1987

health technology assessment



Lievens et al. Acta Oncol 2015

cost lung cancer radiotherapy



Hulstaert et al, Report 198 KCE 2013
Lievens et al, JTO 2015

What is the cost of

a new linear accelerator?

What is the cost of

treating patients with a new linear accelerator?

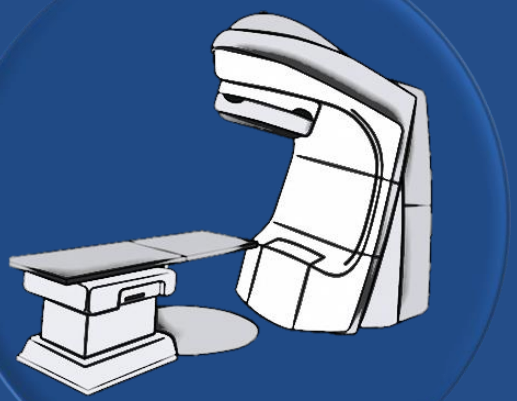
What will determine the cost of

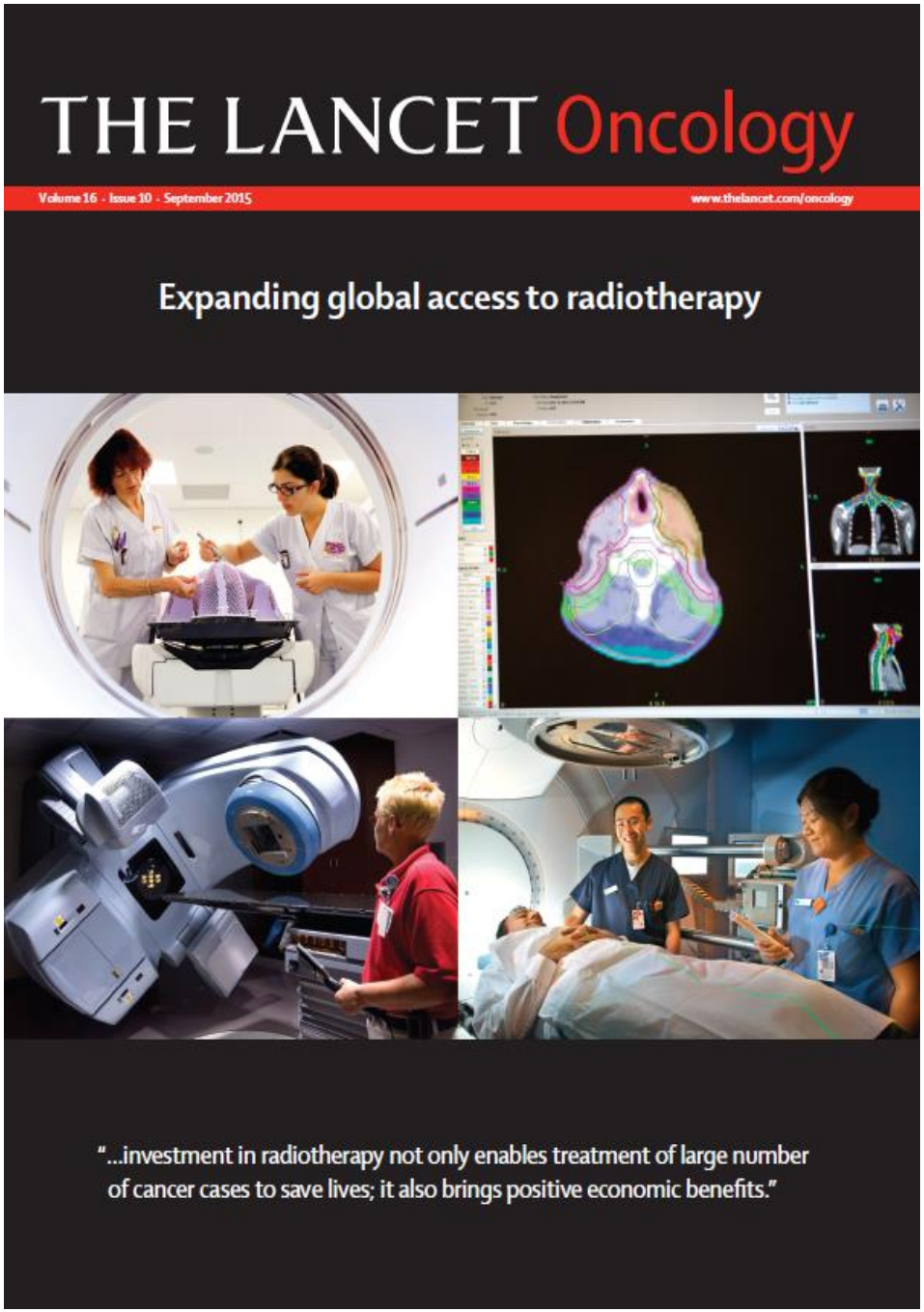
radiotherapy using a new linear accelerator?

