



# **Performance of systems of cancer care in OECD countries: exploration of the relation between resources, process quality, governance and survival in patients with breast, cervical, colorectal and lung cancers**

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# The importance of studying cancer care performance

- One of the major public health issues in OECD countries:
  - the first or second ranked cause of death,
  - accounting for more than a quarter of all deaths,
  - one-third could potentially have been prevented,
  - another third cured if detected on time.
  - substantial cost of medical and social care.

# The importance of studying cancer care performance

- Dealing with cancer may have **implications** for the rest of the health system.
- How resources can be used most effectively and which organisational and governance characteristics result in the **best quality of care** and related health care **outcomes**.

# Cancer care as a priority area

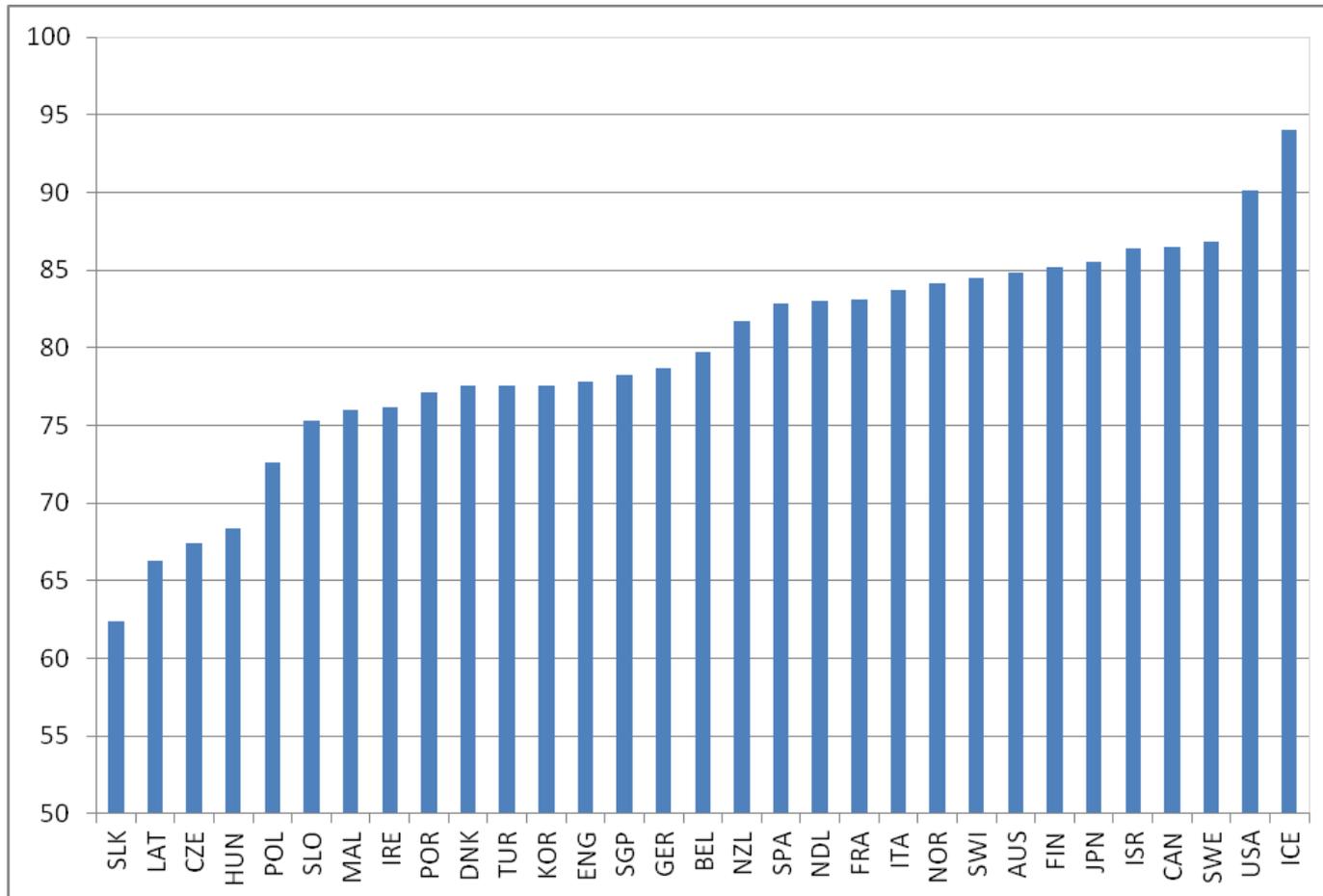
- The maturity of available **indicators** and the policy relevance of **cancer mortality** across OECD countries.
- Thorough evaluation of the functioning of the various components of national cancer care systems is of use to **policy makers** and other stakeholders.
- Exploring the system characteristics in light of variations in cancer outcomes may contribute to identifying which **practices** are amenable to higher quality cancer care and better cancer outcomes.

# Differences in cancer outcomes

- Survival rates have been constantly improving, but substantial **differences** between countries still remain:
  - the US vs Europe
  - east-west European gap
  - the UK/Denmark vs. western Europe
- Recently published studies showed significant **wealth** and **social-class gradients** with respect to cancer survival.

# Differences in cancer outcomes

Five-year relative survival of patients diagnosed with breast cancer (%) in 2000-2002



