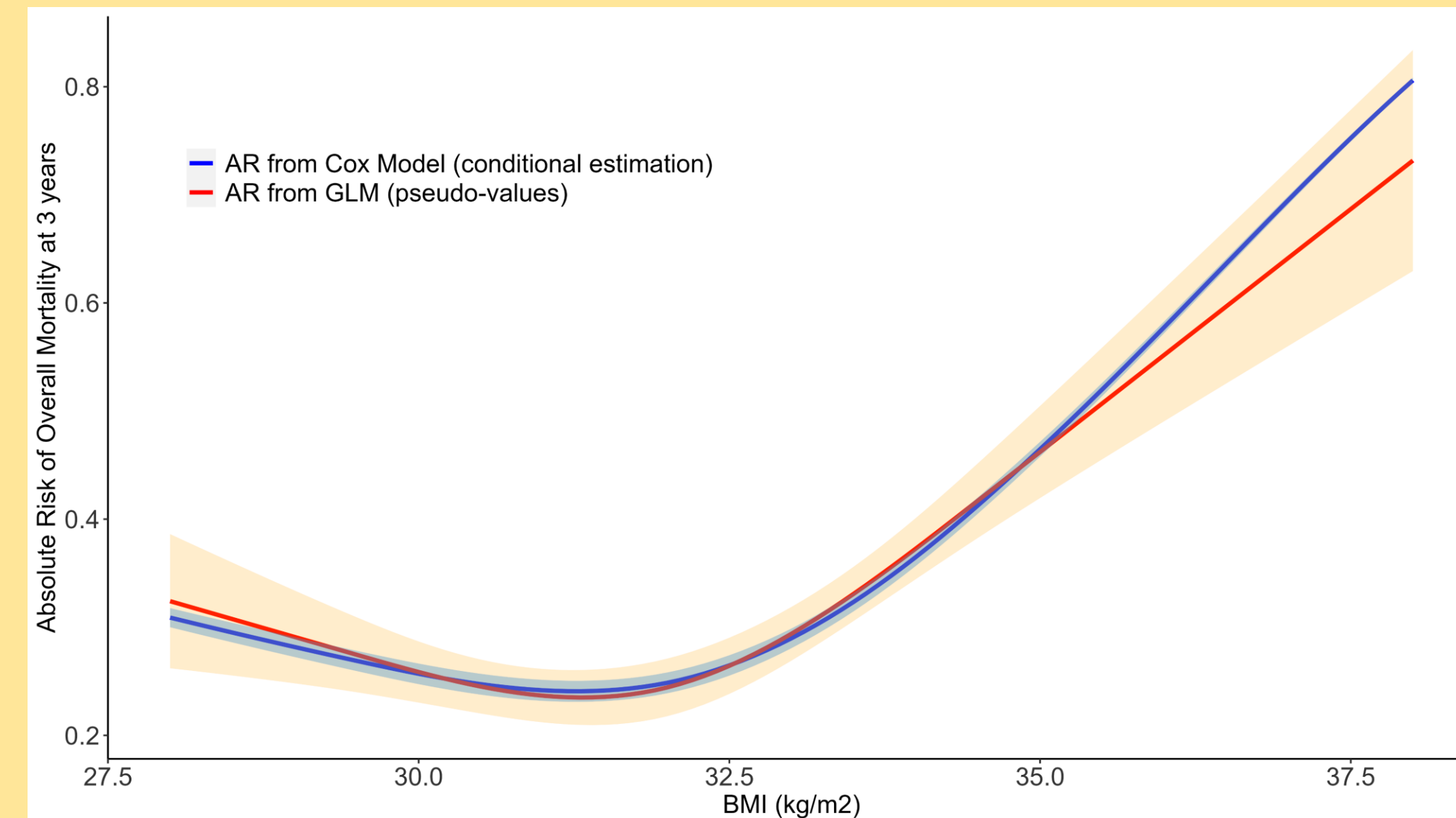
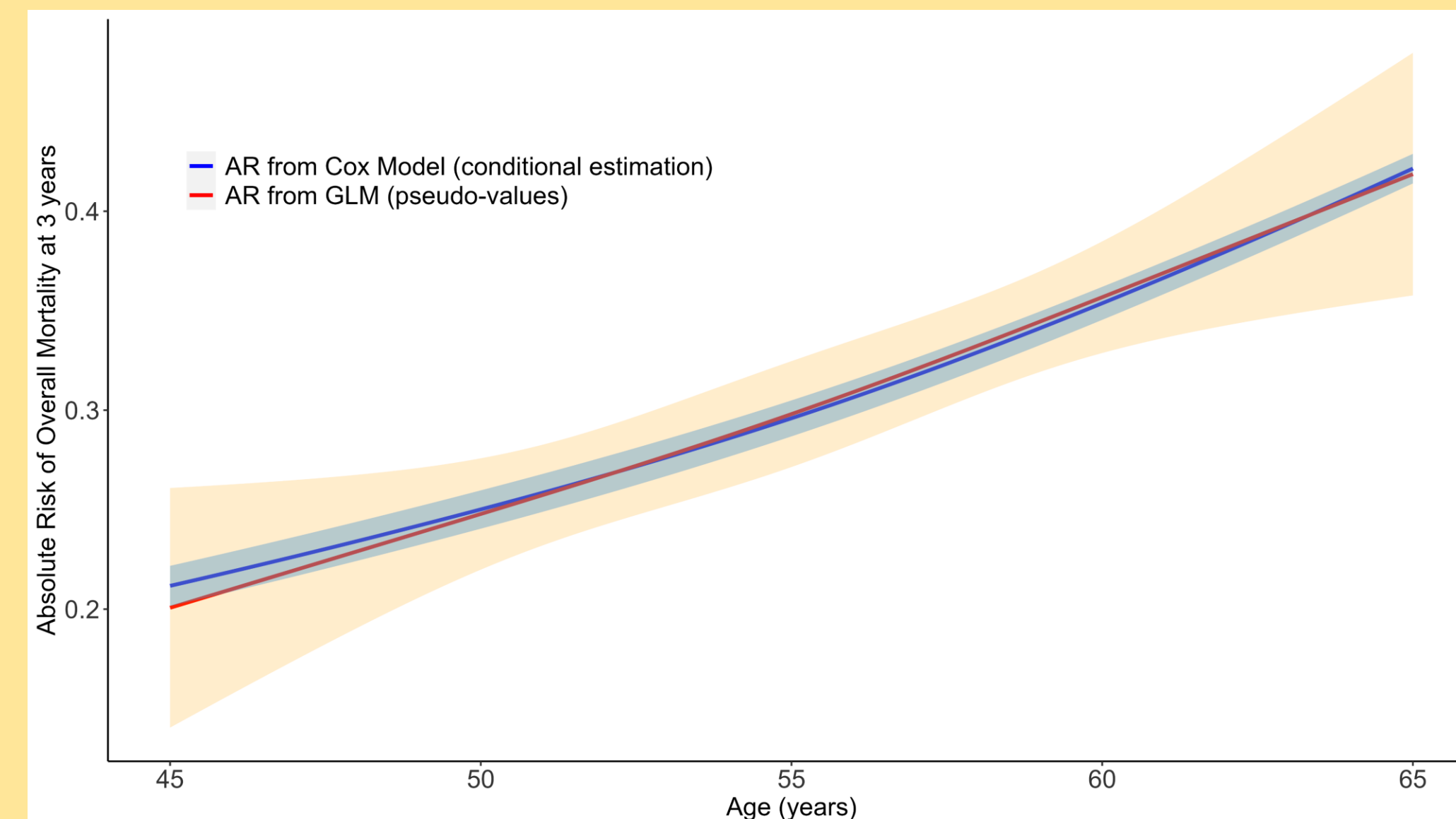


