Stata: a short history
viewed through epidemiology

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2025 Stata Biostatistics and Epidemiology Virtual Symposium

A personal perspective

- This talk is a personal reflection on 35+ years of applied research in epidemiology
- Given from a UK perspective
- Aims:
  - Pay tribute to influential contributors
  - Share some highlights
  - Offer reflections

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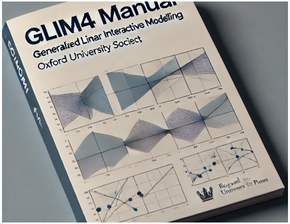
Overview

1. Some history
   - Before Stata
   - The 1990s
   - The 2000s
   - The 2010s
   - The 2020s
2. ...

Life before Stata

- Dominant software: GLIM

(*Generalised Linear Interactive Modelling*



- Stemmed from a Royal Statistical Society WP
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Life before Stata
Statistical software in the UK

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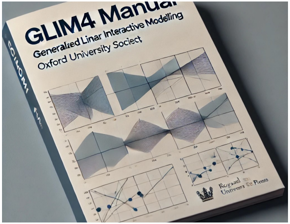

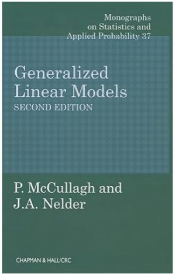

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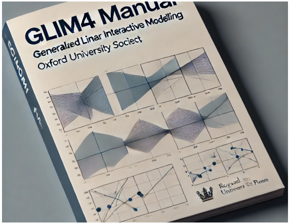

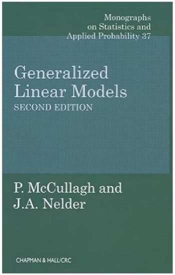

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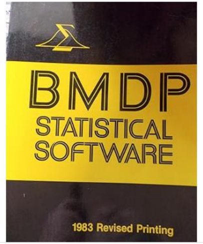

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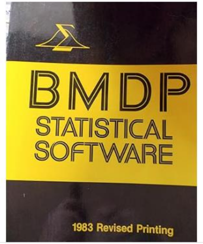

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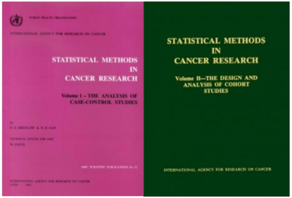
- Reference books in epidemiology:



- Included several Fortran programs specific for analyses of epi studies (*e.g.* conditional logistic regression)

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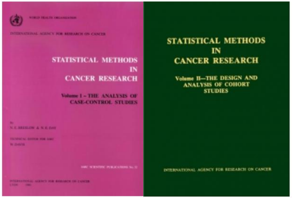
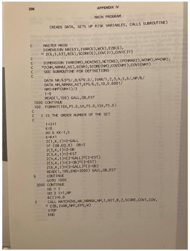




298 APPENDIX IV

MAIN PROGRAM

(READS DATA, SETS UP RISK VARIABLES, CALLS SUBROUTINE)

```
C     MASTER MAIN
      DIMENSION NR(63),IVAR(6),W(6),EZB(6),
     * Z(6,5,63),B(6),SCORE(6),COV(21),COVI(21)
C
C     DIMENSION IVAR(NM),NCA(NS),NCT(NS),IP(NMAX2),W(NM),WW(NM),
C    *Z(NM,NRMAX,NS),B(NM),SCORE(NM),COV(NM1),COVI(NM1)
C     SEE SUBROUTINE FOR DEFINITIONS
C
      DATA NR/63*5/,B/6*0.0/,IVAR/1,2,3,4,5,6/,NP/6/
      DATA NM,NRMAX,NIT,EPS/6,5,10,0.0001/
      NM1=NM*(NM+1)/2
      I-0
      READ(1,100) GALL,OB,EST
 1000 CONTINUE
  100 FORMAT(10X,F5.0,5X,F5.0,15X,F5.0)
C
C   I IS THE ORDER NUMBER OF THE SET
C
      I=I+1
      K=0
      DO 6 KK-1,5
      K=K+1
      Z(1,K,I)=2-GALL
      IF (OB.EQ.9)  OB=2
      Z(2,K,I)=2-OB
      Z(3,K,I)=2-EST
      Z(4,K,I)=(2-GALL)*(2-EST)
      Z(5,K,I)=(2-OB)*(2-EST)
      Z(6,K,I)=(2-GALL)*(2-OB)
      READ(1,100,END=2000) GALL,OB,EST
 6    CONTINUE
      GOTO 1000
 2000 CONTINUE
      NS = I
      DO 2 I=1,NP
      B(I)=0.0
 2    CALL MATCH(NS,NR,NRMAX,NM,I,NIT,B,Z,SCORE,COVI,COV,
     * EZB,IVAR,NM1,EPS,W)
      STOP
      END
```