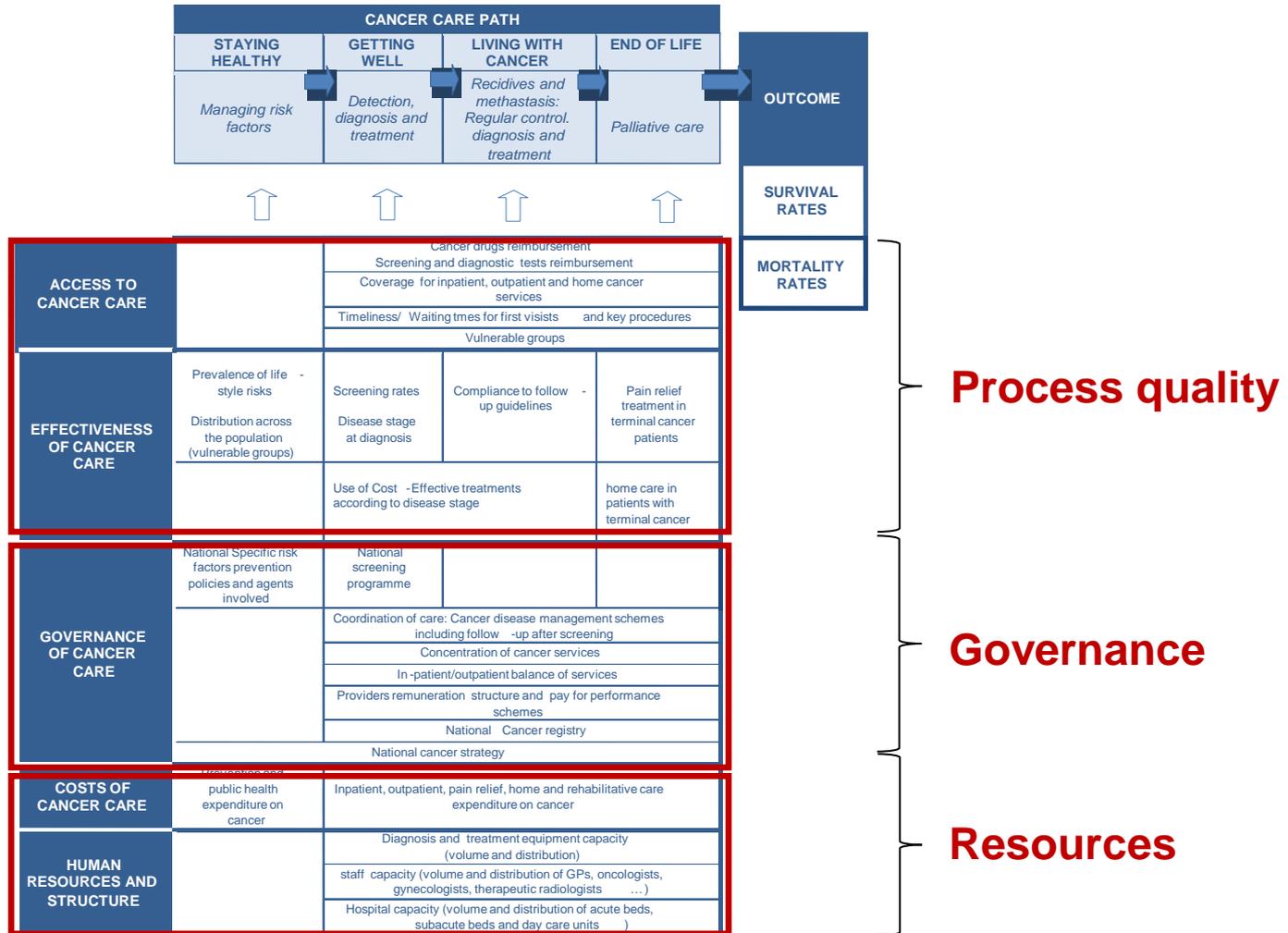
Source: EUROCORE-4 study

# Reasons behind survival differences

## *The first phase of the study (2008-2009)*

- **Endorsement** by the HCQI Expert Group and the OECD Health Committee in 2008.
- The development of a conceptual framework model including five domains of cancer care at system level.
- A **macro-level analysis** based on readily available HCQI and OECD Health Data was completed in June 2009.

# Conceptual framework model



# Macro-level analysis

- The analysis was focused on breast, cervical, colorectal and lung cancers, and survival and mortality as the outcome measures.
- This work illustrated the importance of having **national cancer control strategies** in place and highlighted the need to **investigate the institutional characteristics of cancer care systems** across countries in more detail to understand the reported differences between countries.

# Reasons behind survival differences

## *The second phase of the study (2010-2011)*

Recommendation by the HCQI Expert Group for the continuation of the work with the **aim** of:

- **Exploring the characteristics of systems of cancer care in OECD countries,**
- **Assessing the relative effect of the main domains of the system of care, in particular governance, on survival outcome of patients with breast, cervical, colorectal and lung cancers.**

# Cancer Experts network

The HCQI Experts from 38 OECD and non-OECD countries nominated national cancer data and policy experts in 2009:

**Australia, Belgium, Canada, Chile, Cyprus, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Japan, Korea, Latvia, Luxembourg, Malta, Mexico, the Netherlands, New Zealand, Norway, Poland, Portugal, Singapore, the Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Turkey, the United Kingdom (England and Scotland) and the United States.**

## Collaborating partners

The Secretariat also entered into collaboration agreements with key partners in the area of cancer:

- **Prof Michel Coleman**, Department of Non-Communicable Disease Epidemiology at the London School of Hygiene and Tropical Medicine and coordinator of the **CONCORD** study
- **Prof Andrea Micheli**, Fondazione IRCCS “Istituto Nazionale dei Tumori” (Milan), EC funded **EUROCHIP** projects
- **Dr Riccardo Capocaccia**, Istituto Superiore di Sanità (Rome), **EUROCARE** projects

# Data sources - questionnaires

The **Questionnaire on Cancer Screening** and the **Questionnaire on Systems of Cancer Care** developed by:

- using evidence of best practice from literature reviews,
- the Secretariat's experience in collecting health system characteristics information,
- feedback from our collaborating partners.

# Questionnaire on Systems of Cancer Care

- Designed to collect more detailed information on the five domains of the conceptual model: **access, governance, effectiveness, costs, and human resources/structure.**
- Emphasis was given to all phases of care involved in the natural course of cancer: **early detection and screening, diagnostic evaluation, primary and adjuvant treatment, surveillance and follow-up care.**
- **Prevention and palliative/end of life care** were exempted. The former was considered too complex to assess in a meaningful international-comparable way, and the latter was considered not having much impact on survival.

## Data sources - questionnaires

- Both questionnaires were sent to Cancer Policy Experts, the Cancer Screening at the end of 2009 and the Systems of Cancer Care in January 2010.
- Responses to questionnaires were received from January to August 2010.
- The **OECD Health Data** and **System of Health Accounts**, including Cost of Illness study, were also used.

## Data sources - interviews

- Telephone interviews were carried out with **Cancer Policy Experts** between February and August 2010.
- Each interview was carefully planned in advance:
  - thorough review of the country's response,
  - identification of topics for further discussion,
  - preparation of a list of supplementary questions supplied before the interview.
- Responses were mostly gathered via the interview and few in a written form. The final records were made on the basis of notes by both interviewers.

## Data sources – survival rates

- The age-standardised 5-year relative survival rates for breast, cervical, colorectal and lung cancers for 2000-2002 were collected through the **EUROCARE-4** study involving 26 European countries.
- The US survival data were obtained through the **US SEER** (Surveillance, Epidemiology, and End Results) programme.

## Data sources - survival rates

- The Secretariat requested the **Cancer Data Experts** from the other countries to provide survival data 2000-2003 calculated by using the same Eurocare-4 study specifications. Ten countries submitted the data: Australia, Canada, Hungary, Israel, Japan, Korea, Latvia, New Zealand, Singapore and Turkey.
- The 5-year relative survival rates for 2002-2004 were collected through the regular **OECD HCQI data collection** in January-April 2011.

## Data sources - survival rates

- The cancer survival data used in this analysis have been collected systematically using precise definitions in order to ensure representativeness and inter-country comparability.
- Relative survival was calculated by **period analysis** (Brenner, 1997) using data for adult patients aged 15-44, 45-54, 55-64, 65-74, 75+ years, diagnosed with cancer from 1996 to 2002 and followed up to the end of 2003.
- Expected survival was calculated using **Hakulinen's method** (Hakulinen, 1982).
- Age-standardised survival rates were computed using **Corazziari's method** (Corazziari, 2004).

## Independent variables – resources

- gross domestic product (GDP) in US\$ per capita adjusted for purchasing power parity (PPP),
- total national expenditure on health (TNEH),
- computer tomography (CT) scanners per 1M and GDP,
- positron emission tomography (PET) scanners per 1M people (Hastings J, 2006),
- clinical use of innovative cancer drugs such as Herceptin (trastuzumab), Avastin (bevacizumab), Aromasin (exemestane), Femara (letrozole), Arimidex (anastrozole), Evista (raloxifene), Erbitux (cetuximab), Eloxatin (oxaliplatin), Camptosar (irinotecan) and Xeloda (capecitabine)(Parkin, 2001; Wilking, 2005),
- oncologists per 1M people,
- comprehensive treatment centres per 1M people.