socio-
economic
environment

robustness
efficiency
sustainability

ancillary equipment
construction
human resources



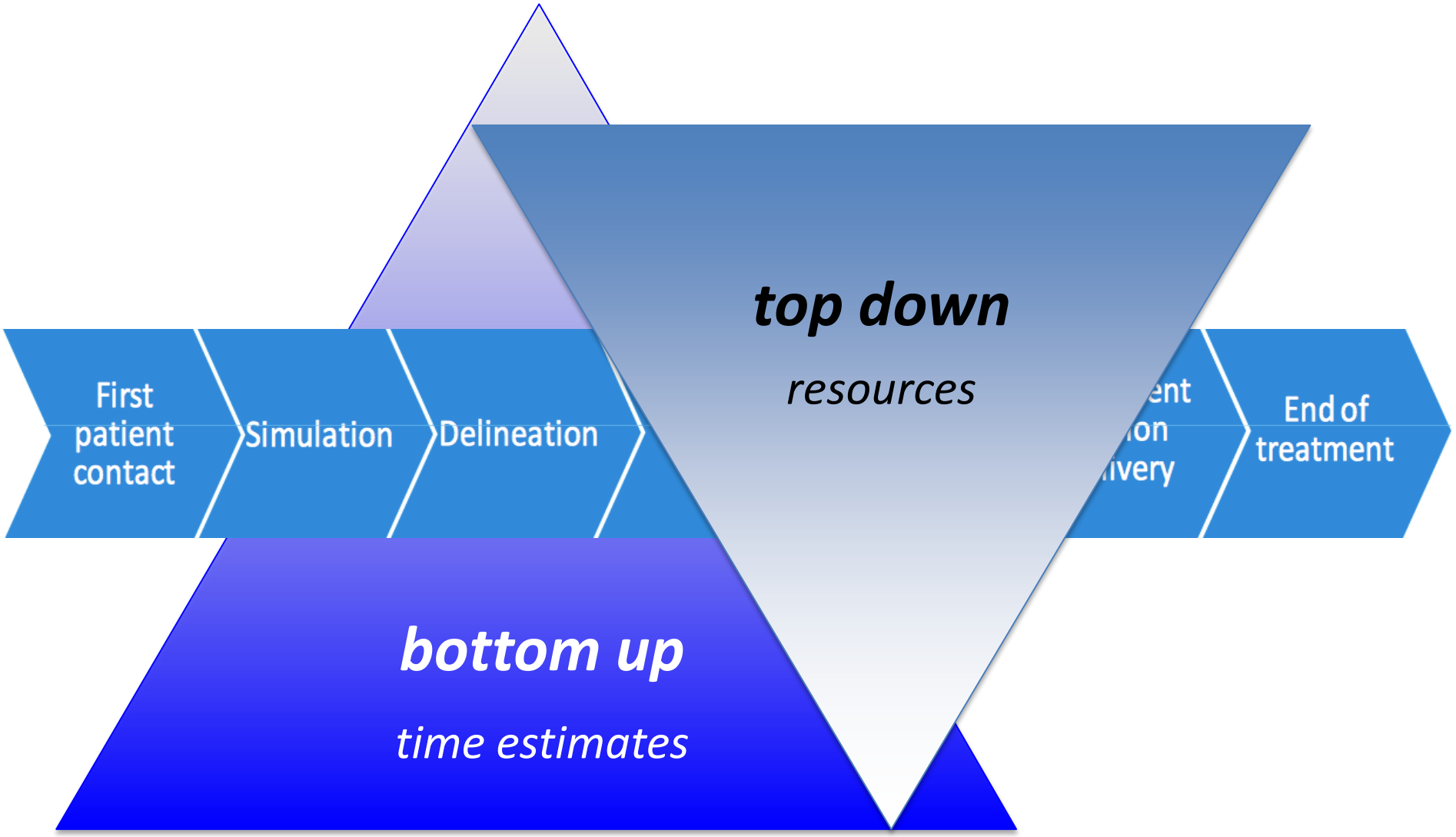


Cost Calculator
Staffing Estimator

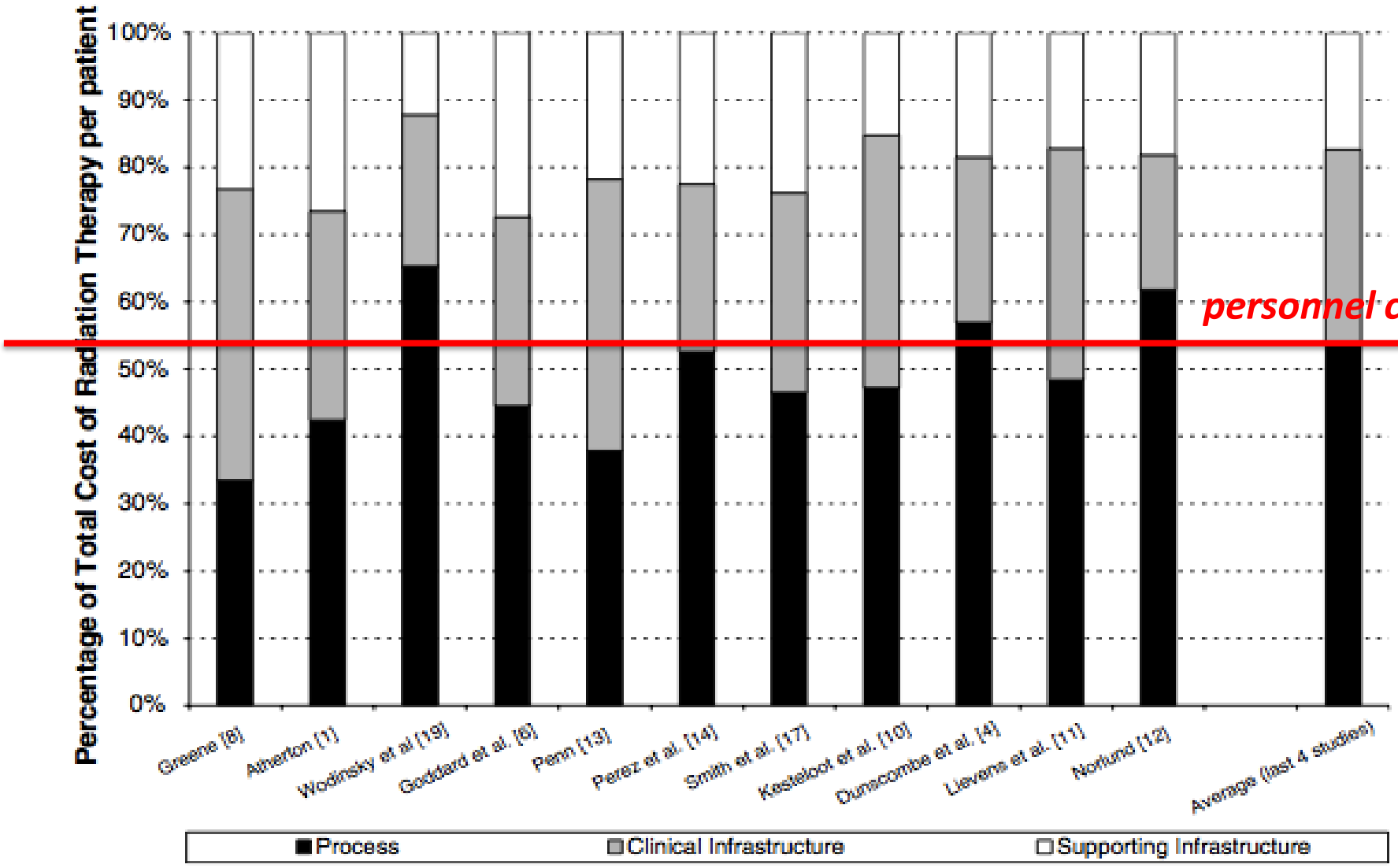
http://nucleus.iaea.org/HHW/RadiationOncology/Makingthecaseforradiotherapyinyourcountry/Roleofradiotherapyincancercare/Radiotherapyisacosteffectivesystemwhichneedsabalance/index.html

IAEA
International Atomic Energy Agency

Time-Driven Activity-Based Costing



resource cost components



staff
consumables

major & additional
equipment

administration
building & land

Ploquin and Dunscombe, R&O 2008

resources in the GTFRCC model

infrastructure

- 2 megavoltage treatment units
- 1 CT simulator
- a 3D-CRT-capable radiation treatment planning system
- an oncology information management system
- appropriate dosimetry, QA, radiation protection equipment
- facility layout and size conform (IAEA) guidance documents

staff

- RO, MP, RTT, nurses, dosimetrists, engineers
- requirements assuming optimal equipment use

costs

- IAEA references *(infrastructure)*
- Delphi questionnaire GTFRCC collaborators *(wages, training)*

Atun et al., Lancet Oncology 2015

resources in the GTFRCC model

equipment: fixed purchase price

Linac	1,361,000 US$ single energy 1,976,000 US$ dual energy
CT simulator	409,000 US$
TP System	272,000 US$
R&V System	130,000 US$
HDR Afterloader	454,000 US$