- Included several Fortran programs specific for analyses of epi studies (*e.g.* conditional logistic regression)

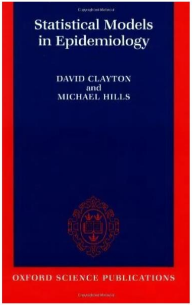
1984

- Stata arrives!

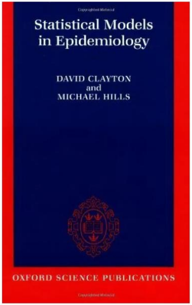
Commands in Stata 1.0 and Stata 1.1

append	dir	infile	plot	spool
beep	do	input	query	summarize
by	drop	label	regress	tabulate
capture	erase	list	rename	test
confirm	exit	macro	replace	type
convert	expand	merge	run	use
correlate	format	modify	save	
count	generate	more	set	
describe	help	outfile	sort	

- Developed for personal computers


Statistical Models
in Epidemiology
DAVID CLAYTON
and
MICHAEL HILLS
OXFORD SCIENCE PUBLICATIONS

The 1990s
Michael Hills and David Clayton and Stata



Acknowledgments

The original version of `strate` was written by David Clayton (retired) of the Cambridge Institute for Medical Research and Michael Hills (1934–2021) of the London School of Hygiene and Tropical Medicine.

Acknowledgments

`stsplit` and `stjoin` are extensions of `lexis` by David Clayton (retired) of the Cambridge Institute for Medical Research and Michael Hills (1934–2021) of the London School of Hygiene and Tropical Medicine (Clayton and Hills 1995). The original `stsplit` and `stjoin` commands were written by Jeroen Weesie of the Department of Sociology at Utrecht University, The Netherlands

- London School of Hygiene and Tropical Medicine
- European Education Program in Epidemiology in Florence

Michael in Florence

Ana Timberlake

The 1990s
Teaching with Michael Hills

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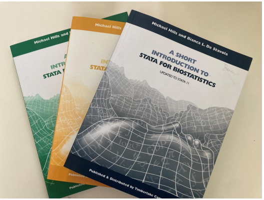
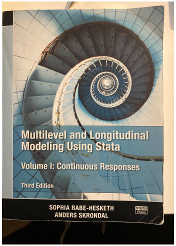
The Stata manuals . . .

Michael's version!

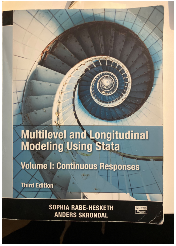


The 2000s

- Mixed effects models
- Missing data



Multilevel and Longitudinal Modeling Using Stata
Volume I: Continuous Responses
Third Edition
SOPHIA RABE-HESKETH
ANDERS SKRONDAL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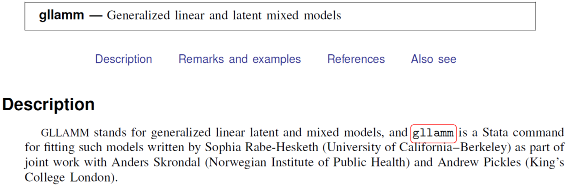
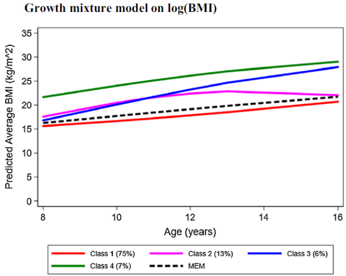

gllamm — Generalized linear and latent mixed models

Description Remarks and examples References Also see

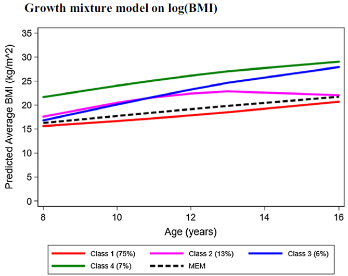
Description

GLLAMM stands for generalized linear latent and mixed models, and gllamm is a Stata command for fitting such models written by Sophia Rabe-Hesketh (University of California–Berkeley) as part of joint work with Anders Skrondal (Norwegian Institute of Public Health) and Andrew Pickles (King's College London).