## Independent variables – process quality

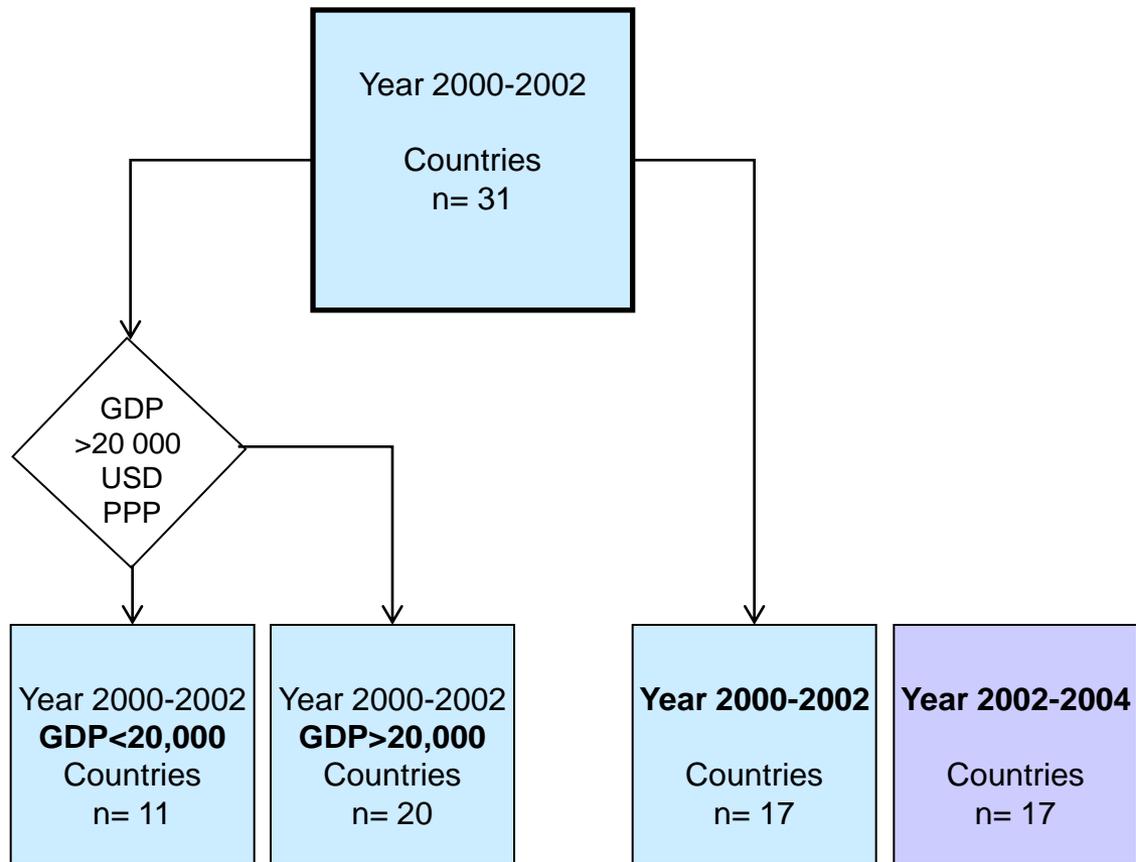
- characteristics of cancer screening program (interval, target population, low age, coverage, national rollout, provision free of charge),
- referral time (GP to specialist),
- waiting time (diagnosis to treatment),
- provision of optimal treatment (combination of surgery, radiotherapy and chemotherapy if patient is diagnosed early at a localised stage).

## Independent variables – governance

- introducing National Cancer Control Plan (NCCP),
- setting up cancer-specific targets,
- making additional funding available to achieve targets,
- assigning the lead person or organisation to oversee the implementation,
- putting quality assurance mechanisms in place,
- coordinating care and developing networks for service delivery,
- identifying the key milestones and timeframes,
- monitoring the progress,
- making someone responsible if targets are not met,
- national guidelines (screening, diagnosis, treatment),
- case management and multidisciplinary teams
- accreditation of health professionals,
- licensing of hospitals.

- Relations between variables of health system characteristics on one side and cancer survival on the other side, were investigated by **fractional polynomials method**.
- Advantages in comparison to similar techniques:
  - the use of both continuous and binary variables,
  - rigorous process for variables/function selection,
  - non-linear fitted models.

# Methods



# Methodological approach

- **Univariate fractional polynomials modelling** was used to assess relations between individual variables of health system characteristics (resources, process quality, governance) and cancer survival.
- **Multivariable fractional polynomials modelling** was performed to select the explanatory variables that best predict the outcome variable for each domain.
- **Multivariable fractional polynomials modelling** was performed by using selected variables across all domains in order to compare the actual and predicted survival based on cancer care system characteristics.

# Univariate FP modelling

- FP of degree  $m$  with powers  $p = (p_1, \dots, p_m)$  is defined as:

$$P(m) = b_1 X^{p_1} + b_2 X^{p_2} + \dots + b_m X^{p_m}$$

- The powers  $p$  are taken from a predefined set **S=(-2, -1, -0.5, 0, 0.5, 1, 2, 3)**, where  $X^0$  denotes  $\log(X)$ .
- The set includes no transformation ( $p=1$ ) and the reciprocal, logarithmic, square root and square transformations
- The FP1 function models are fitted by using each of 8 values of  $p$ .

# Univariate FP modelling

- The FP2 function models with powers ( $p_1, p_2$ ) are defined as:

$$P(m) = b_1 X^{p_1} + b_2 X^{p_2}$$

or

$$P(m) = b_1 X^p + b_2 X^p * \log(X)$$

- The latter one is the so-called repeated-powers model if  $p_1 = p_2$ .
- A total of 36 FP2 function models are fitted.
- In practice, higher order functions are seldom needed because 8 FP1 and 36 FP2 models provide a reasonable good fit in the modelling procedure.

# Variables selection

The following procedure was used to select variables and FP function (Ambler, 2001; Royston, 2005):

