



# From Survival Analysis to Projecting Disability Payments

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# Introduction



# Group disability insurance





# Group disability insurance





# Group disability insurance





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# Group disability insurance







# Group disability insurance



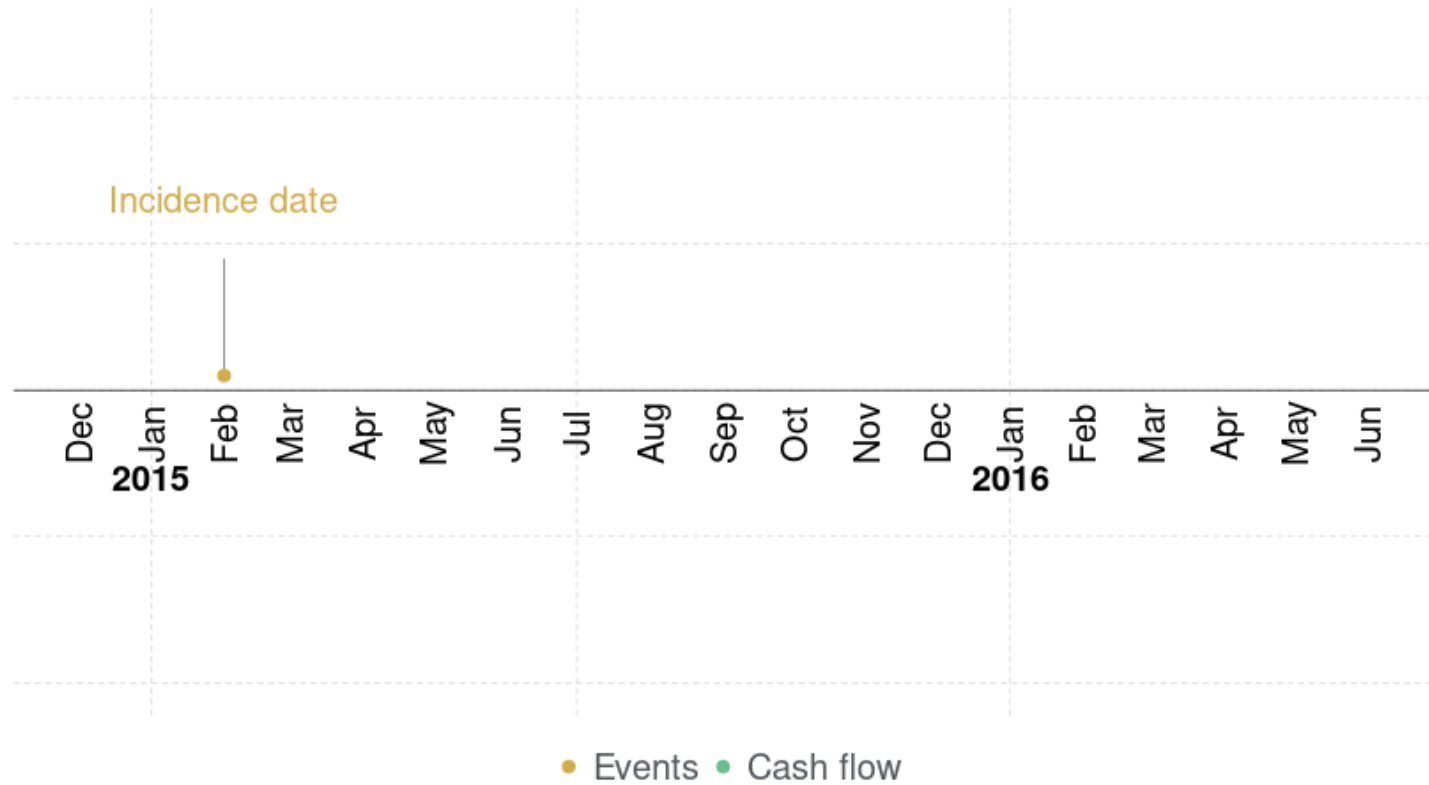


# Group disability insurance



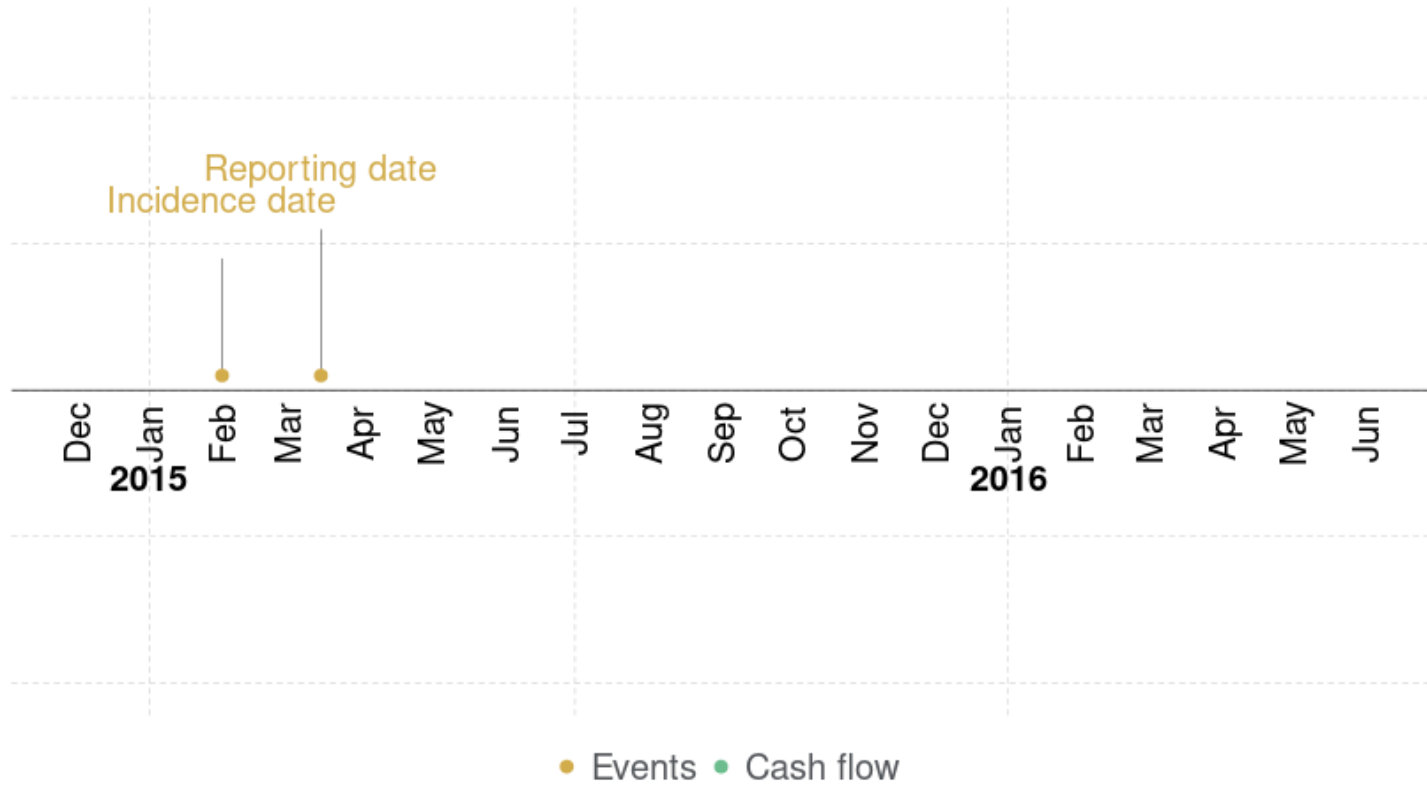