4

1

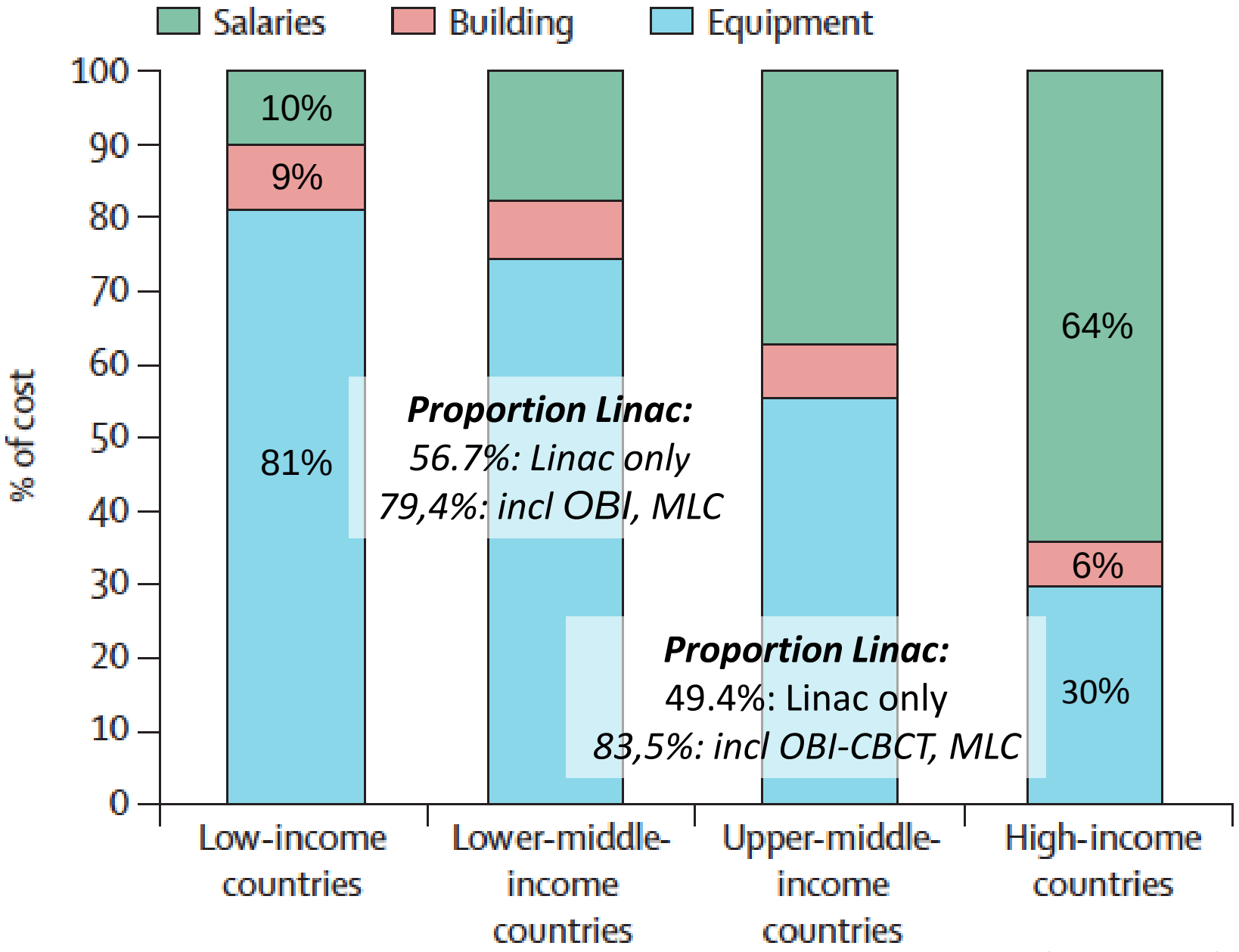
→ fixed costs translate into maintenance and amortization