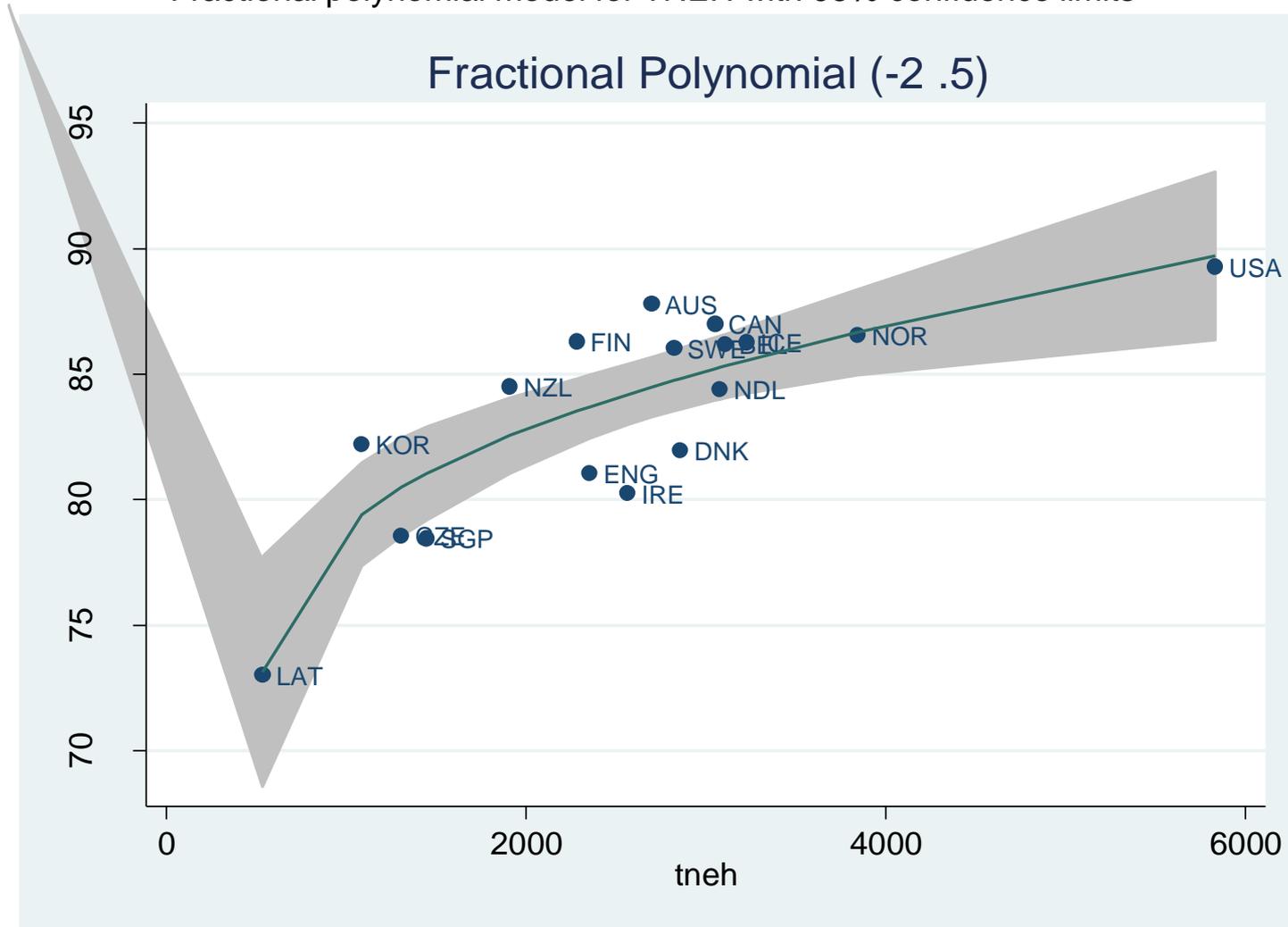
- The best fitting FP2 model was compared with one from which only  $X$  has been omitted. If the p-value from this test was not significant,  $X$  was omitted from the model.
- Non-linearity of the effect of  $X$  was tested by comparing FP2 model with linear one. The linear model was accepted if the test statistic was not significant.
- Comparison was made between FP2 and FP1 models. In the case of a not significant p-value, the simpler FP1 function was chosen, otherwise the more complex FP2 function was selected.

## Results – resources for cancer care

- **GDP** and **TNEH** are strong predictors of cancer survival across all cancer sites ( $p < 0.01$ , lung  $p = 0.08$ ).
- Adjusted coefficient of determination ( $AdjR^2$ ) shows a similar proportion of the explained variation.
- TNEH has been selected as a more specific expenditure measure of cancer health care and as a better predictor for countries with the low GDP levels.

# Results – resources for cancer care

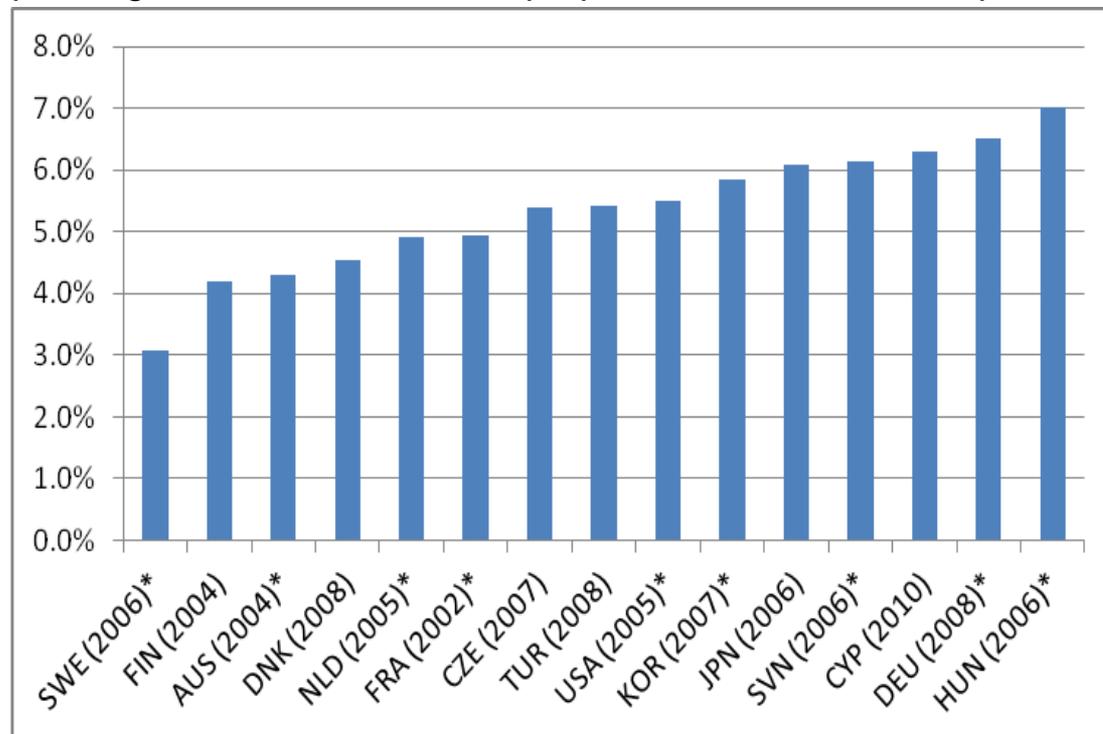
Fractional polynomial model for TNEH with 95% confidence limits



# Results – resources for cancer care

- Cancer specific expenditure data is hardly available. Despite considerable efforts to collect data, only 13 countries supplied estimates at varying levels of detail.

