Life and Health Actuarial Pricing: a Biostatistics Approach

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Outline

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Context I

- It is generally thought that patients having suffered from a cancer have a lower probability of survival compared to healthy people
  - Due to this aggravated risk and the relatively small number of patients wishing to take out insurance coverage in case of death, the insurance industry is reluctant to grant such a guarantee
  - In Belgium, charging clients based on health is legal and clients must declare if they have cancer
- However, survival and life expectancy of cancer patients have been increasing over the last decades
  - And we can reasonably assume that they will keep increasing in the future thanks to medical and technological progress
- In regard to this, France passed a law referred as "the right to forget" (Sapin and Touraine, 2017)

Context II

- That is, the right for a person subscribing to a contract not to declare a previous cancer after a period of 10 years after the end of the therapeutic protocol
- This period being reduced to 5 years if the person is a minor
- But some questions remain:
  1. The thresholds of 10 and 5 years are arbitrary and does not reflect survival of the diseased persons
  2. There remains some ambiguity about what is considered as treatment → what marks the end of a therapeutic protocol? → when the patient will start to benefit from this right?
  3. (This right is very binary and not flexible at all)

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Aims

- The aim of the project is twofold:
  1. To develop a method to adequately estimate the threshold after which cancer patients can be considered as cured, and
  2. To find a proper way to adapt the actuarial pricing of life insurance products to each category of risk, disease, person, etc.
- The goal is also to demonstrate that for some types of cancer, the survivors actually have a chance of survival comparable to that of the general population, or pose a moderately increased risk and could therefore be covered in the event of death
- This involves measuring and quantifying the potential excess mortality so that the premiums claimed reflect the risk in terms of financial services

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Significance

- Cancer is one of the leading causes of death in OECD countries and in 2013, 25% of death are cancer related (OECD, 2015)
- Still in OECD countries, about 5% of the total health cost involves cancer and the financial burden of cancer is growing in most countries due to[1]
  1. increasing incidence (*i.e.*, more people are diagnosed with cancer and at earlier stage)
  2. prolonged survival (*i.e.*, decreasing cancer mortality and population aging)
  3. high medical costs
- Insurance companies are threatened through more benefits paid to more patients

[1] Yue et al. (2017).

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Data

- Data from the Belgian Cancer Registry (BCR)
- Focus on patients from 20 to 40-50 years old
  - Age range when people are most likely to take a loan
  - Older than that, non-cancer related deaths increase substantially and older people are less likely to start looking for financial services
- Focus on 2-3 cancers (which ones still to be determined) Criteria are:
  - High number of incidences, with a significant share occurring before the age of 40
  - Cancers with a relatively high survival rate or high cured rate
  - "Well-known" to the public

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Relative survival

- Defined as the ratio of the observed survival of the cancer patients to the expected survival of a comparable group from the population (Dickman et al., 2004):

$$r(t) = \frac{S(t)}{S^*(t)} \quad (1)$$

- Pros and cons:
  + Standard measure of patient survival for population-based cancer registries so well documented in the literature
  + No need to know the cause of deaths (which is often inaccurate or unavailable)
  - Dependent on factors such as changing diagnostic criteria and improved diagnostics methods → impossible to compare relative survival across time (Lenner, 1990)
  - Dependent on the mortality of the general population → not suitable for cross-country comparisons (Perme et al., 2012)

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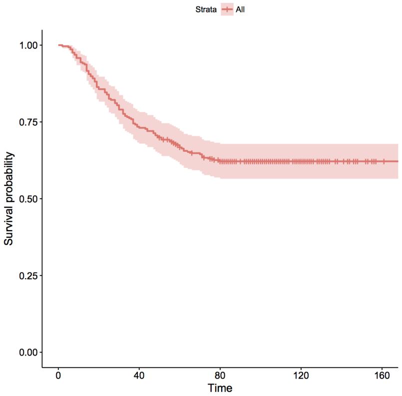
Cure models

- Cure models refer to survival models when a fraction of the subjects will never develop the event of interest (death from cancer in our case)
- Illustrated by a "plateau" in the tail of a survival function.[2] This plateau corresponds to cured subjects:

[2] Data from Wang et al. (2005).