# Disability insurance: Classic claim unwinding



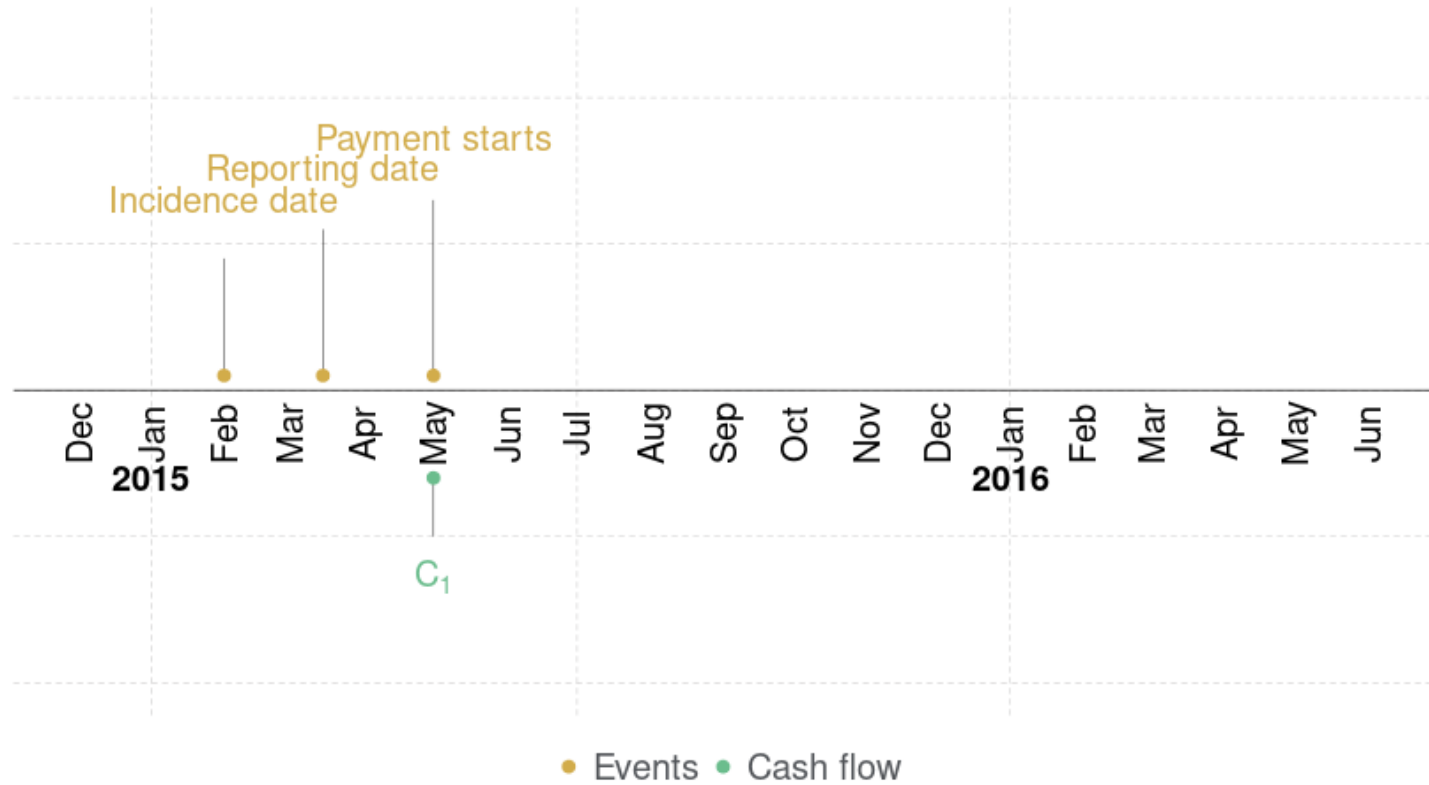


# Disability insurance: Classic claim unwinding



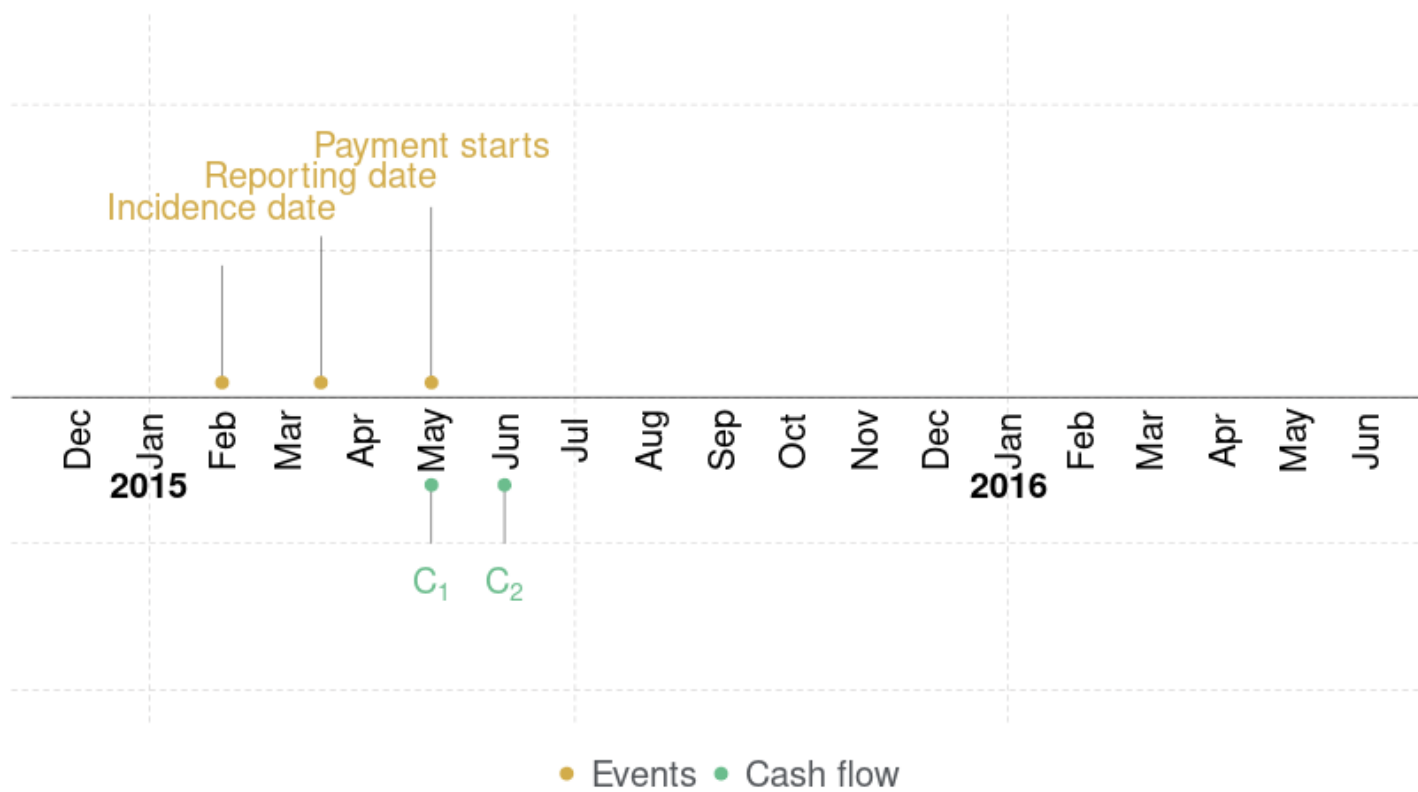


# Disability insurance: Classic claim unwinding



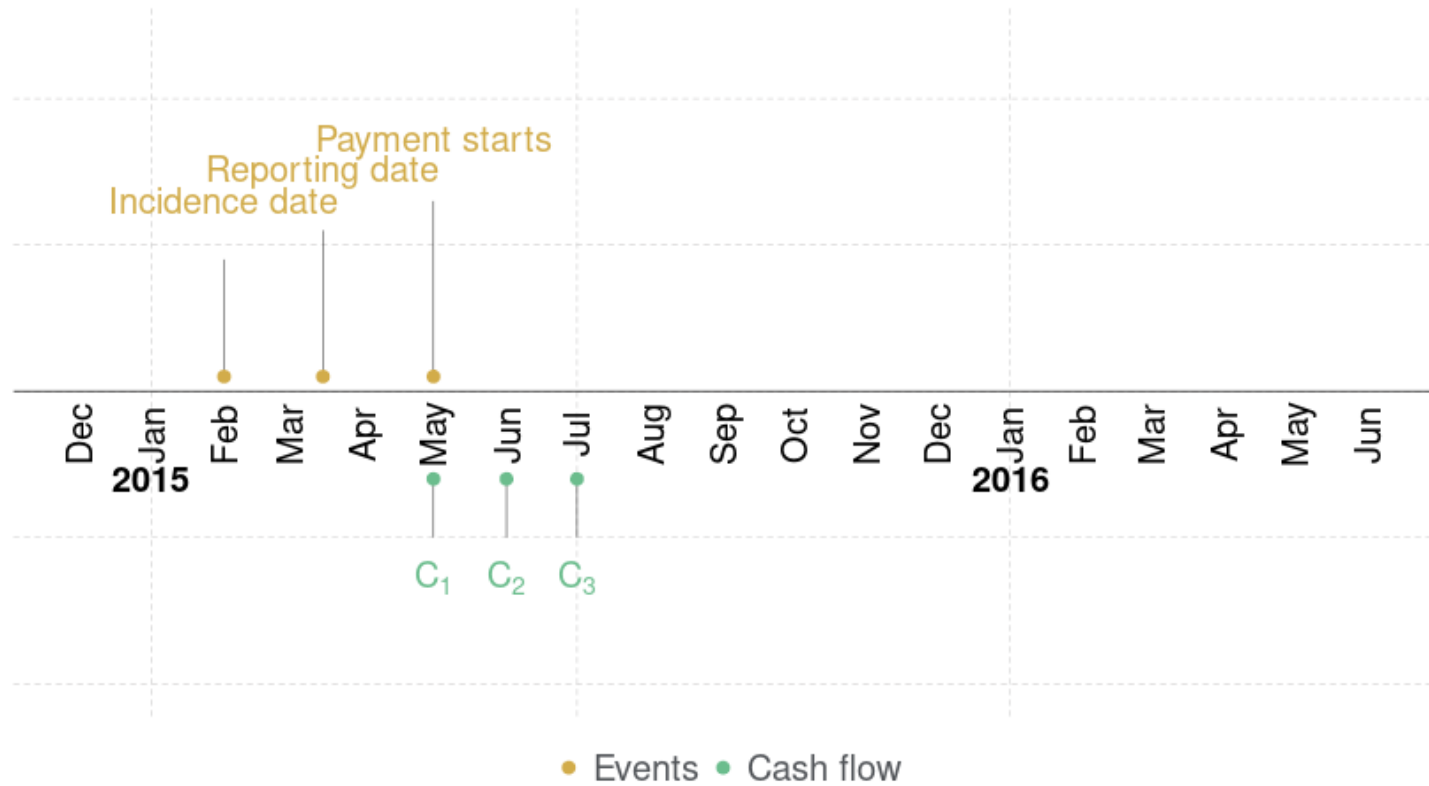


# Disability insurance: Classic claim unwinding

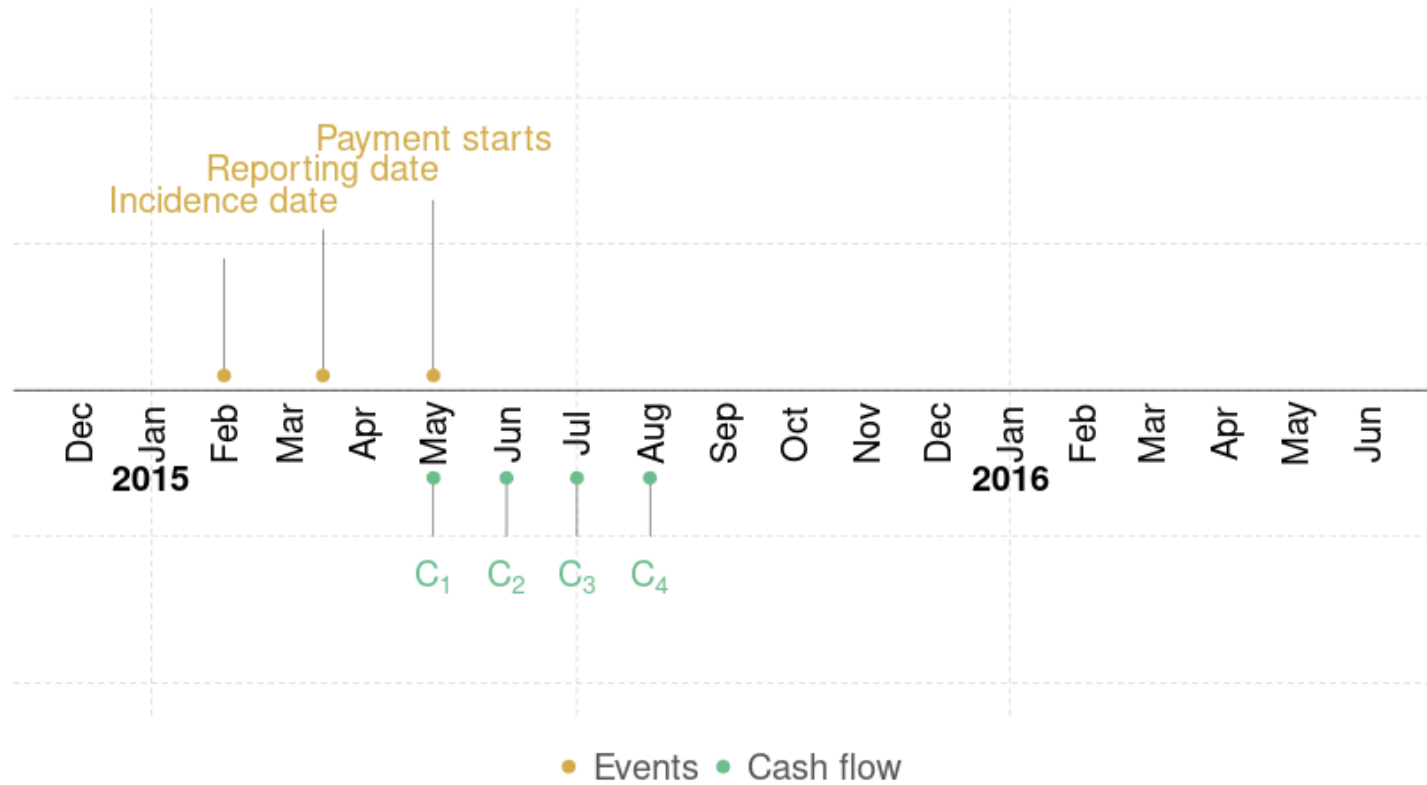




# Disability insurance: Classic claim unwinding



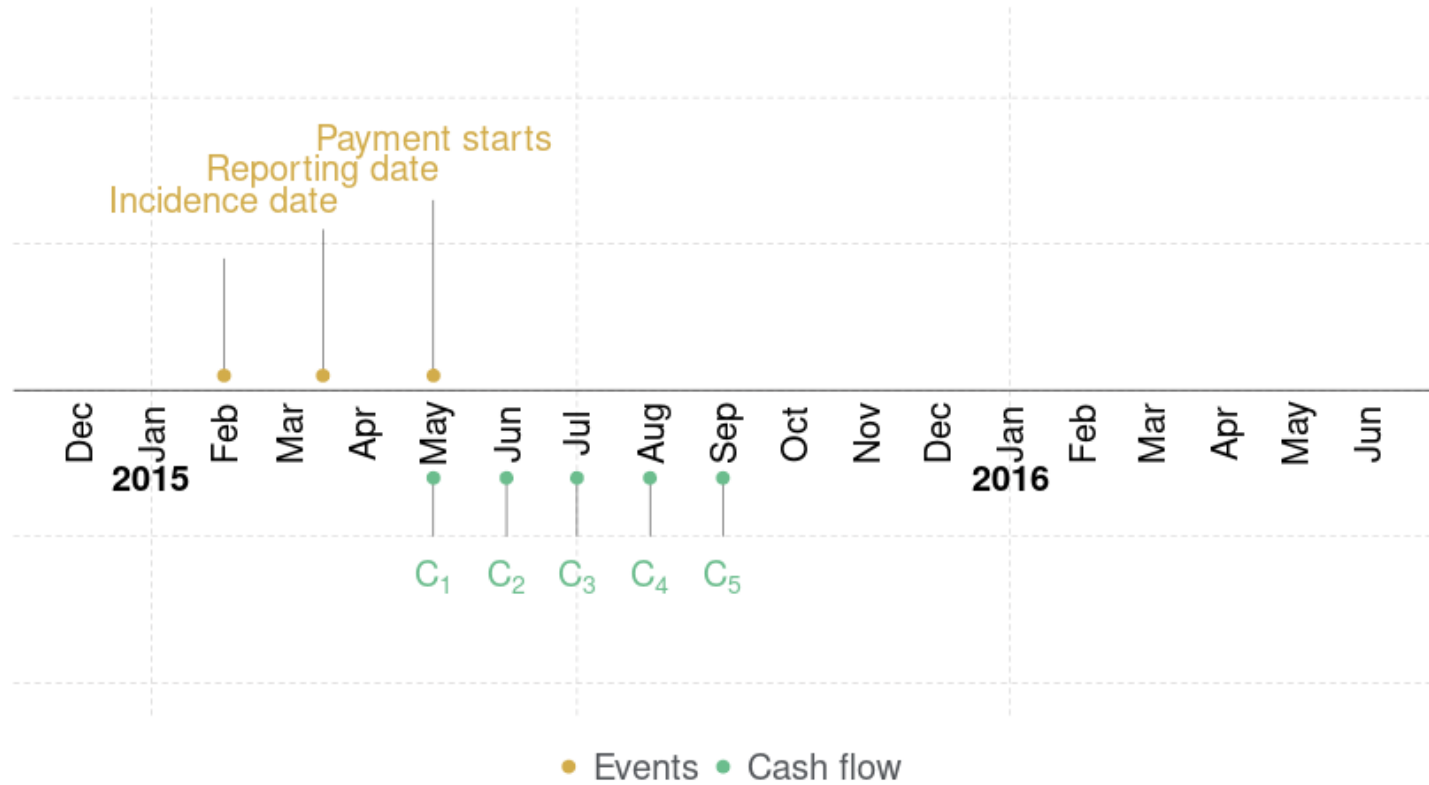
# Disability insurance: Classic claim unwinding