Spending on cancer care as the proportion of total health expenditure

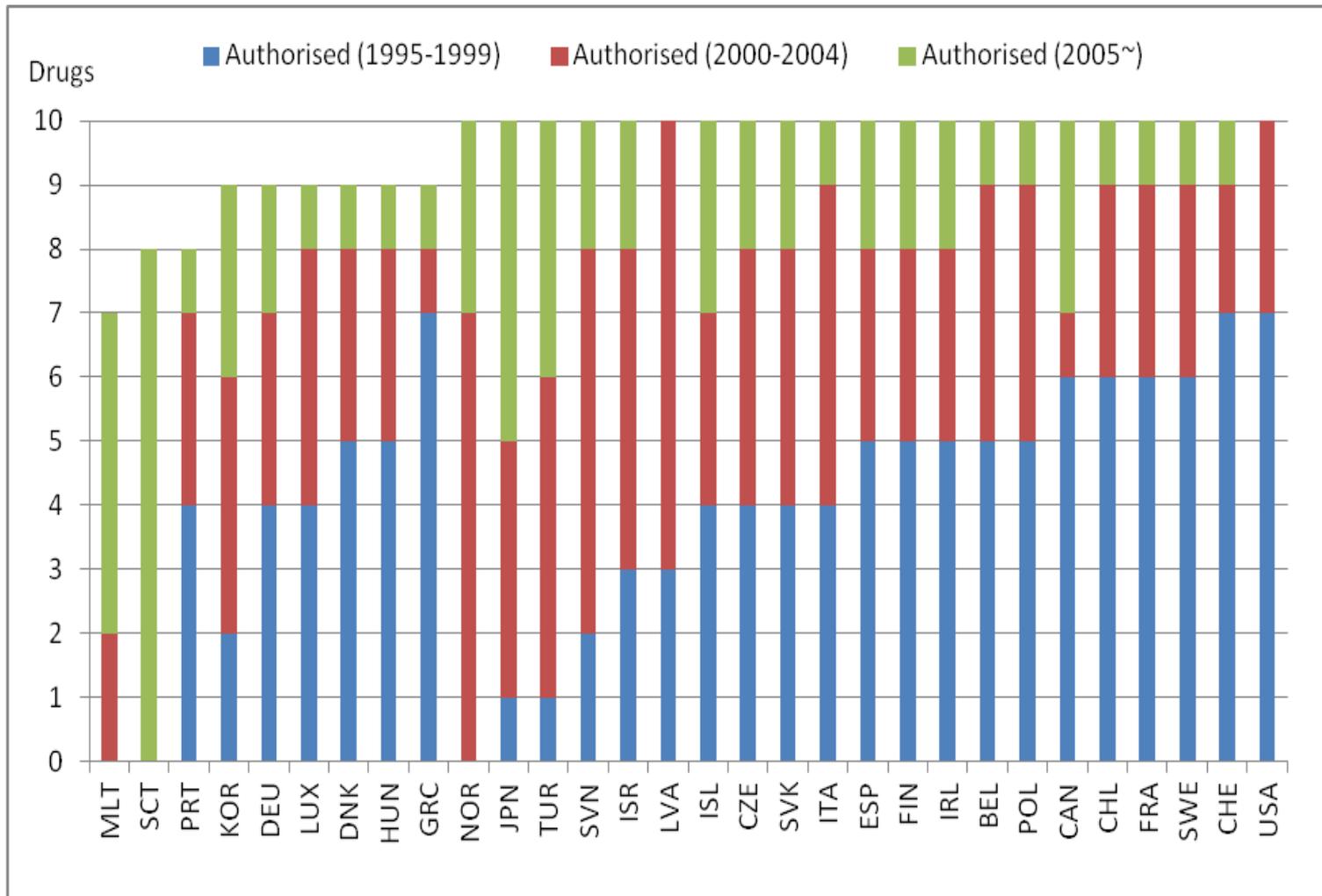


## Results – resources for cancer care

- Survival is strongly associated with the investment in **innovative drugs** for all cancers, and to a lesser extent for lung cancer.
- The availability of innovative cancer drugs appears to be a more important explanatory variable than the provision of drugs free of charge.
- There is significant correlation between the clinical use of innovative cancer drugs and survival by the countries' general income level.

# Results – resources for cancer care

## Years of authorisation for 10 selected drugs

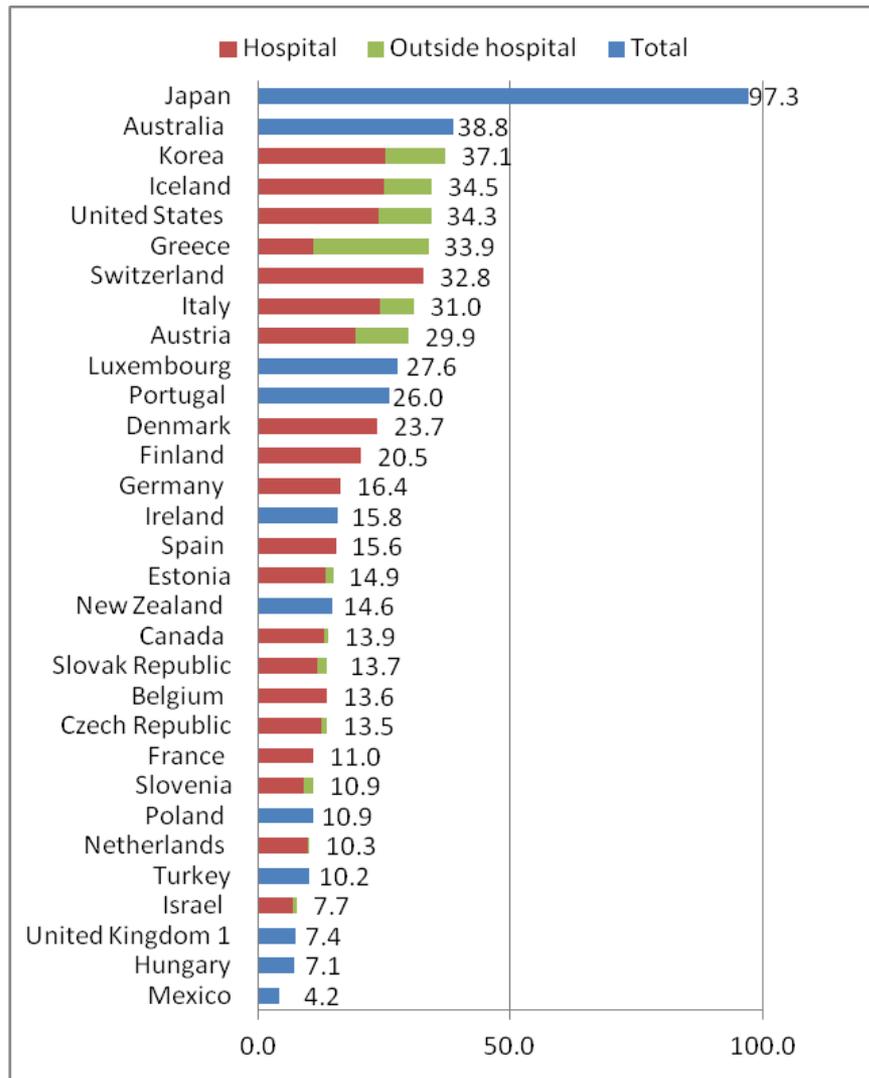


## Results – resources for cancer care

- Investment in technology (**CT scanners** divided by GDP) is also highly correlated with cancer survival in all countries, but especially in those with lower income levels (the same finding as by Verdecchia et al., 2008).
- The number of **oncologists** and comprehensive **cancer treatment centres** are more strongly correlated with survival in countries with GDP levels below US\$ 20,000 per capita (apart from oncologists in the breast cancer model).