building: cost/m²

staff: wages and training costs

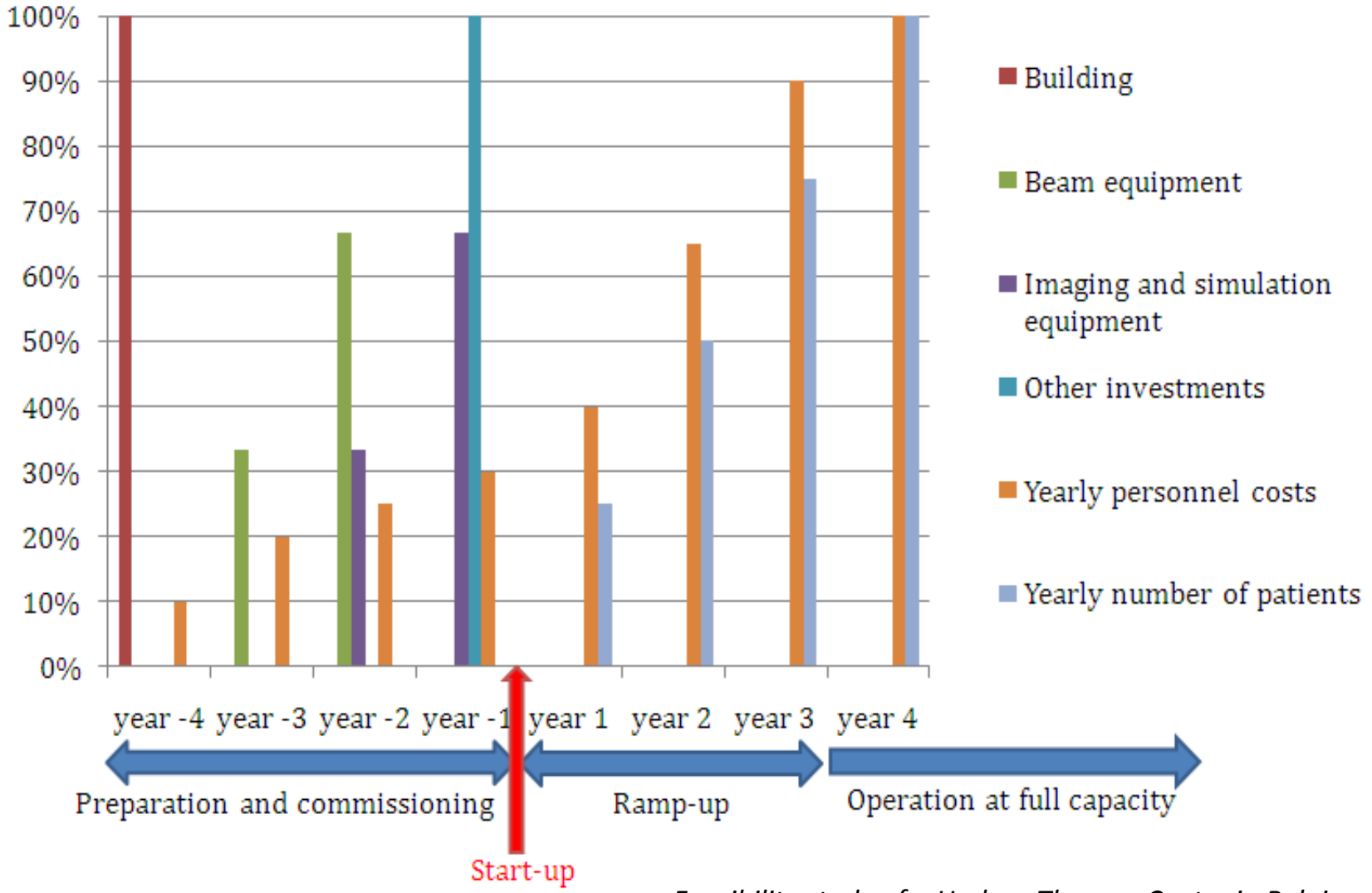
different by GNI region

Atun et al., Lancet Oncology 2015



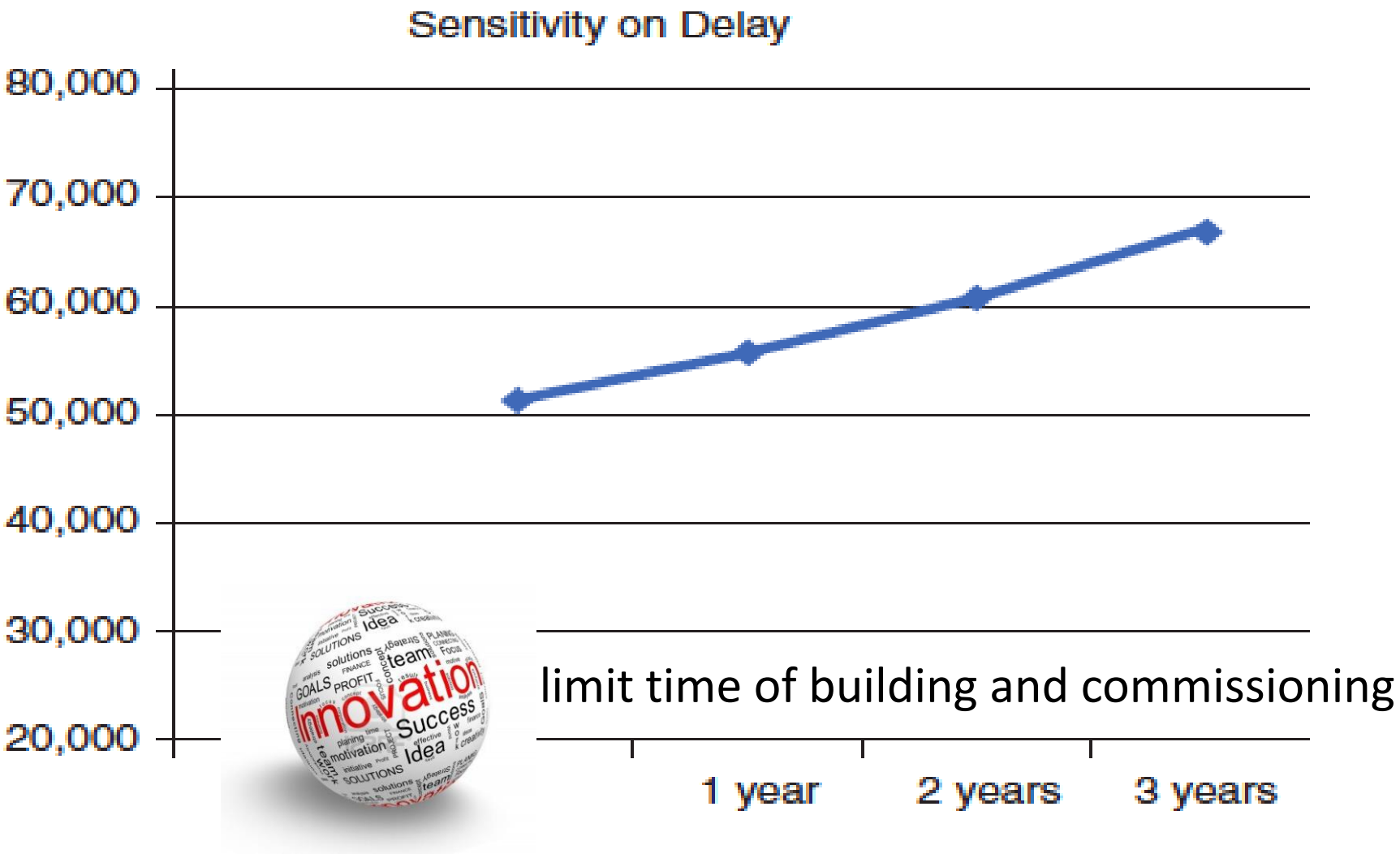
Atun et al., Lancet Oncology 2015

impact of building and commissioning time



Feasibility study of a Hadron Therapy Centre in Belgium - 2013

impact of building and commissioning time



Feasibility study of a Hadron Therapy Centre in Belgium - 2013

cost of construction

Forster – Sandwich - Construction system

Cost savings

Shorter construction time

Cost savings in demolition and for removal and reinstatement

cost of personnel and training

GTFRCC model:

- salary costs and cost per trainee vary by GNI/capita
- estimated from the GTFRCC survey, LABORSTA and IAEA training resources: ***large uncertainty!***

reduce impact of personnel cost in treatment cost?

- less personnel (per shift)
- lower personnel cost: task shifts?

innovative approaches to training

- lower training cost
- more personnel trained
- prohibit brain drain

investment *vs.* operation

upfront costs to develop a new facility

- investment in construction
- investment in equipment
- human-resource training costs

operating costs to deliver treatments

- human resources
- maintenance
- consumables
- overhead
- amortisation costs of equipment and facilities