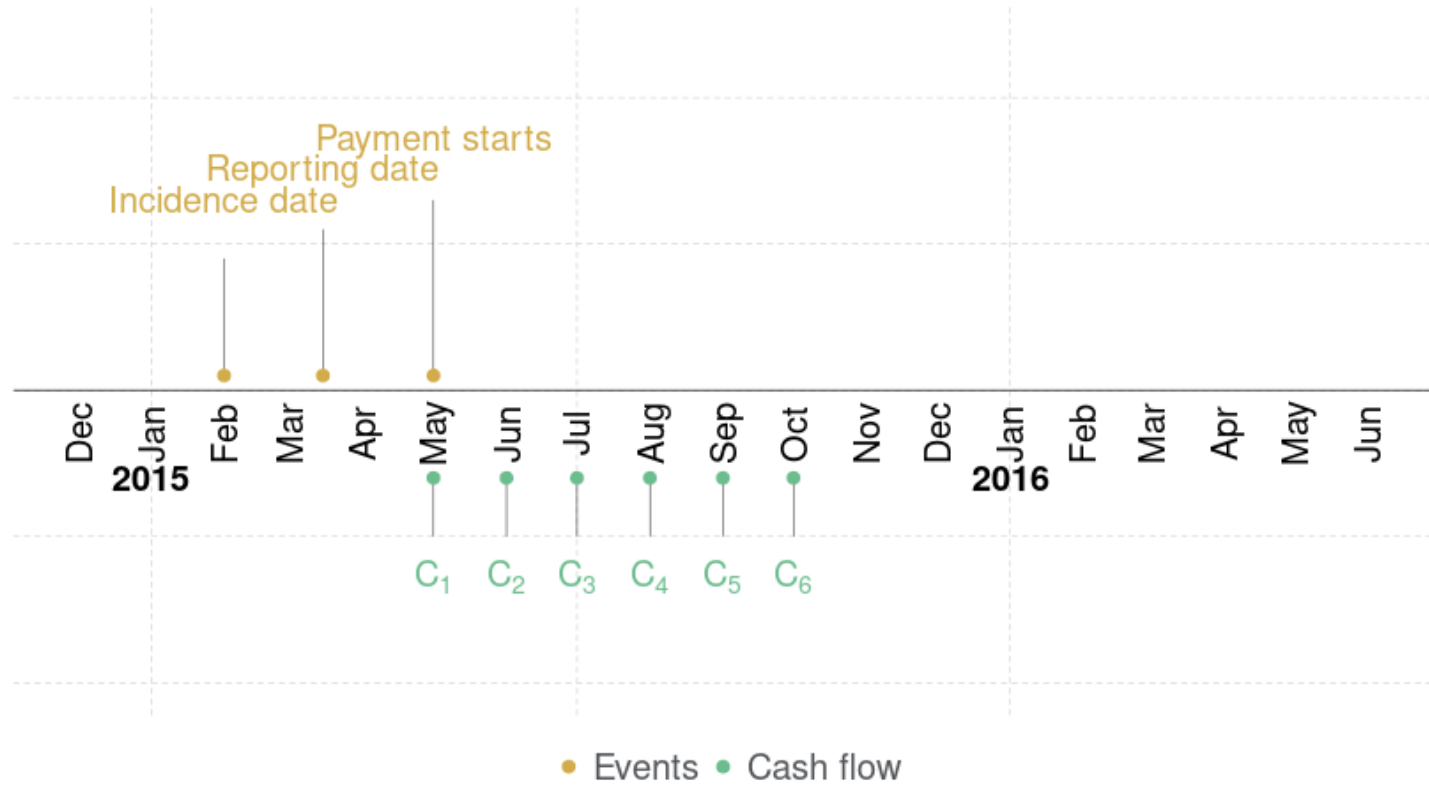


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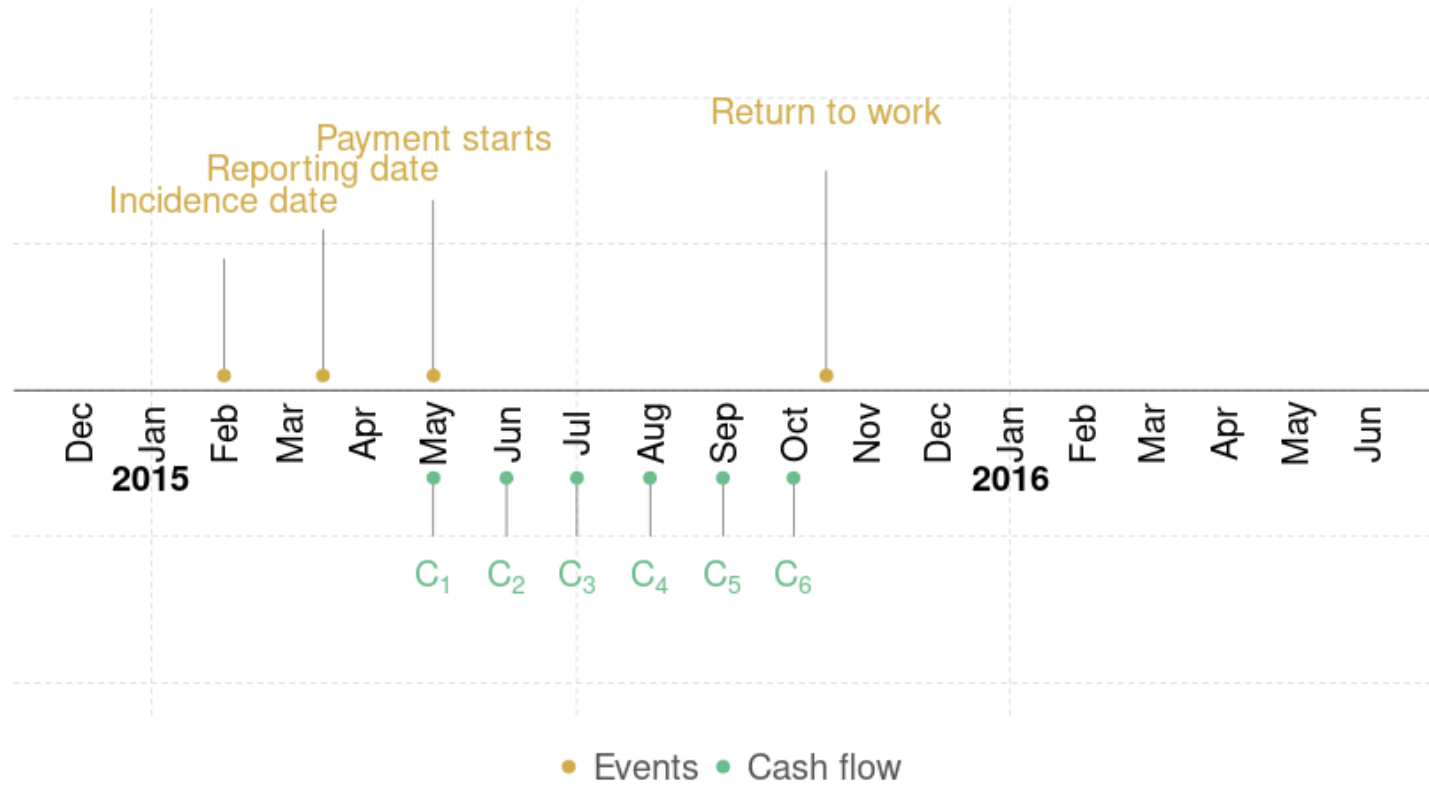


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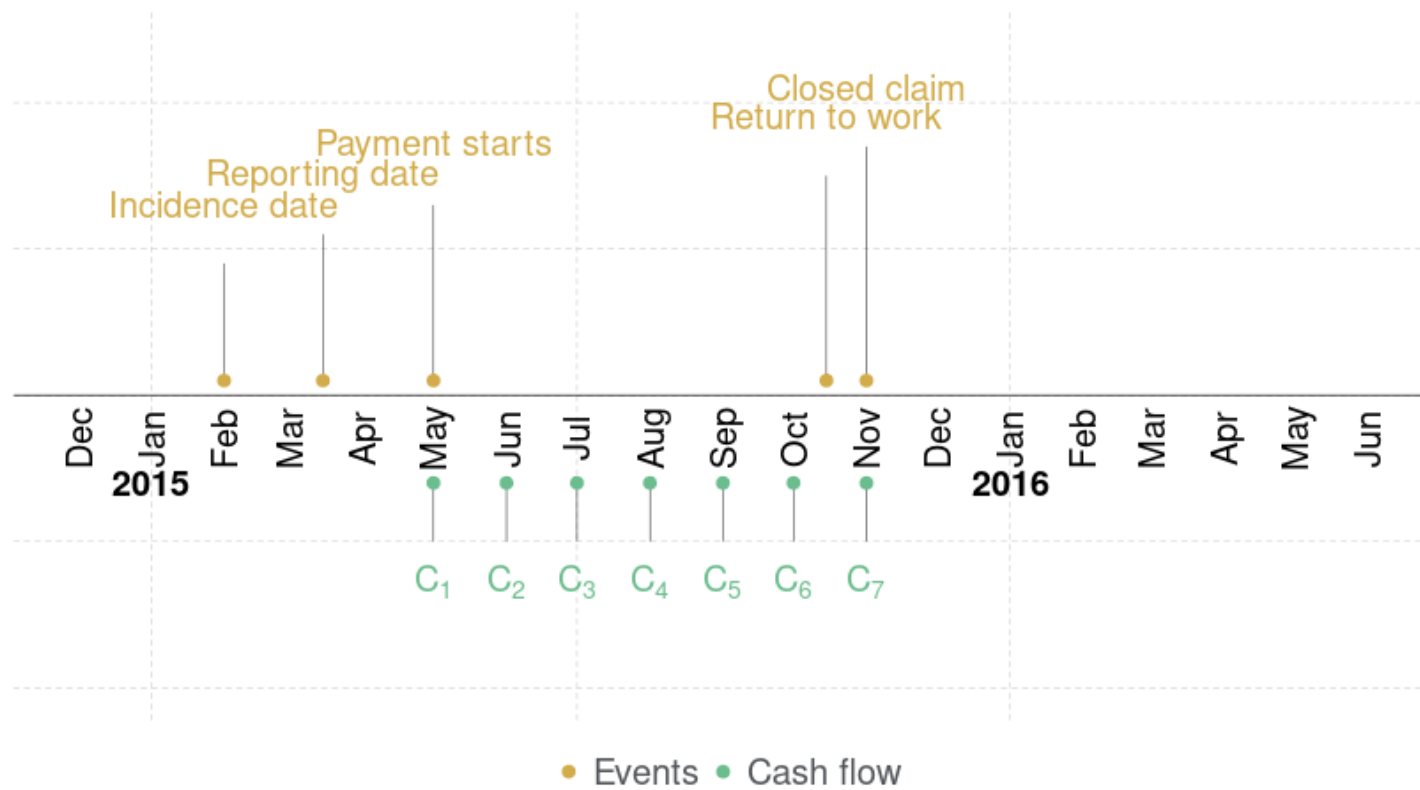