## INTRODUCTION

- Absolute Risks (AR, or event probabilities), represent a clinically relevant measure in survival analysis that should complement HRs in regular practice
- Splines transformations are recommended to incorporate potential non-linearities when evaluating continuous covariates in regression models
- We reviewed current approaches for estimating time-specific ARs from statistical models, and extended SAS and R material to flexibly account for non-linearities



**Figure.** Absolute Risk of Overall Mortality at 3 years over levels of age (upper panel) and BMI (lower panel), modeled with restricted cubic splines in a Cox model (blue lines) and GLM model with pseudo-values (red line), in a simulated population.



**Contact:** [mgpalazzolo@bwh.harvard.edu](mailto:mgpalazzolo@bwh.harvard.edu)  
[timi.org/biostatistics](http://timi.org/biostatistics)

### References:

- 1Sjölander A. Estimation of causal effect measures with the R-package *stdReg*. EJE. 2018.
- 2 Gerds TA et al. Absolute risk regression for competing risks: interpretation, link functions, and prediction. Stat in medicine. 2012.
- 3 Sachs MC, Gabriel EE. Event history regression with pseudo-observations. Journal of Statistical Software. 2022
- 4 Klein JP, et al.. SAS and R functions to compute pseudo-values for censored data regression. Computer methods and programs in biomedicine. 2008

## Table: R and SAS function to estimate Absolute Risks from statistical models

<b>Risk prediction after regression modeling of the hazard</b>	<b>R:</b> <ul style="list-style-type: none"> <li>• <code>predict</code> functions from <code>survival</code> and <code>rms</code> packages</li> <li>• <code>predictSurvProb</code> from <code>pec</code> package</li> <li>• <code>stdReg</code><sup>1</sup></li> </ul>
	<b>SAS:</b> <ul style="list-style-type: none"> <li>• PROC PHREG (BASELINE)</li> <li>• %ANALY_PHREG_RCS*</li> </ul>
<b>Direct modeling of absolute risk</b>	<b>R:</b> <ul style="list-style-type: none"> <li>• <code>eventglm</code> (GLM with PV)<sup>2</sup></li> <li>• <code>riskRegression</code><sup>3</sup></li> </ul>
	<b>SAS:</b> <ul style="list-style-type: none"> <li>• Original macro for pseudo values<sup>4</sup></li> <li>• Extension: %ANALY_PSEUDO_RCS*</li> </ul>

\* SAS macros developed by the Authors and downloadable using the QR code link

## CONCLUSIONS

- Several R packages are available to estimate AR with different modeling techniques
- We extended some of the available software to include splines modeling and flexible display of AR, and developed a new set of SAS macros
- Future work will include incorporating interactions with flexible transformation and their estimation on the risk scale
- Tools are available to present results in terms of both hazard and risk after multivariable adjustment in survival analysis

## ILLUSTRATIVE EXAMPLE

- Simulated data on 10,000 individuals with 3 years of follow-up. Data based on Weibull distribution; age has a log-linear effect while BMI has a quadratic effect on overall mortality.
- The figure show an example of splines modeled using a flexible display of time-specific AR for both a linear (panel A) and non-linear (panel B) example. Scan QR code for simulation details
- SAS macro and R code for flexible estimation of ARs available online (scan QR code)