Atun et al., Lancet Oncology 2015

upfront costs to develop a new facility

$$\text{Operational cost per fraction} = \left(\frac{\text{Oper} + \text{Equip (mnt} + \text{amort)} + \text{Bldng (mnt} + \text{amort)}}{\text{Number of fractions per year}} \right) \times 1 \cdot 2 \text{ (overhead)}$$

operating costs to deliver treatments

$$\text{Total capital expense} = \frac{\text{Building costs} + \text{equipment costs} + \text{training costs}}{\text{Number of fractions per year}}$$

Atun et al., Lancet Oncology 2015

operational parameters: the nominal model

- Departmental operation
  - 12 hours/day, 5days/week, 1,5 shift per day, 3 RTTs/shift
- Detailed time estimates per activity

  e.g. treatment time slots:
  - 3D CRT: 4 fractions/hr, 1 EPI/wk
  - IGRT: 3.3 fractions/hr
  - IMRT/IGRT: 2.5 fractions/hr
- Equipment maintenance
  - 10% of initial cost/year
- Amortization
  - equipment over 12 years, 5 years for software
  - buildings over 30 years
- Overhead: 20% *(including energy consumption)*

cost of energy

Lake Constance Radiation Oncology Centre (Germany)

"During the summer, the array's output will be more than the Radiation Oncology Centre needs to run its two linear accelerators, a large bore CT system and the clinic's IT technology, lighting and air-conditioning."