# Disability insurance: Classic claim unwinding



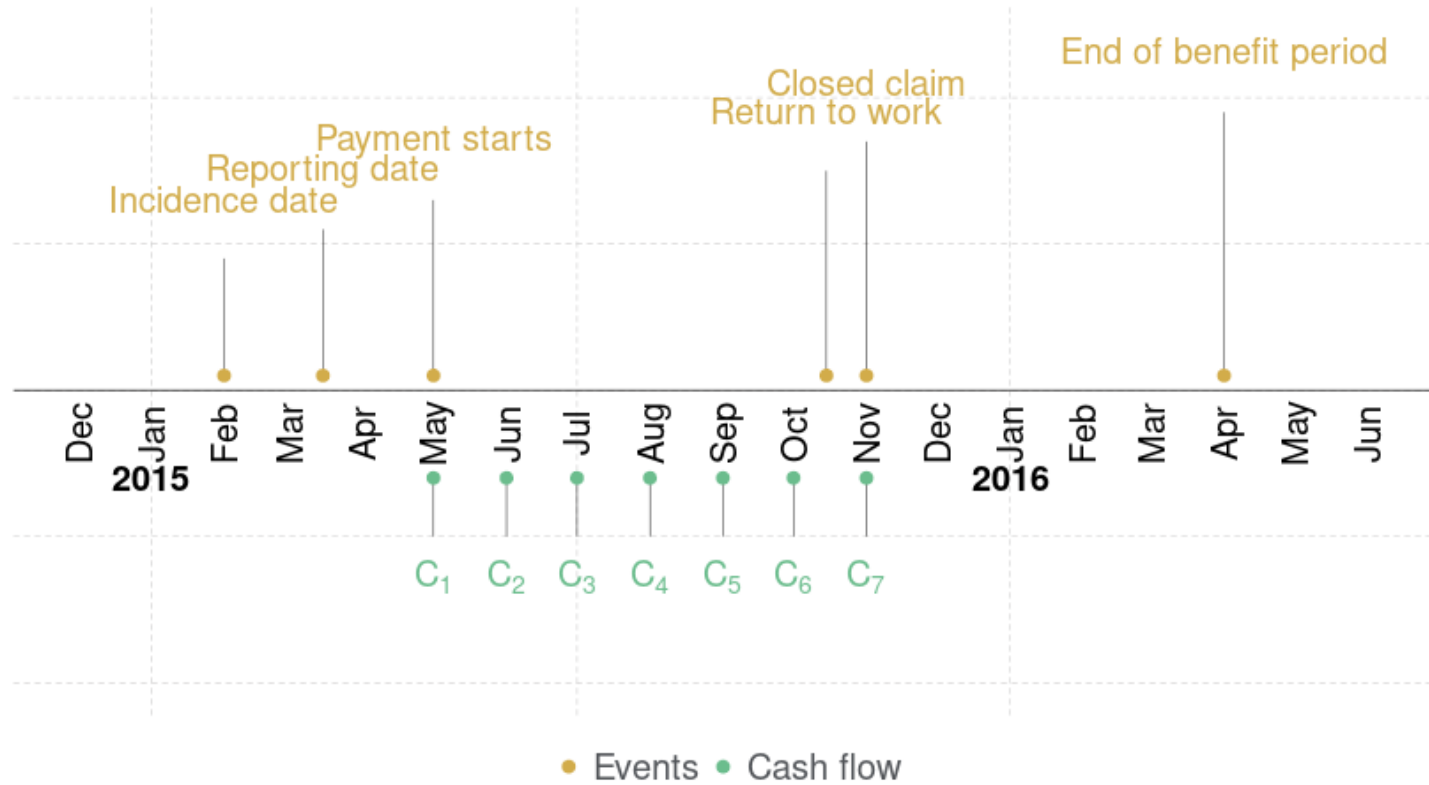


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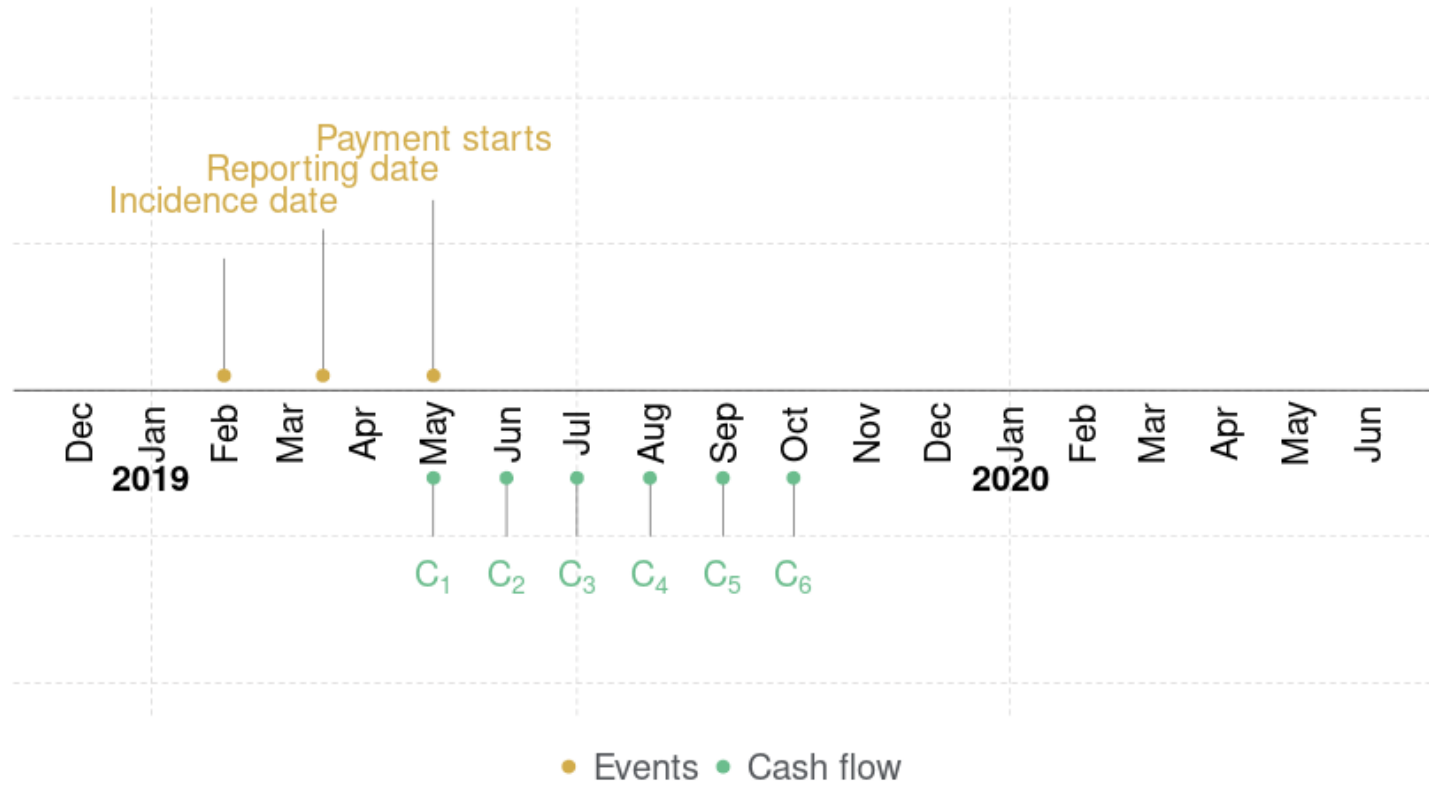