# Results – resources for cancer care

Computed Tomography scanners, per million population, 2009



## Results – resources for cancer care

- The combination of four explanatory variables
  - **total national expenditure on health,**
  - **number of new cancer drugs in clinical use,**
  - **number of CT scanners per 1M per GDP,**
  - **number of cancer treatment centres per 1M,**resulted in models with statistically significant test statistics ( $p < 0.01$ ,  $\text{AdjR}^2 = 0.37-0.51$ ) for all cancer sites.
- This indicates that almost a half of differences in cancer survival may be explained by the available resources.

## Results – process quality of the delivery

- The following **screening programme** characteristics are used for the purpose of modelling: access to screening tests (screening interval in years), target population (age range), lower age eligibility limit, nationwide coverage, completed national rollout, and screening tests free of charge.
- Significant descriptors of an effective breast screening programme are the **national rollout** completed at least 5 years before the end of time periods used in this analyses (i.e. 1997 and 1999), **nationwide coverage**, and to a lesser extent screening intervals.
- The most robust descriptor of the cervical screening programme is also an early national rollout of the programme.

# Results – process quality of the delivery

Multivariable model for breast screening programme characteristics

Source	SS	df	MS	Number of obs =	31
Model	538.94675	3	179.648917	F( 3, 27) =	4.93
Residual	983.348757	27	36.4203243	Prob > F =	0.0074
Total	1522.29551	30	50.7431836	R-squared =	0.3540
				Adj R-squared =	0.2823
				Root MSE =	6.0349

surv5brst	Coef.	Std. Err.	t	P> t	[95% Conf. Interval]	
scrb_int	6.413598	4.516125	1.42	0.167	-2.852724	15.67992
scrb_pop	7.756599	3.299338	2.35	0.026	.9869173	14.52628
scrb_r97	7.164	2.844891	2.52	0.018	1.326765	13.00123
_cons	65.5614	5.431433	12.07	0.000	54.41702	76.70578

## Results – process quality of the delivery

- The access to cancer care services was assessed by the average **referral time** (from primary care physician to specialist) and **waiting time** (from diagnosis to initial treatment).
- The waiting time below 30 days appears to be a more robust predictor of survival with significant test statistics ( $p < 0.05$ ) for breast and colorectal cancers.

# Results – process quality of the delivery

Average waiting time between cancer diagnosis and initial treatment, latest year available

	Breast cancer	Cervical cancer	Colorectal cancer	Lung cancer	All cancers
Canada	30 days (Median)	20 days (Median)	21 days (Median)	29 days (Median)	25 days (Median)
Cyprus	17 days	11 days	8 days	10 days	11 days
Czech Republic*	weeks not months	weeks not months	weeks not months	weeks not months	weeks not months
France	26 days	-	-	20 days	-
Germany	7 days	7-14 days	7-14 days	7-14 days	7-14 days
Iceland*	1-4 days	1-4 days	1-4 days	1-4 days	1-4 days
Israel	Radiotherapy: 15-45 days	Radiotherapy: 15-45 days	Radiotherapy: 15-45 days	Radiotherapy: 15-45 days	Radiotherapy: 15-45 days
Japan*	same day-weeks	same day-weeks	same day-weeks	same day-weeks	same day-weeks
Korea	31.1 days	19.2 days	51.3 days	38.7 days	48.7 days
Luxembourg*	<3 days	<3 days	<3 days	<3 days	<3 days
Latvia	30 days (Median)	30 days	30 days	30 days	30 days
Malta*	weeks not months	weeks not months	weeks not months	weeks not months	weeks not months
Netherlands	25 days	15 days	10-50 days (up to 1st treatment for rectum or colon cancers)	21 days	approx. 40 days
Norway*	2-4 weeks	-	-	-	-
Poland	3-12 weeks	3-6 weeks	4-8 weeks	4-6 weeks	4-6 weeks
Scotland	24 days	-	23 days	25 days	-
Slovak Republic	7-21 days	7-21 days	7-21 days	7-21 days	7-21 days
Slovenia*	3-6 months	3-6 months	2 months	2 months	-
Sweden	19 days	weeks not months	weeks not months	weeks not months	weeks not months

## Results – process quality of the delivery

- The proportion of patients who received **optimal treatment** (combined surgery, chemo- and radio-therapy), if diagnosed at an early/localised stage, is seldom published, hence primarily based on anecdotal evidence provided by cancer experts.
- The provision of optimal treatment is strongly associated with the survival outcome with significant p-values across all four cancer sites.
- This is more notable in the case of countries with the lower level of GDP per capita.
- Information on the **level of compliance** with the agreed guidelines is rarely available.

## Results – process quality of the delivery

- The combination of
  - **screening programme characteristics,**
  - **waiting time from diagnosis to initial treatment,**
  - **reported provision of optimal treatment,**resulted in models with statistically significant test statistics ( $p < 0.01$ ) for all cancers apart from lung.
- The process quality of the delivery of cancer care may explain approximately one third of differences in cancer survival.



## Results – governance

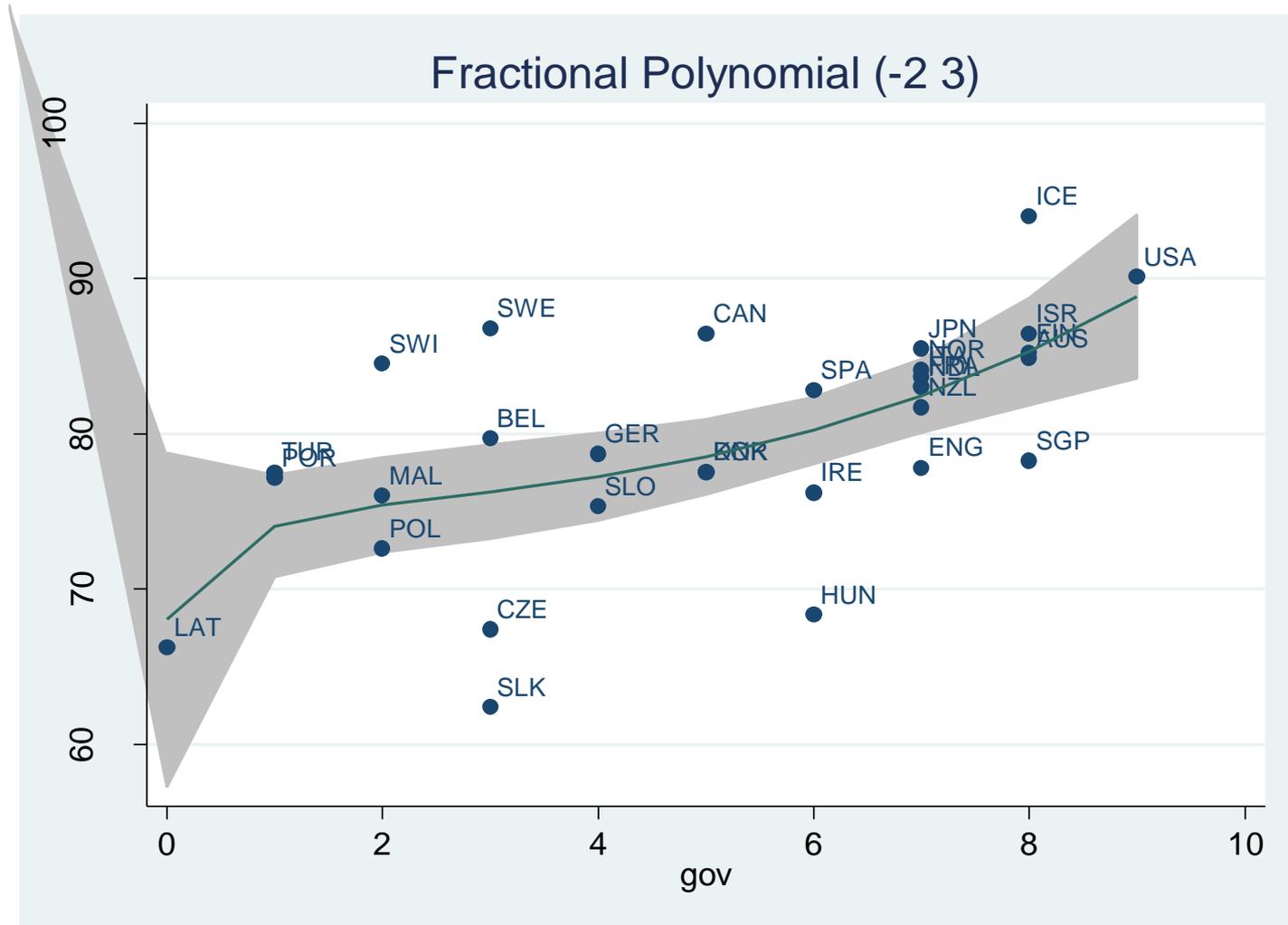
- Instead of using only NCCP's as an independent variable, it has been explored whether improved health outcomes could be achieved by incorporating certain characteristics into national cancer policies:
  - setting up cancer-specific **targets**,
  - making **additional funding** available to achieve these objectives,
  - assigning the **lead** person/organisation to oversee the implementation,
  - putting **quality assurance** and control mechanisms in place,
  - **coordinating** care and developing networks for service delivery,
  - identifying the key milestones and **timeframes**,
  - **monitoring** the progress, and
  - making someone **responsible** if objectives are unmet.