"solar energy has lowest energy cost (2,6 c€/kW/hr)"
(Chinese investment project)

cost per fraction
to install and operate radiotherapy

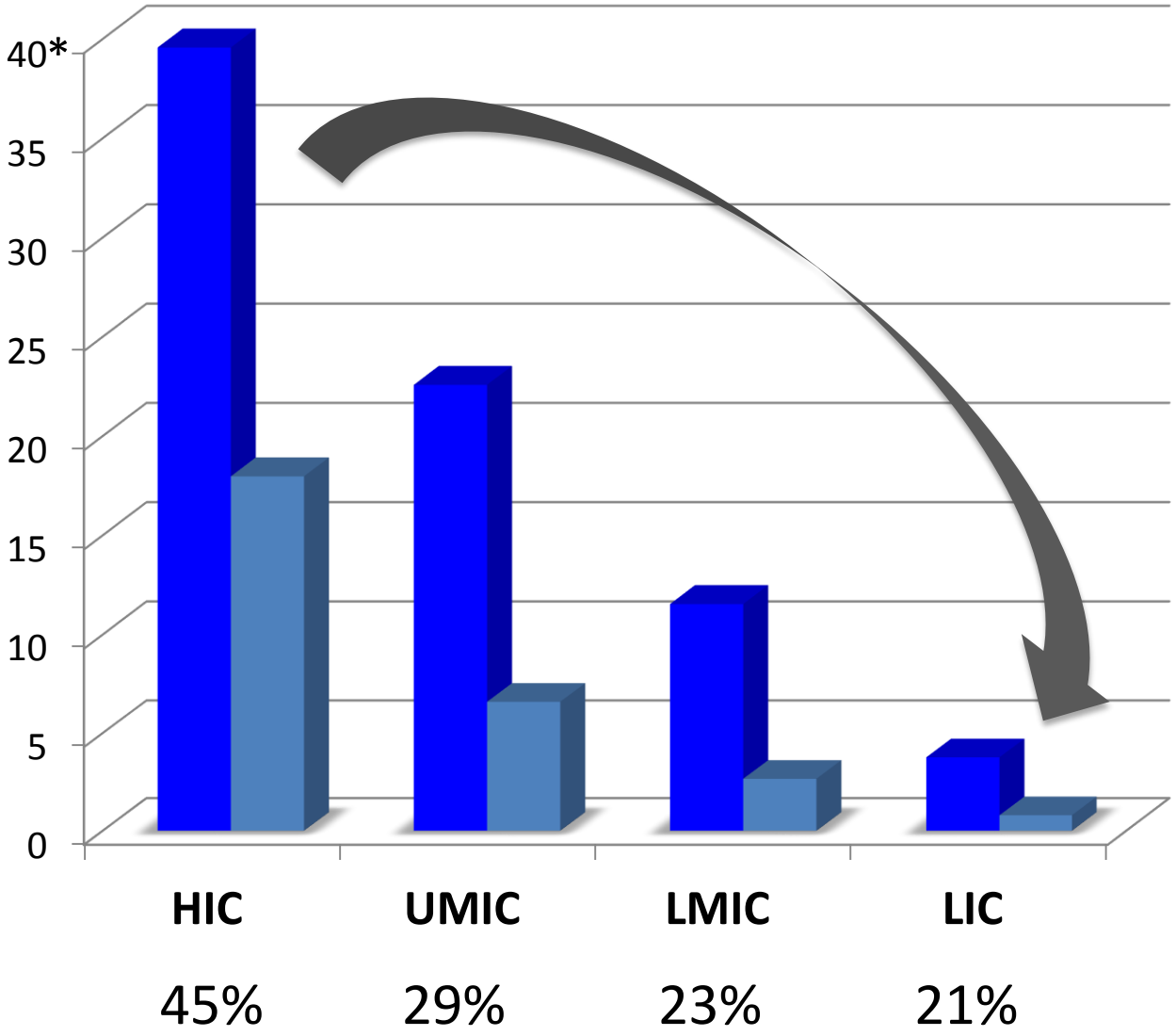
	High-income countries	Upper-middle-income countries	Lower-middle-income countries	Low-income countries
Operating cost per fraction	235	86	65	60
Upfront cost per fraction	803	357	349	352

Estimated on the basis of the activity-based model. Data are cost in US$. Operating cost=cost / fractions delivered. Upfront cost=one-off cost required to create the capacity, after which operating costs are incurred.

% training cost / investment: 35% HICs, 17-19% LMICs

Atun et al., Lancet Oncology 2015

investment *(by 2035)* *vs.* annual operation



total investment cost

annual operational cost

** In billion US$*

personnel costs!