# Disability insurance: Classic claim unwinding



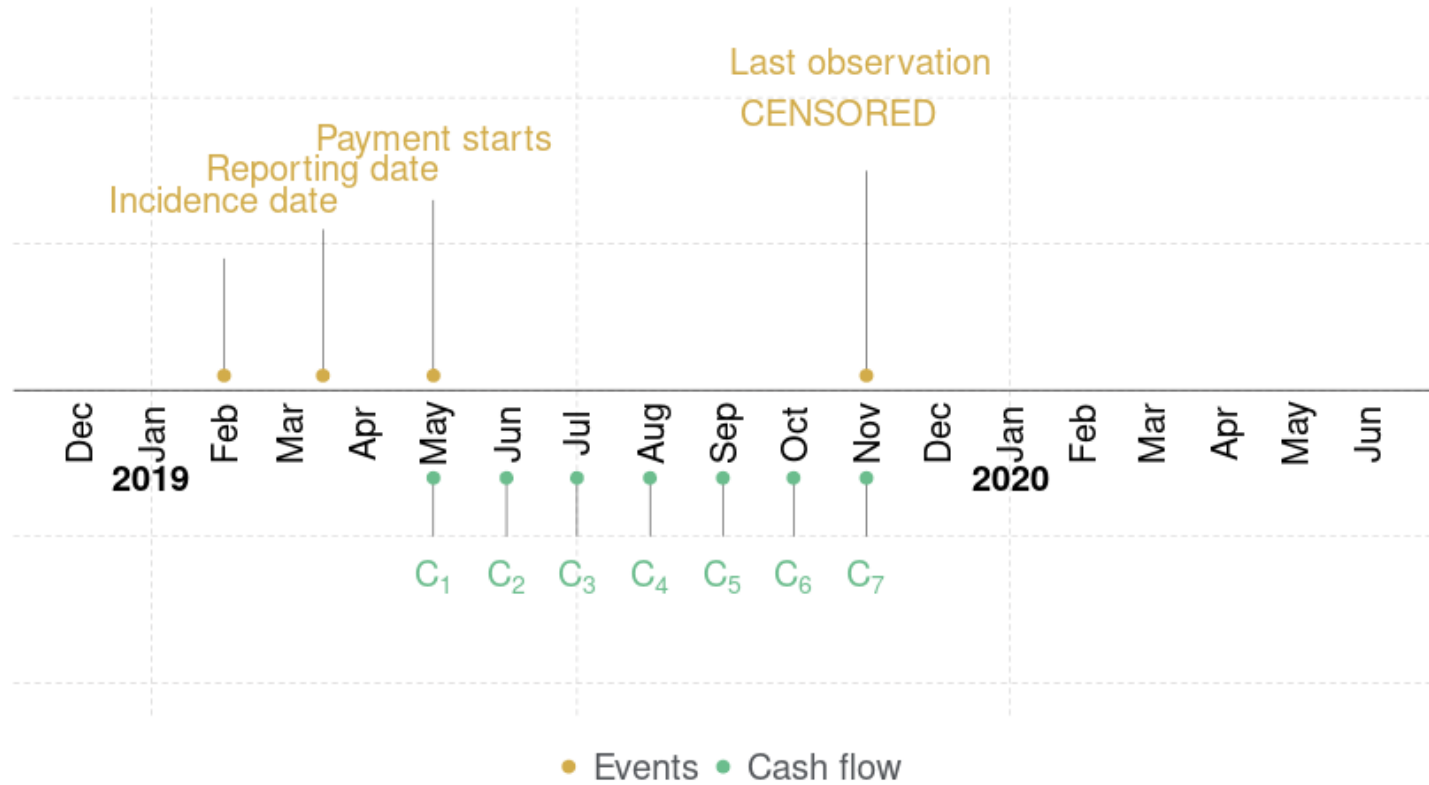


# Disability insurance: Open claim and censoring



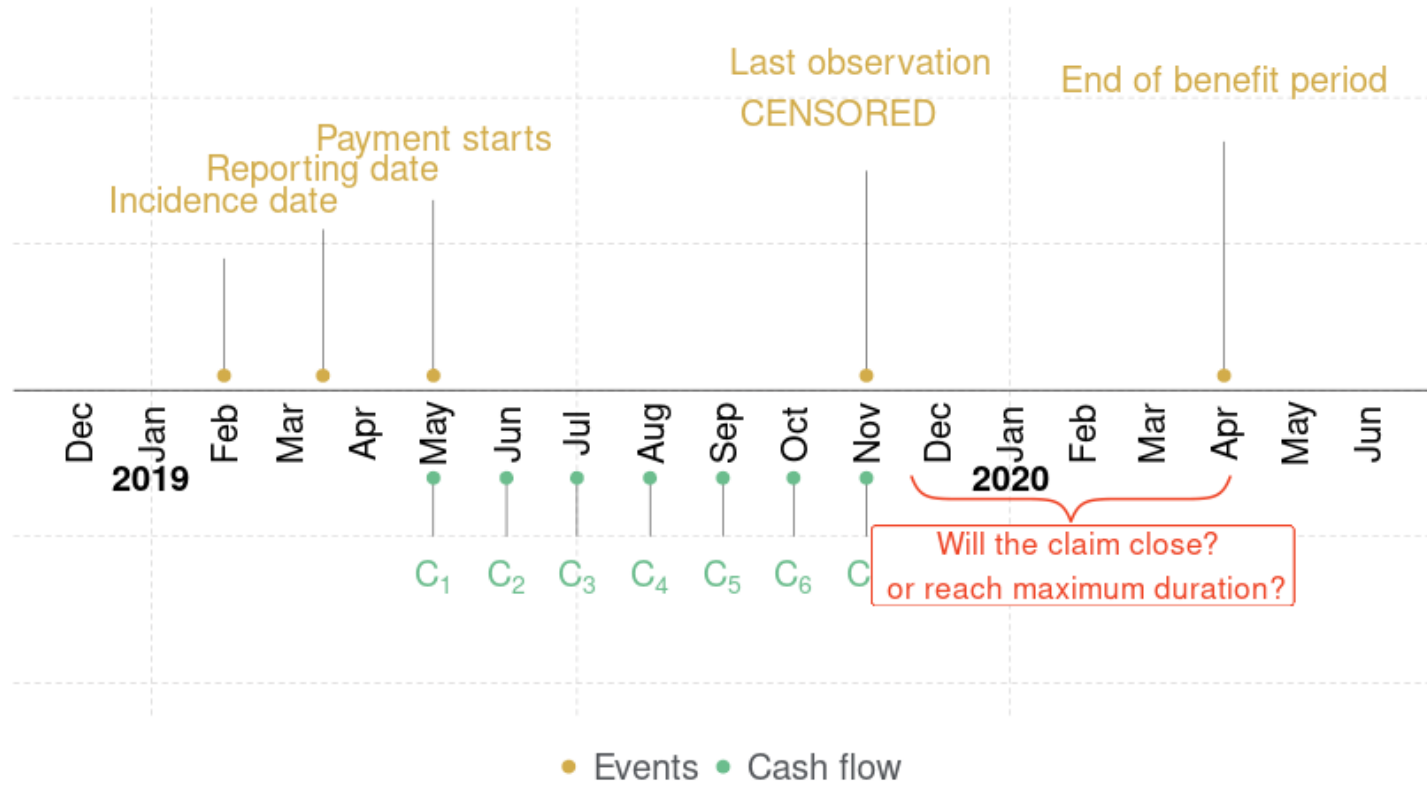


# Disability insurance: Open claim and censoring



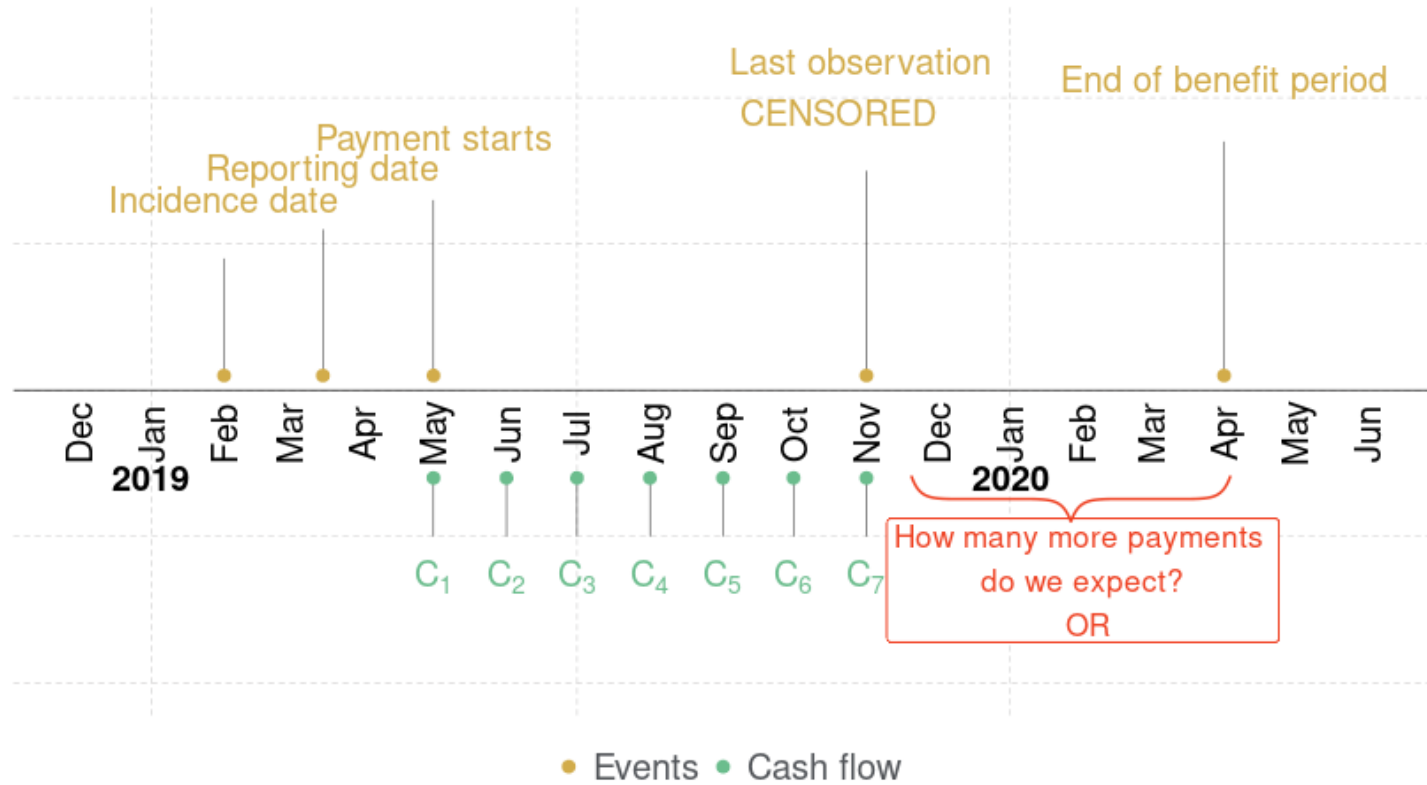


# Disability insurance: Open claim and censoring

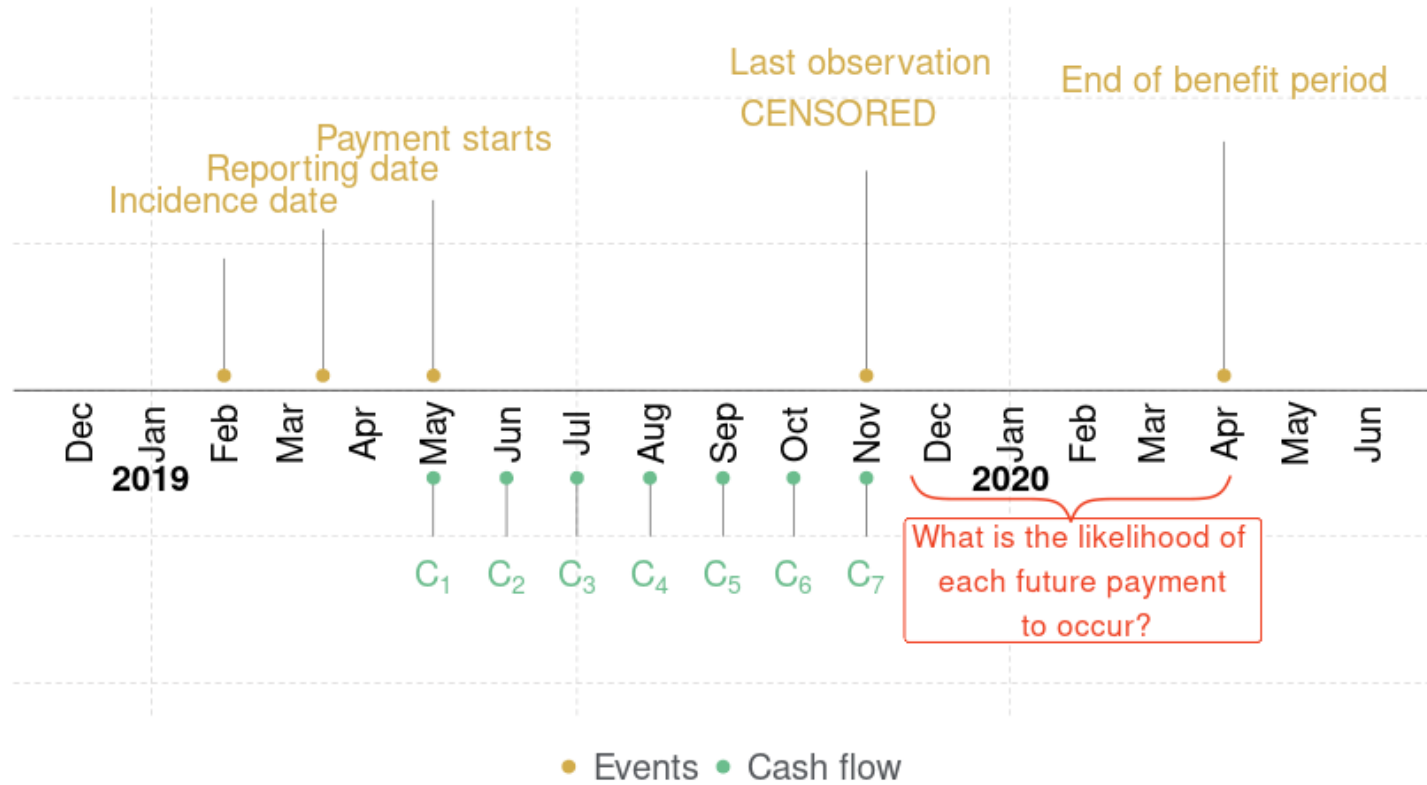




# Disability insurance: Open claim and censoring



# Disability insurance: Open claim and censoring





# A termination study evolving into a reserving tool

- Project emerged from a strong client-PartnerRe relationship.
- Provided us with claims data to perform multivariate analysis on claims duration.
- Multiple iterations on the course of 4 years.
- Developed into a tool for projecting the cost for the (re)insurer of such disability claims.