## Results – governance

- The following nine characteristics were most commonly associated with an effective cancer care system and good survival outcome:
  - implemented NCCP,
  - cancer specific targets,
  - stewardship,
  - timeframes,
  - monitoring,
  - guidelines,
  - case management,
  - coordination,
  - quality assurance.
- Based statistically significant test statistics and high adjusted coefficient of determination.

# Results – governance

Fractional polynomial model for breast cancer governance characteristics



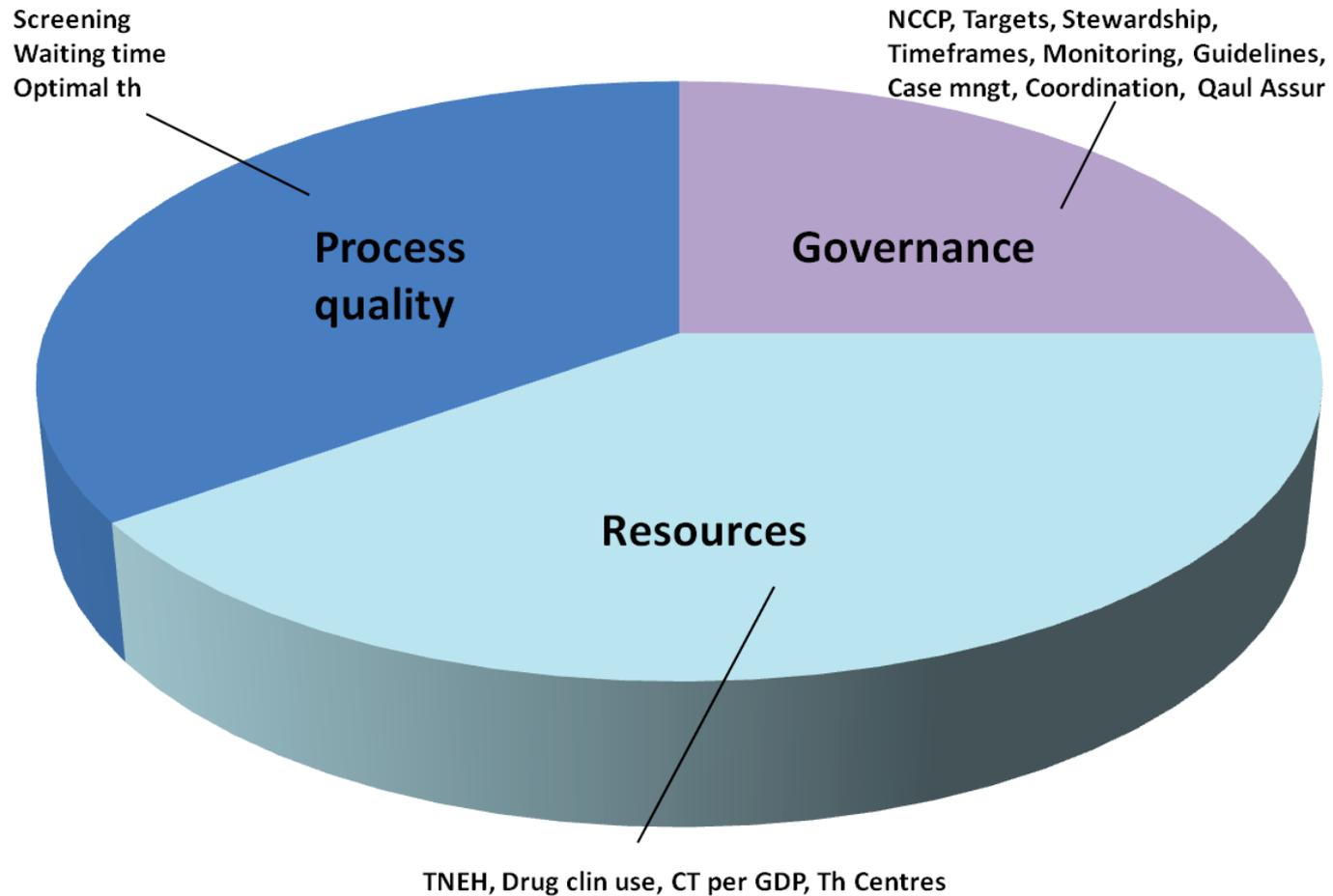
## Results – governance

- By comparing the difference between two time periods, the results indicate that setting up cancer-specific **targets** and **timeframes**, **monitoring** progress and ensuring that **guidelines** and **quality control** are put in place, are the most important elements of the cancer control during the initial phase.
- Fully implemented **NCCP**, assigned **lead person or organisation**, someone made **responsible** for achieving targets and ensuring **coordinated care delivery** are relevant elements of the cancer control during the later phase.

## Results – governance

- The combination of the nine most **relevant policy characteristics** resulted in models with statistically significant test statistics ( $p < 0.05$ ) for breast and colorectal cancers.
- According to the results of modelling, approximately one quarter of differences in cancer survival may be explained by governance.