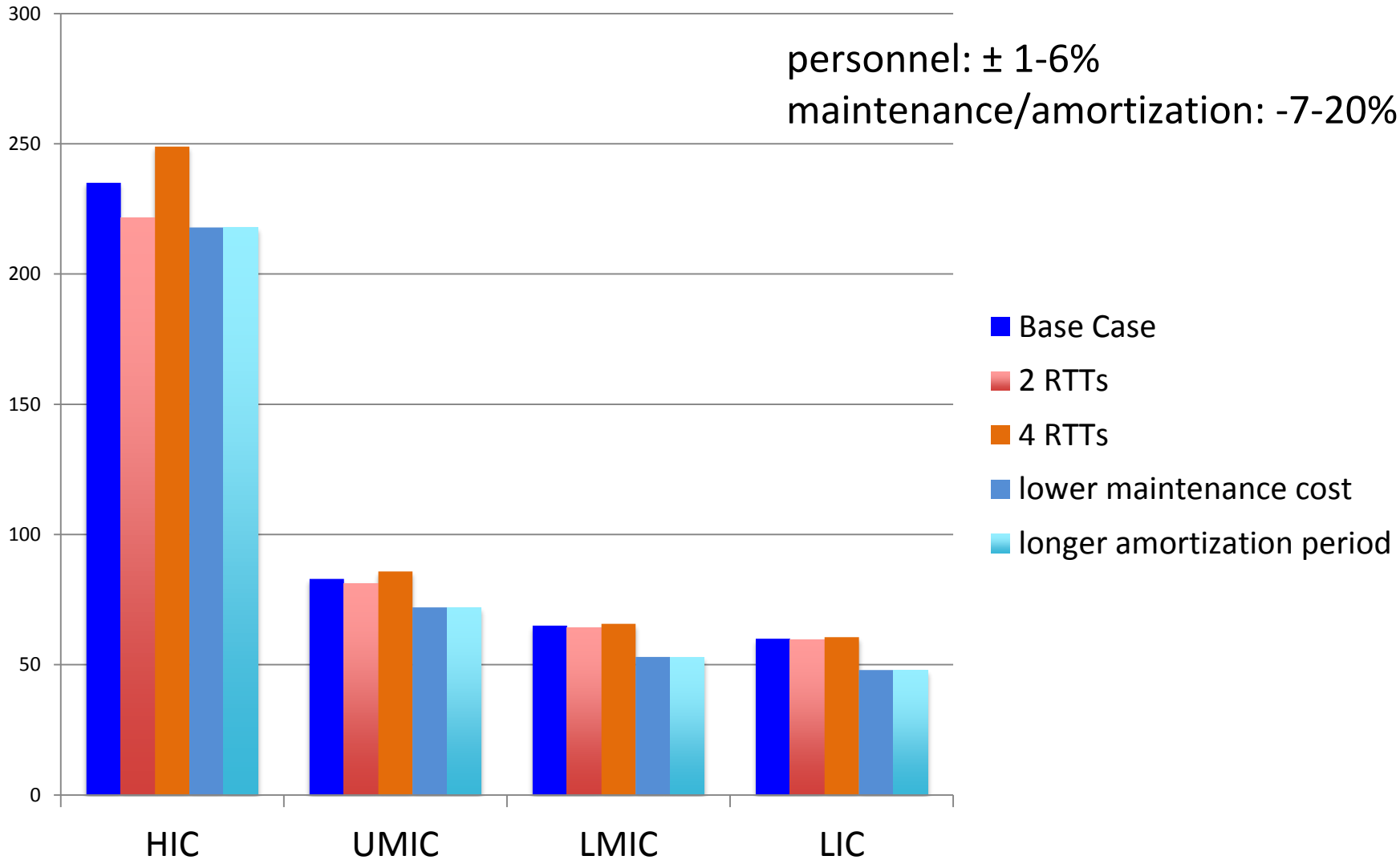
potential to reduce operational costs

	Operating cost per fraction: sensitivity analysis			Cost savings relative to base scenario			
	Automation: efficiency	Longer hours	Bulk purchase	High-income countries	Upper-middle-income countries	Lower-middle-income countries	Low-income countries
Combination 1	X	..	..	25%	21%	21%	21%
Combination 2	..	X	..	13%	18%	23%	25%
Combination 3	..	..	X	8%	16%	21%	23%
Combination 4	X	X	..	33%	34%	39%	40%
Combination 5	..	X	X	19%	34%	38%	42%
Combination 6	X	..	X	31%	34%	38%	39%
Combination 7	X	X	X	37%	43%	51%	53%

The operating cost model allows for improved efficiency, longer treatment hours per day, and bulk purchasing savings. These factors can occur alone or in combination, resulting in seven different combinations. X shows the inclusion of a factor in the sensitivity analysis.

Atun et al., Lancet Oncology 2015

potential to reduce operational costs



conclusions

- proportional cost of resources depends of **socio-economic context**
  - impact of **equipment cost** increases with decreasing GNI/c
  - **personnel cost** (wage, training) dominates in higher GNI/c
- **the linac cannot be seen in isolation**
  - costs are determined by all equipment, personnel and building
  - the impact of innovative approaches should be investigated
- investment needs are important, but **operational costs dominate the cost picture**
  - there is a **potential of process optimization, automation and better use of capital investment** to limit radiotherapy costs, yet the **human approach** during treatment should not be sacrificed

*"What we should be doing is developing **low cost, robust** technologies that work anywhere in the world and that will be used in developed contexts as well.*

*Ideally, the technologies would be **modular** so that people can buy the basic low cost version and buy the **add-ons** as they have more money and/or **more capabilities** of running more sophisticated techniques."*