# Pseudo-Individual Predictions as Interventional Health Programs - Shattering the Individual into Data Points

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# Motivation

- We like to predict outcomes in health care
- Prediction is becomming even more prevalent
  - Due to more advanced maschine learning models available
  - Due to larger and more comprehensive data sets
  - Due to computational developments making frequent / on-demand predictions feasible
  - Because practioneers, politicians and patients like predictions
- But this carries risks as different prediction aims
  - Differ in precision and reliability
  - Differ in balance between risks and gains

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# Four levels of aims for prediction models

- Modelling the population to predict on population level
  - Example: Extending time trends in diabetes incidence, taking into acount demographic change
- Modelling the individual to predict on population level
  - Example: Predict expected characteristics of future cancer diagnoses in an area, based on individual level registry data
- Modelling the individual to decide individual diagnoses
  - Example: Predicting osteoporotic fracture risk to refer to DXA scan
- Modelling the individual to decide individual intervention
  - Example: Predicting effect of drug to decide on chemotherapy choice

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# Modelling the population to predict on population level

- Classical modelling of time trends in epidemiology and demographics
- Often regression models or time-series approaches
- We have been good in these predictions for decades
- Examples
  - Predicting trends of incidence and prevalence of diseases
  - Population forcasts for fertility and mortality
- Risks are mainly:
  - Unexpected changes / shocks in time trends
  - Extrapolation to non-representative populations
  - Assuming the population trend holds for subgroups

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# Modelling the individual to predict on population level

- Utilizing detailed individual data to predict expected outcome on a group level
- Regression models, but in priciple also other types of models
- The model might provide individual predictions, but we do not use those
- Examples:
  - Predict expected case numbers for different hospitals based on nearby population characteristics
  - Predict changes in population based on very detailed fertility forecasts
- Risk are mainly:
  - Do the subgroups meaningfully stratify the population for the application
  - Extrapolation to the future may overlook population changes

# Modelling the individual to decide individual diagnoses

- Developing prediction models with the aim of diagnosing diseases or identifying risk factors
- Regression models or machine learning models
- Has been possible for long time, but increasingly used in practice the last years
- Examples
  - Identify individuals at high risk of osteoporosis for referral to DXA scanning
  - Risk-stratify diabetes patients to decide on frequency of follow-up visits
- Risk are mainly:
  - Systematic bad performance in subgroups
  - Undesirable balance between sensitivity and specificity
- False positives: Mostly benign, but depending on diagnostic procedure and resource use
- False negatives: Undesirable, but similar to the program not existing

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# Modelling the individual to decide individual intervention

- Developing prediction models with the aim of active intervention
- Regression models or machine learning models
- Not very common yet, but many suggestions
- Examples
  - Identify individuals at high risk of osteoporosis for pharmacological treatment
  - Predict expected effect of chemotherapy to decide on cancer treatment
- Risk are mainly:
  - Mispredicting atypical patients
  - Undesirable balance between sensitivity and specificity
- False positives: Problematic due to initiating unecessary treatment
- False negatives: Problematic due to withholding treatment

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# The counterfactual question on the models existence

- How many and which patients would be better / worse off, if the model did not exist?
- Mathematically: False positives (FP), false negatives (FN)
- But the weight / utility / loss can be very different between FP and FN
- And very different between different individuals or subgroups
- Ofen not entirely clear, what to compare with:
  - Guessing: Worst case, not very realistic
  - Oracle: Best case, not at all realistic
  - Current practice (often reasonable, but might not be future-proof)
  - Other suggested approaches (reasonable, but hard in practice)

# Conclusions and perspectives

- Prediction models have very different aims
- And those aims strongly influence the risks involved
- Be aware and communicate the aim of your model
- Reevaluate risks and utilities, when extending the aim

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# Thanks for listening

Questions and discussions