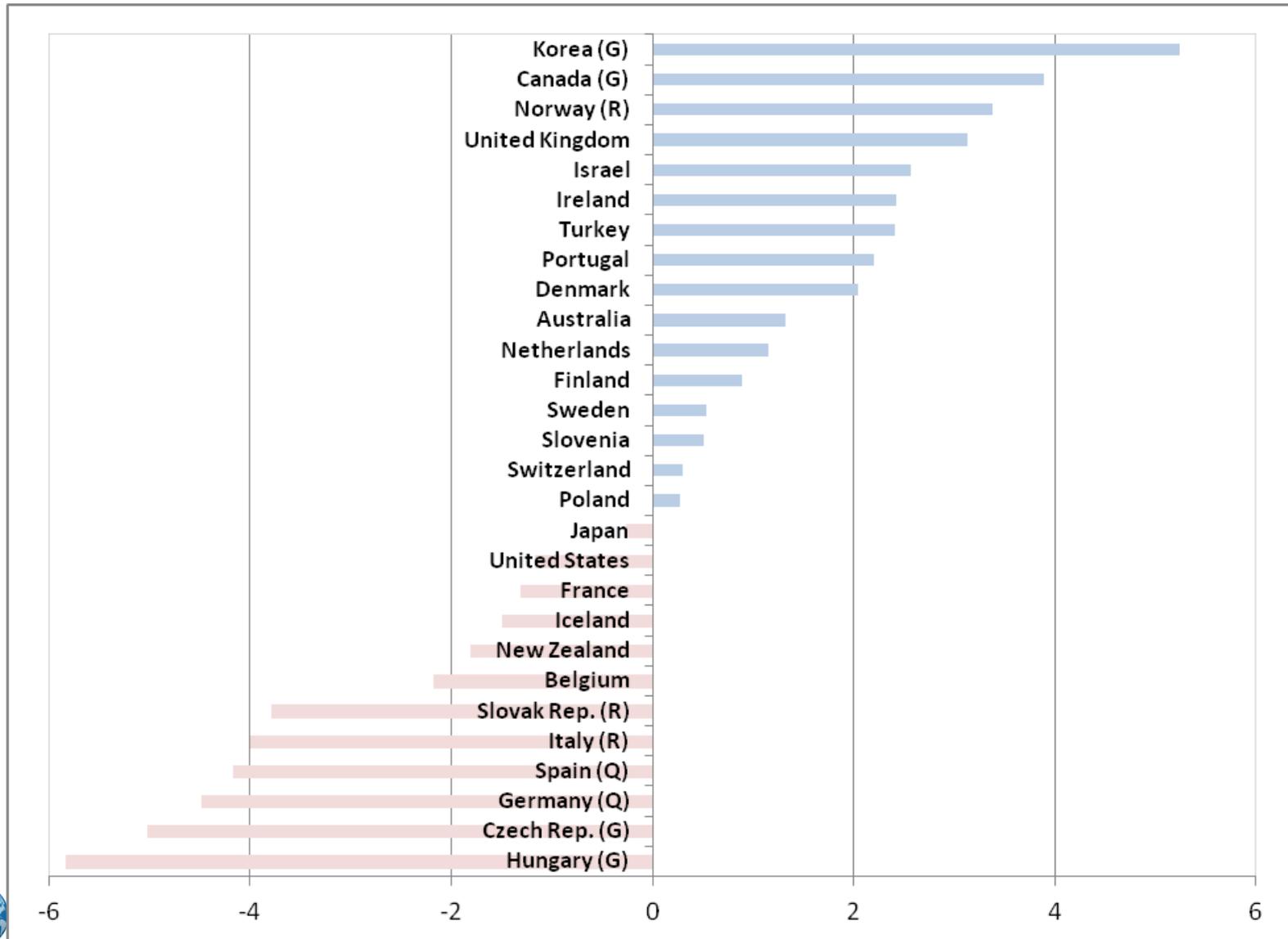
# Results



# Actual vs. predicted survival

- The predicted value of the five-year relative survival rate is calculated on the basis of fractional polynomial models including all best predictors across three major domains.
- The difference is positive if the 5-year relative survival rate is higher than the predicted one and vice versa.
- The domain of major interest in terms of positive or negative performance of health care system is shown in parenthesis for each country (R=resources, Q=process quality, G=governance) if the difference is  $>2$  SE of the estimate.

# Actual vs. predicted survival – cervical cancer



# Actual vs. predicted survival – cervical cancer

	<b>CZE</b>	<b>KOR</b>
TNEH	1086	919
CT_GDP	69	158
THC	1.76	0.69
OPTH	<80%	>80%
NCCP	2004	1996
TARG	No	Yes
TIMEFR	No	Yes
MONIT	No	Yes
5-yr RSR	<b>57.6</b>	<b>74.5</b>
5-yr Pred	<b>62.6</b>	<b>69.2</b>

# Actual vs. predicted survival – colorectal cancer

- The results indicate that countries with a high performing system of cancer care achieve that by focusing mainly on good governance and to a lesser extent to resource input.
- On the other side, “underperforming” countries exhibit issues evenly in the areas of governance and process quality.
- Governance of cancer control, according to these findings, is likely to be of relevance to all countries.

## Closing remarks

- Cancer **survival varies** substantially across countries.
- This reflects the **performance** of the health system.
- **Policy** choices can lead to improved survival rates, but careful identification of which policies matter is necessary if policy makers are to make optimal choices.

## Closing remarks – cont.

- Valuable information has been gathered from the questionnaires, follow-up interviews with cancer experts and additional bespoke data by means of this explorative work.
- The result of this work sheds light on the underlying features of cancer care systems that are associated with cancer outcome variations across 38 OECD and non-OECD countries.

## Closing remarks – cont.

- A significant proportion of variation in cancer survival can be explained by the three domains of resources, process quality and governance.
- All three broad domain groups appear to be significant and some **elements** within domains seem to be particularly important.

## Closing remarks – cont.

- Survival is strongly related to wealth and the level of health investment, especially for lower income countries.
- The relationship between extra resources and better outcomes is weaker once a reasonable **resourcing level** has been reached.

## Closing remarks – cont.

- The **better-performing** richer countries with better cancer survival outcomes have established cancer policy priorities, implemented key elements of cancer control, introduced integrated care processes and actively worked on the delivery of cancer services.
- The analysis suggests which aspects of these domains are particularly important.

## Closing remarks – cont.

- There are a number of **weaknesses** in the work, which imply an agenda for getting better information on outcomes and relevant policies in the future:
  - the need for more **up-to-date survival** data,
  - survival rates estimated by using **period** analysis,
  - **staging** information at the time of diagnosis,
  - information on **waiting times**,
  - the level of **compliance** with guidelines,
  - **cancer-specific expenditure** data (SHA project)
  - information on **screening** programmes (colorectal)

## Future directions

- More detailed analyses could be undertaken by using a **subsample of countries** that already have a centralised monitoring and evaluation system (cancer registry, staging data) and the ability to provide **more specific data** on the key independent variables as they become available.
- Further **in-depth analysis** of the characteristics of the cancer systems that have empirically demonstrated to improve survival outcomes.

# Final report

- The paper presents *preliminary* findings and conclusions of analytical work for further discussion.
- The **table of content** of the final report is added to the paper as an appendix.
- A draft version of **Chapter 3** of the final report, including a systematic description of the main characteristics of the systems of cancer care, is made available as a room document.
- The **final report** is planned to be finalised later this year.

Members of the HCQI Expert Group are invited to

- ***Discuss*** the findings of the analysis,
- ***Make recommendations*** for the continuation of the work,
- ***Make recommendations*** on the set-up of the final report.