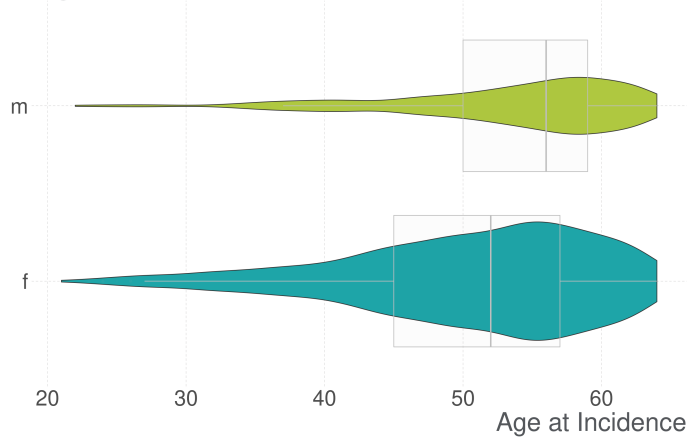




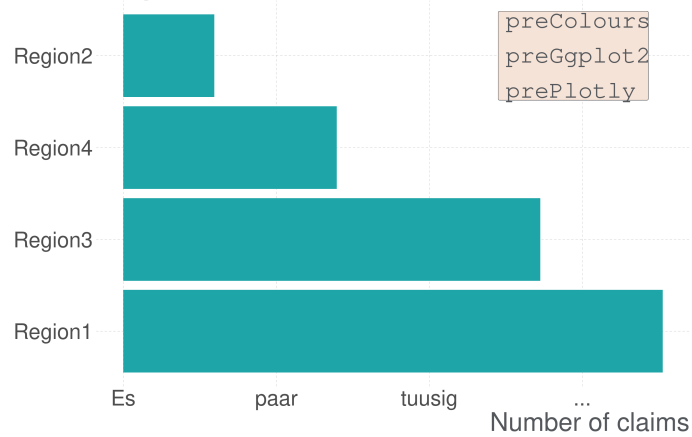
Data



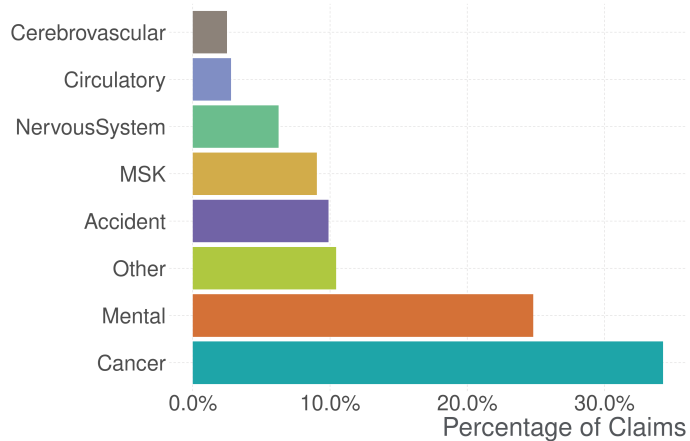
### Age and Gender



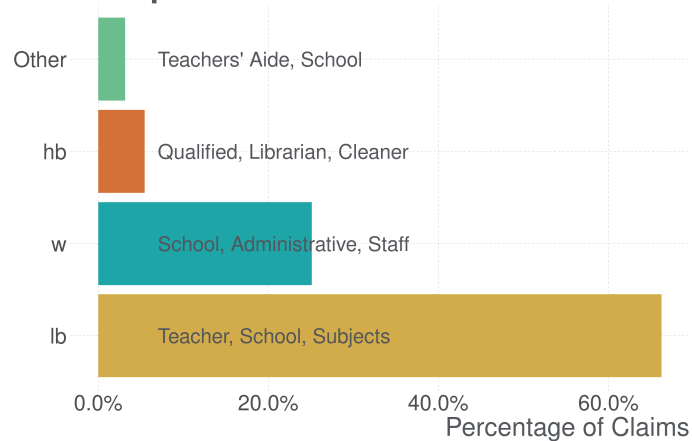
### Region



### Cause of Claim



### Occupation Class

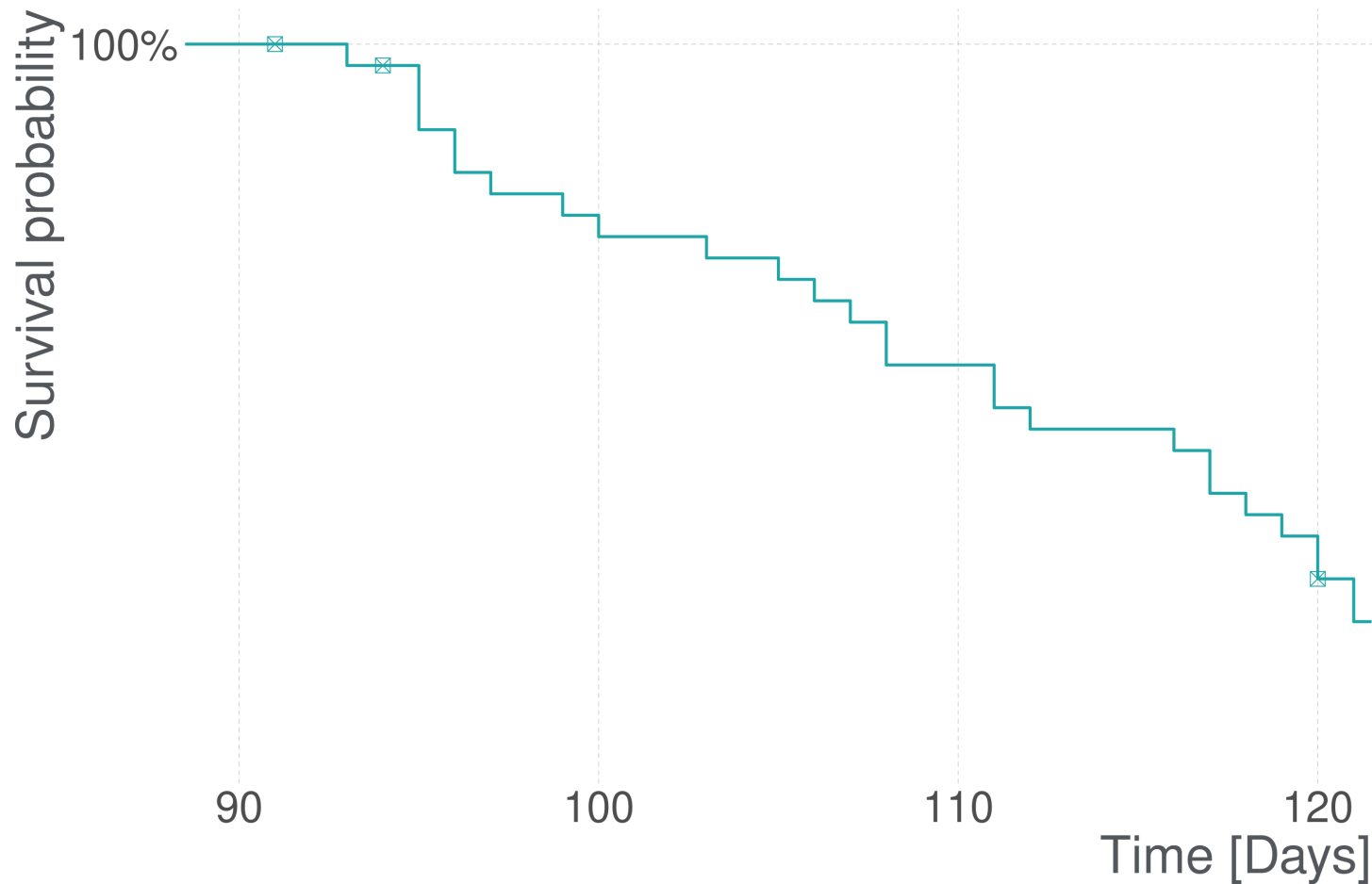




# Modeling



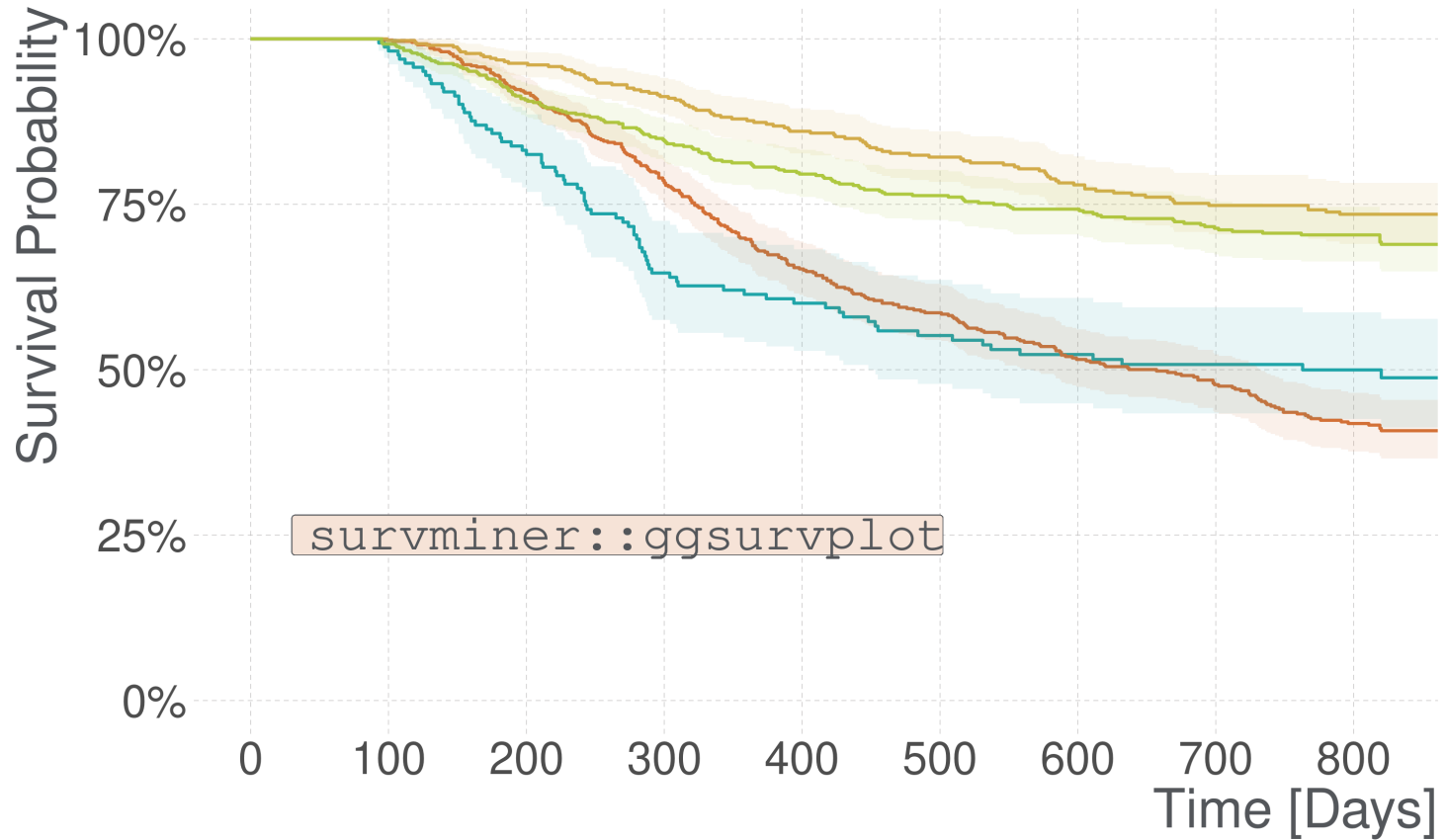
# KM-Estimator for Survival Curve



```
fit_km <- survival::survfit(Surv(openTime, closed) ~ 1, data = claims_new)
```

# KM-Estimator by Cause of Claim

Cause   Accident   Cancer   Mental Health   Other





# Comparison of CoxPH and cForest

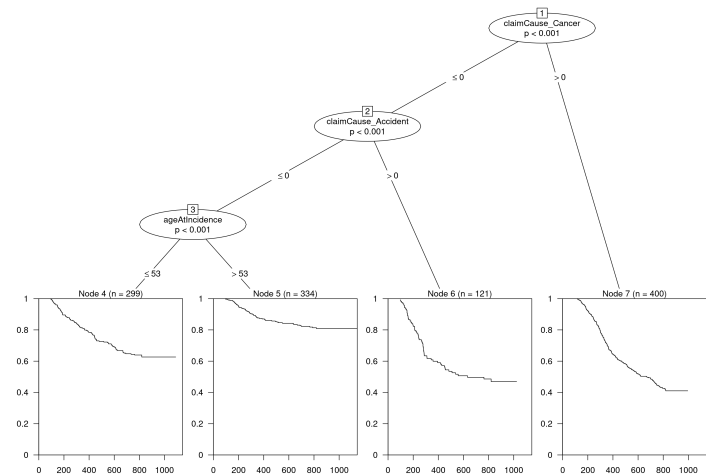
survival::coxph	party::cforest
-----------------	----------------

## Advantages

Experience	Few Assumptions
Transparent	Individual Curves
Computing Time	Good Performance

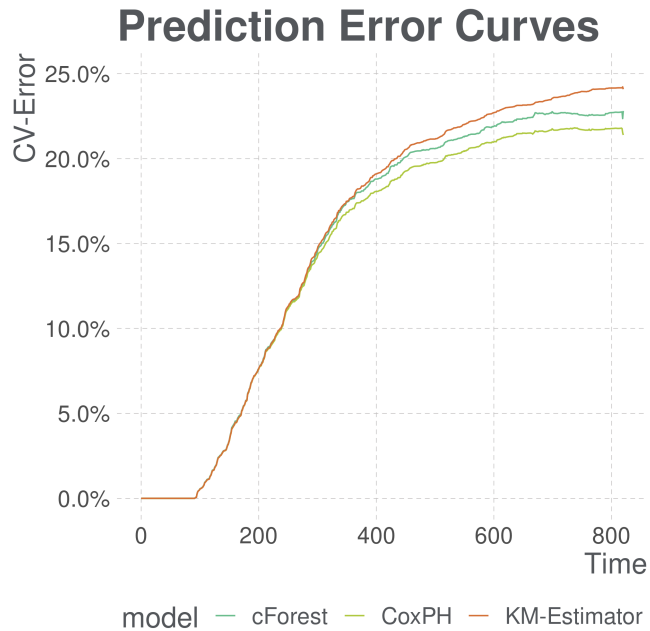
## Disadvantages

PH Assumption	Hard to Interpret
Uncertain Event Times	Data Hungry

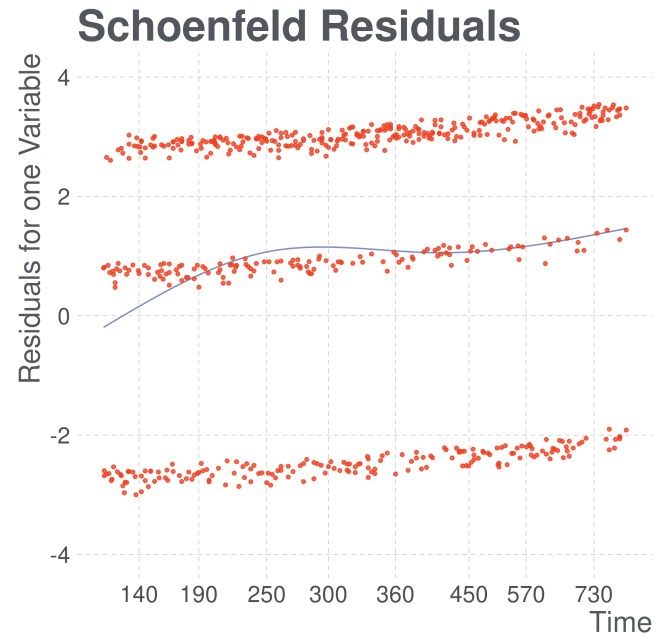


```
tree <- party::ctree(Surv(openTime, closed)
  ~ ..., data = train_forest)
```

# Evaluation Metrics



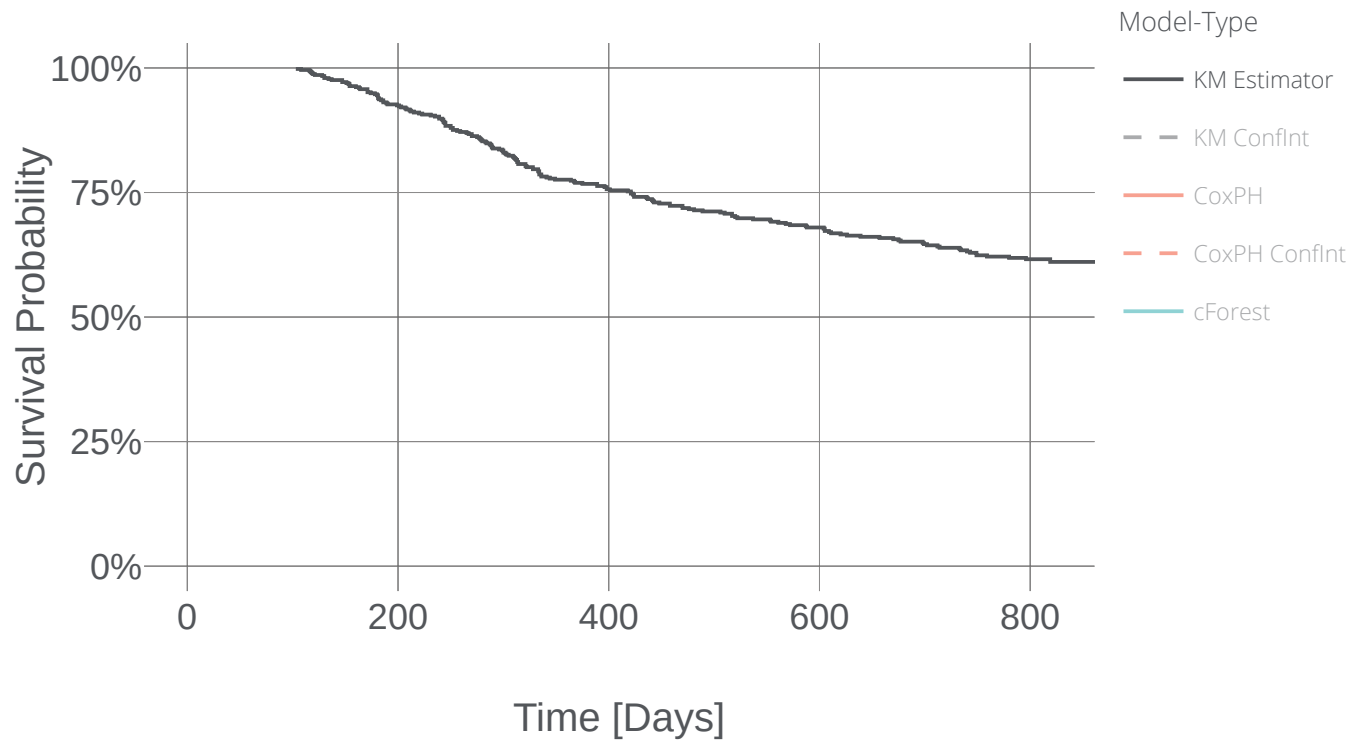
```
pec <- pec::pec(list("cox" = fit_coxph,  
"cforest" = fit_forest_pec), data = claims,  
formula = form, splitMethod = "cv10")
```



```
zph <- survival::cox.zph(fit_coxph,  
transform = "km")  
gg_zph <- survminer::ggcoxzph(zph)
```