Cure models: example

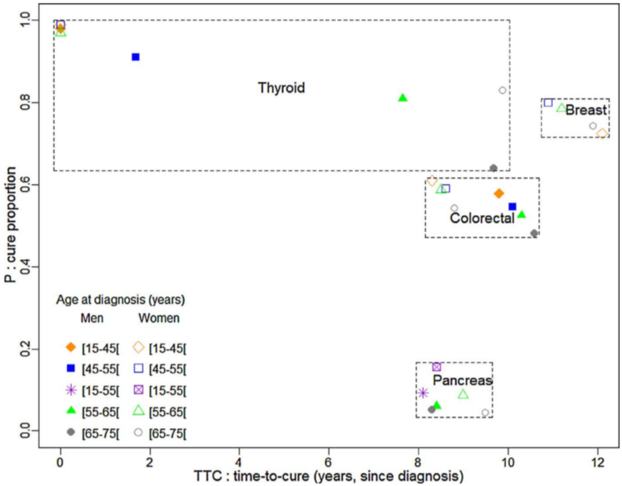


Time-to-cure

- More recently, Boussari et al. (2018) use cure models to estimate the time-to-cure (TTC), that is, the time from which the probability of being cured reaches 95%; $P(t) > 95\%$[3]

[3] $P(t)$ denoting the probability of being cured at a given time t after diagnosis.

Results from Boussari et al. (2018) I



Results from Boussari et al. (2018) II

- Thyroid: for men aged < 45 and women < 65, $P(t)$s were $> 95\%$ just after diagnosis so the estimated TTC was 0 (+)
- Breast (women only): TTC is between 11 and 12 years after diagnosis, which is above the threshold of 10 years currently applied (-)
- Colorectal: for all women, TTC was slightly below 10 years (+), whereas for all men, TTC is slightly above 10 years (-)
- Pancreatic: Regardless of age, TTC was 9 years for women and 8 years for men (+)

Discussion about these results

- Main advantage: TTC is a useful (and simple) indicator to set the time after which a cancer patient should not be penalized anymore (i.e., how many years before the "right to forget" should be applied?)
- On the other hand, we see a short TTC for aggressive cancers such as pancreatic cancer and a long TTC for less aggressive and more common cancers such as breast cancer. Is this what we want?

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Loss of expectancy

- Measured as the difference between the life expectancy if the patient had not been diagnosed with cancer (estimated using mortality data for the general population) and the observed life expectancy for cancer patients (Andersson et al., 2013)
- The loss of expectancy is then:

$$\# \text{ years lost} * \text{"value" of life (e.g., annual salary, etc.)}$$

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Esteve et al. (1990) model I

- We have seen that relative survival is helpful because we do not need the cause of death
    - However, we cannot use it for comparisons between populations and time due to its dependencies on the mortality of the general population and changing diagnostics methods
- Net survival (defined as a measure of patient survival corrected for other causes of death (Dickman et al., 2004)) allows such comparisons but cause of death is needed
- Another option would be to estimate net survival using relative survival
    - However, it is not suitable for populations which lack homogeneity in covariates because it influences either net survival or mortality from other causes
- Alternatives have been proposed to correct this bias (Hakulinen, 1977, 1982)

Esteve et al. (1990) model II

- But these methods still overestimate long-term net survival for groups with heterogeneous life expectancies

- Esteve et al. (1990) proposed a maximum likelihood method for computing net survival when causes of death are not known (or inaccurate) and populations to be compared have different life expectancies

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Combination of two approaches

- Another possibility would be to combine Esteve et al. (1990) model with the TTC from Boussari et al. (2018)

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Conclusion

- This research project attempts to:
  1. Develop a method to adequately estimate the threshold after which a patient can be considered as cured, and
  2. Find a proper way to adapt the pricing of financial services to each category of risk, disease, person, etc.
- The most appropriate approach still has to be chosen among the ones considered: relative survival, cure models, loss of expectancy, Esteve et al. (1990) or a combination of two
- We will start soon with cancer registry data provided by the Belgian Cancer Registry

Thank you!

Questions?

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