## Comparison of Survival Curves and Confidence Intervals

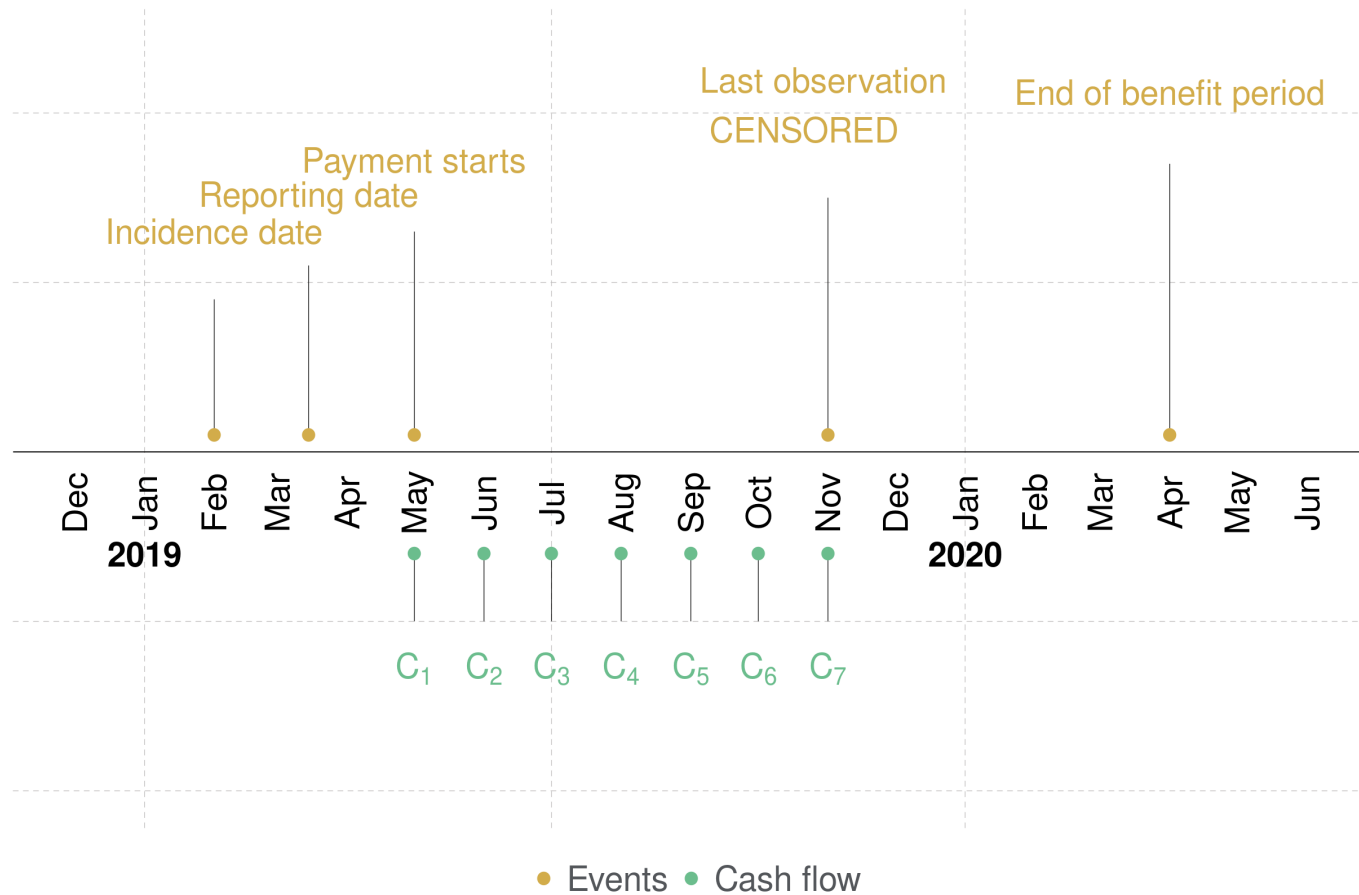




# Packaging

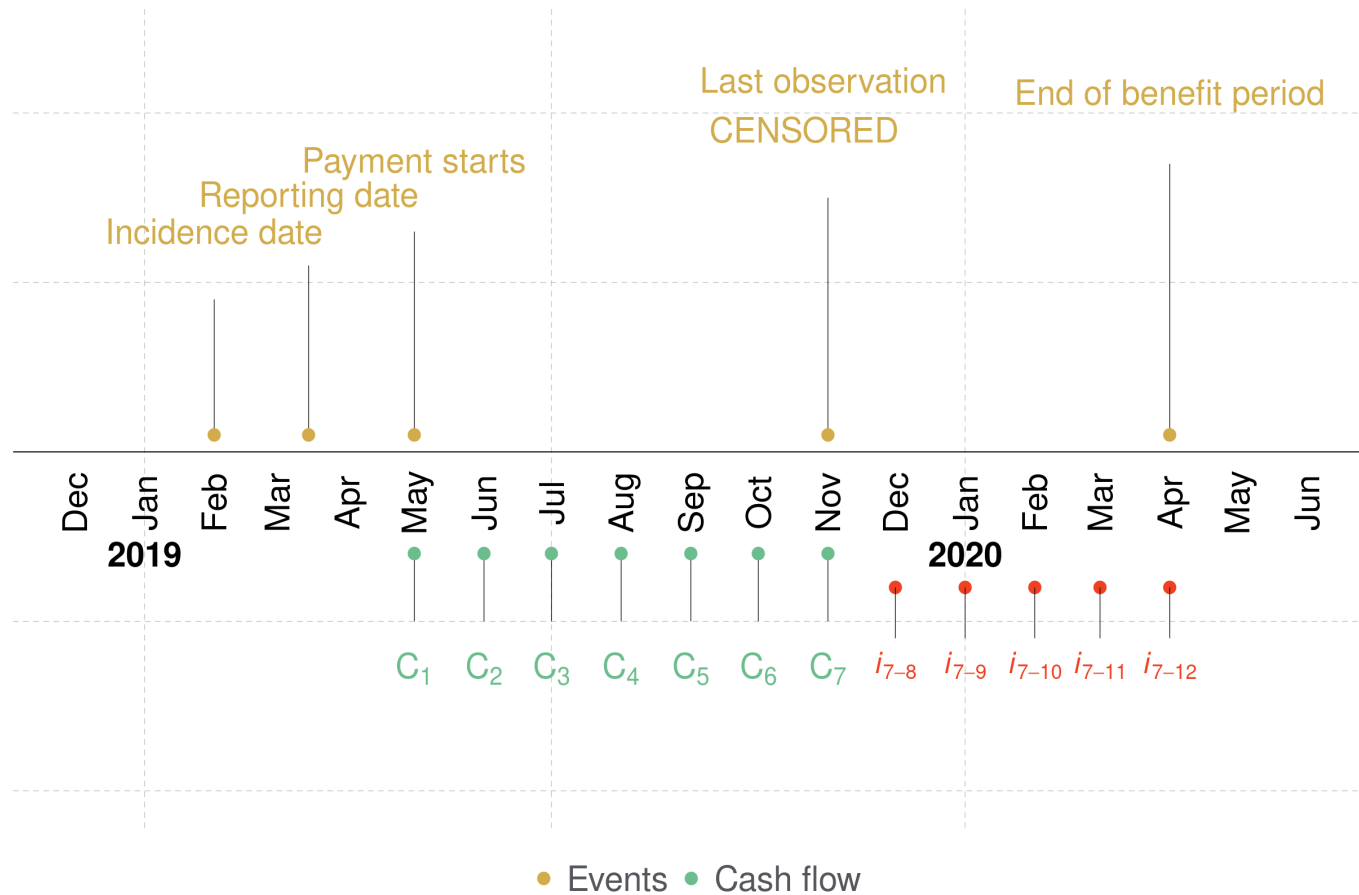


# Projecting disability probabilities





# Projecting disability probabilities



# A two packages set-up

Survival  
Analysis

**Models Package**

**Reserve Calculation Package**

# A two packages set-up



Survival  
Analysis

**Models Package**

Functions  
to access  
models

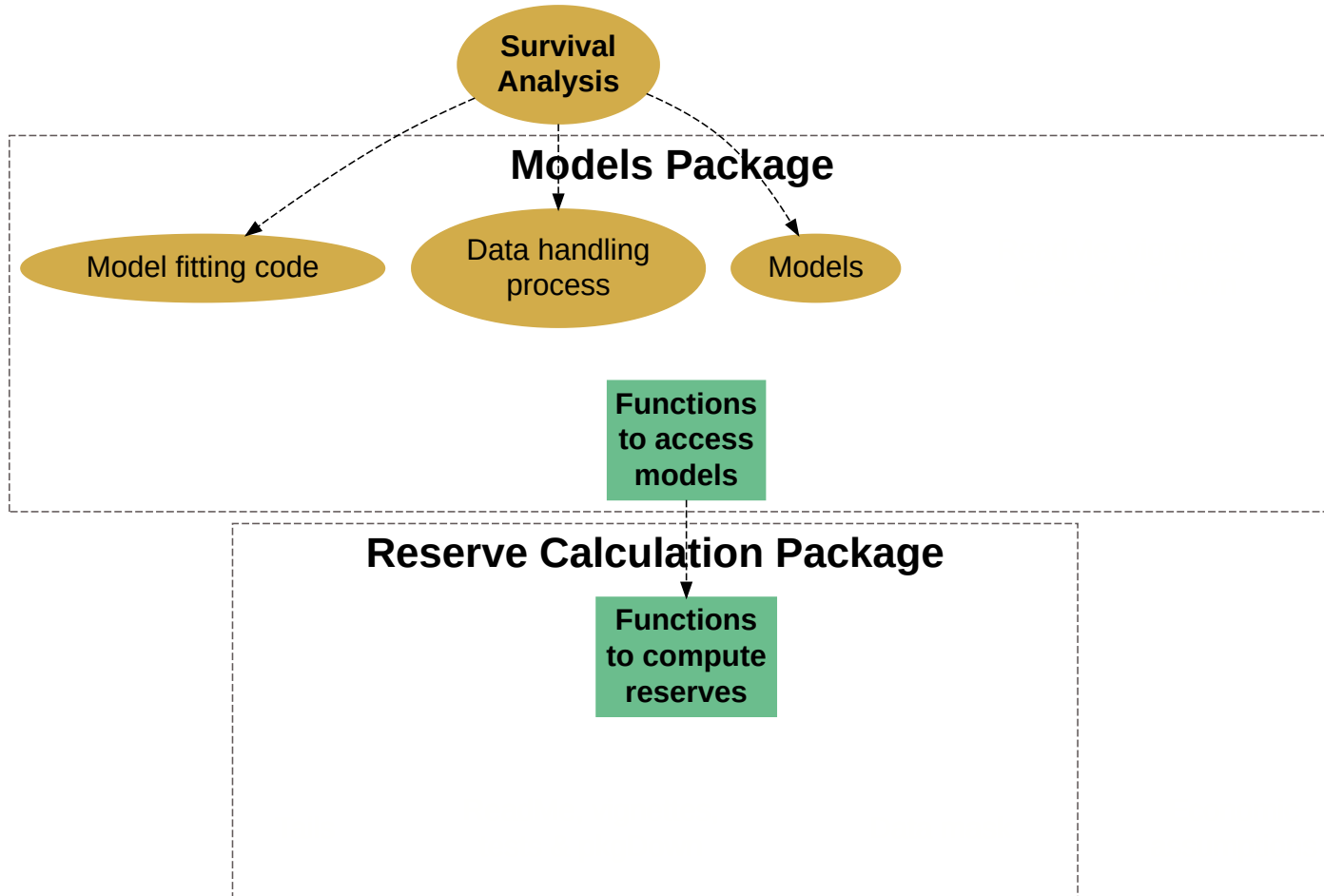
**Reserve Calculation Package**

Functions  
to compute  
reserves

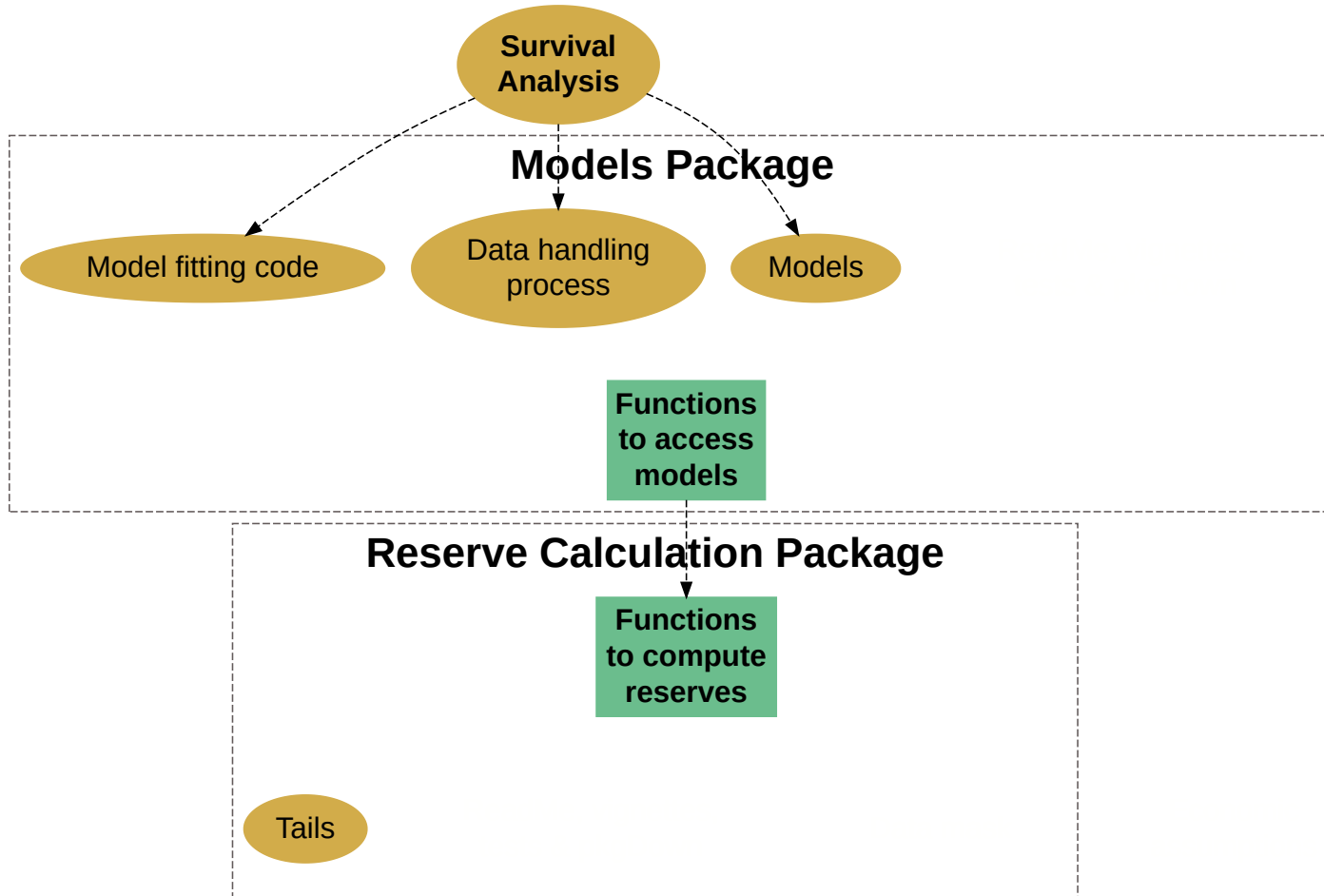




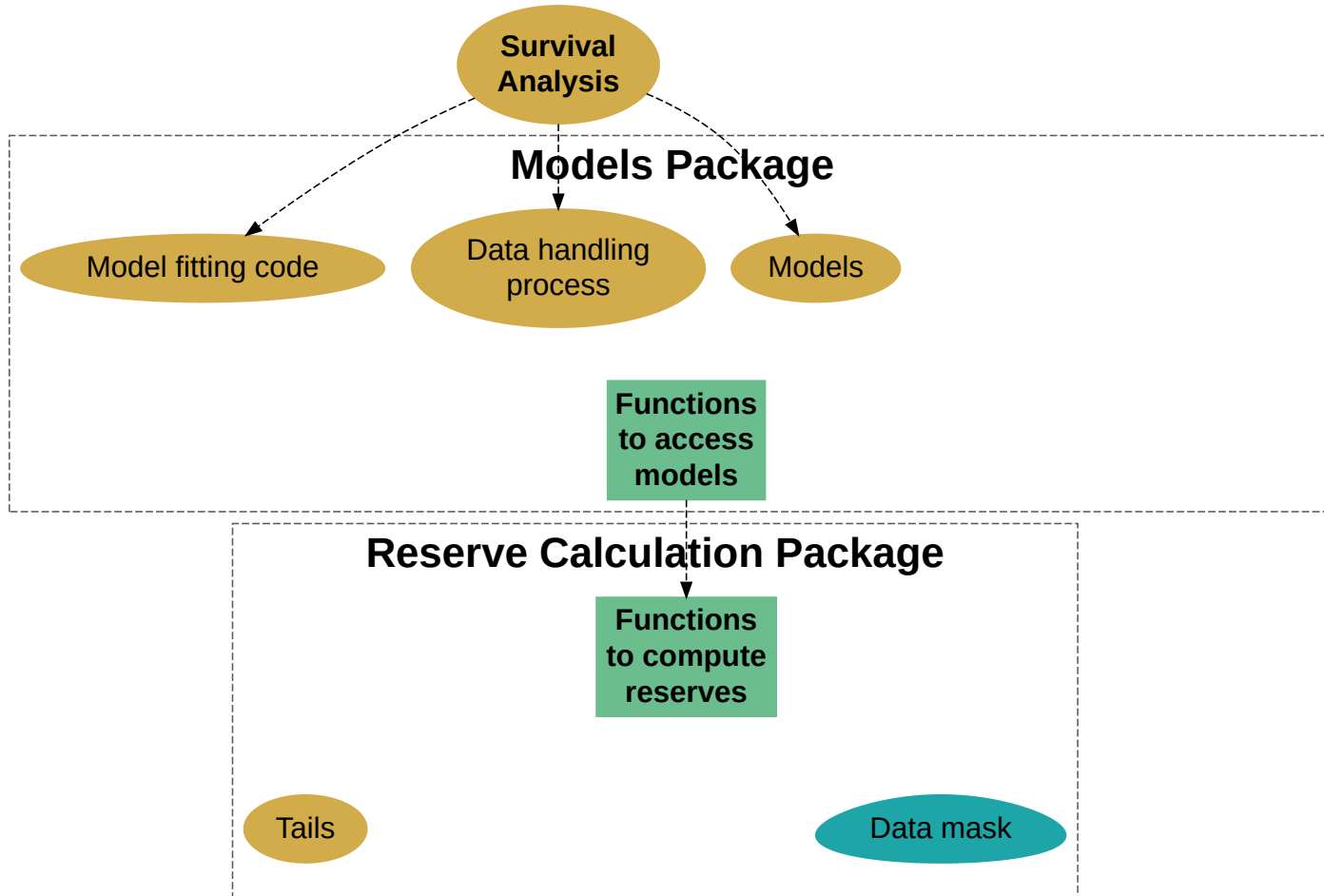
# A two packages set-up



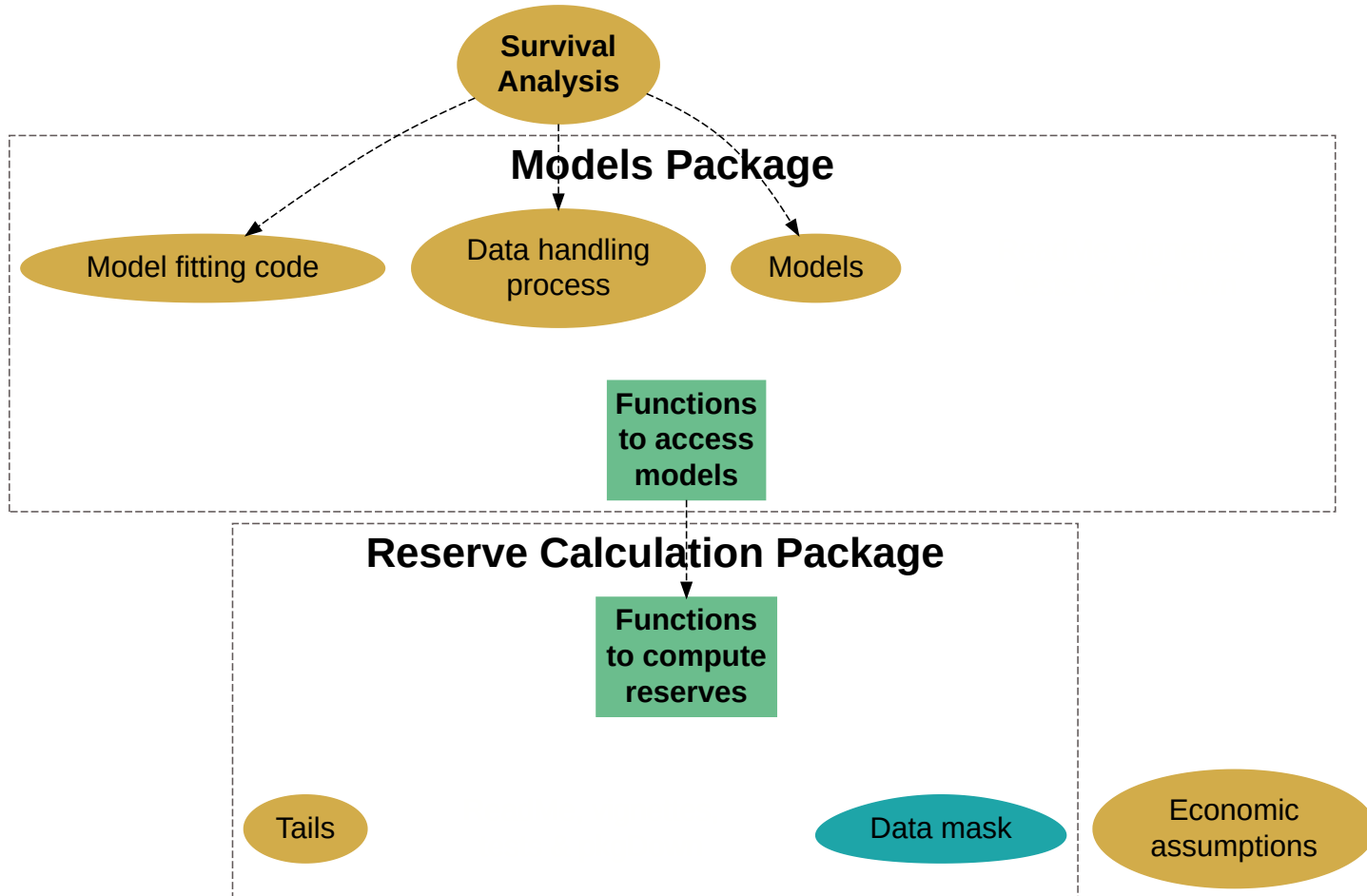
# A two packages set-up



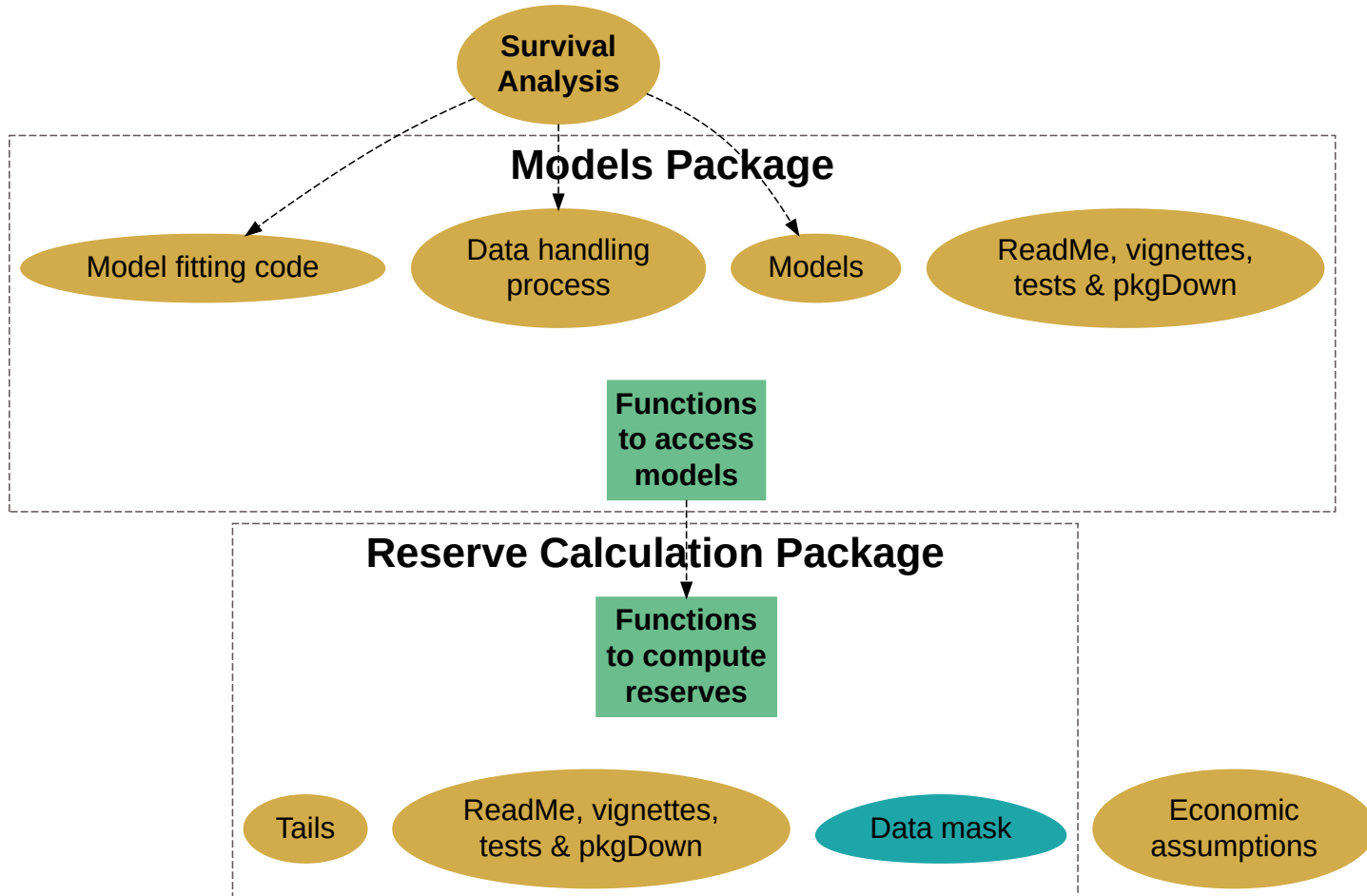
# A two packages set-up



# A two packages set-up



# A two packages set-up





# Conclusion



# From survival analysis to projecting disability payments

- Yearly evaluation of released R tools and packages deepens our understanding of survival analysis.
- Successful textbook case of wrapping-up an analysis into R packages.
- R and its packages enables the construct of production tools in business environments.