Using `mixed` and `gllamm`

[Herle *et al.* EJE 2021]



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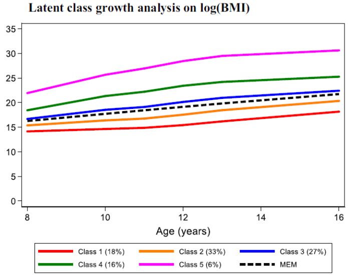
Using `mixed` *and* `traj` *(Jones and Nagin, 2013)*



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- Rubin's Multiple Imputation approach and van Buuren's Multiple Imputation by Chained Equations were starting to gain traction

The 2000s
Missing data

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ice, mim

The Stata Journal (2008)
8, Number 1, pp. 49–67

A new framework for managing and analyzing multiply imputed data in Stata

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Parkville, Australia

Patrick Royston
Cancer and Statistical Methodology Groups
MRC Clinical Trials Unit
London, UK

- Causal inference

- The currently dominant approach in biostatistics and epidemiology relies on potential outcomes (POs) [Rubin, 1974; Robins, 1986; Pearl, 1995]

- Adopting this approach, we are concerned with questions formulated as contrasts of outcomes that would occur under hypothetical interventions on the exposure:
"Would the outcome of an individual differ if they had/not had that exposure?"

- Robins proposed solutions for estimation of POs*:

(a) inverse probability weighting (IPW) (of marginal structural models)
(b) the g-computation formula
(c) g-estimation (of structural nested models)

- `teffects` implements (a) and (b) for time-fixed exposures

* Under assumptions of: no interference & consistency (i.e. SUTVA) and conditional exchangeability

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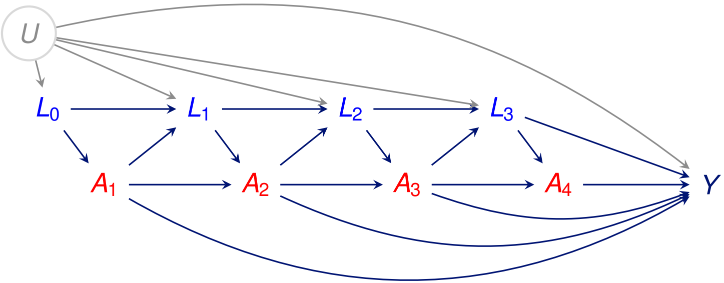
We often deal with scenarios with time-varying confounding of the effect of a time-varying exposure A by a time-varying confounder L:



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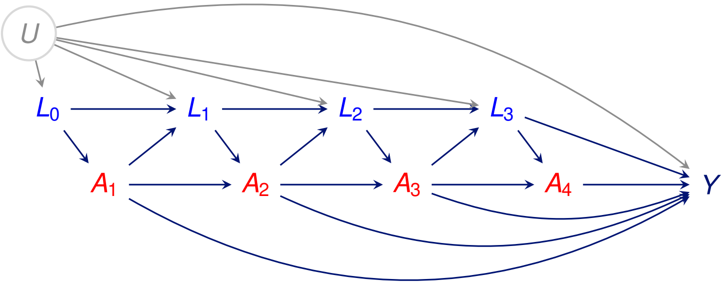

Here the total causal effect of A involves L_1, L_2, L_3, although these are also confounders for A_2, A_3,A_4: standard regression modelling does not work!

The Stata Journal (2011)
11, Number 4, pp. 479–517

gformula: Estimating causal effects in the presence of time-varying confounding or mediation using the g-computation formula

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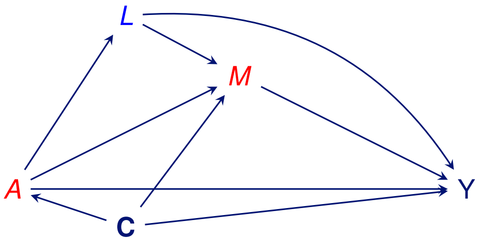
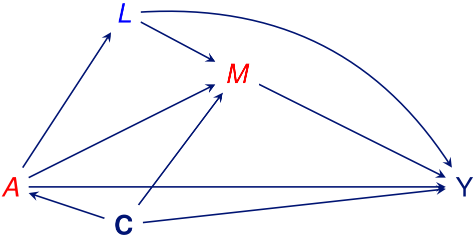


- `gformula` can be used to estimate natural and interventional effects
- `medeff` (Hicks and Tingley, 2011) and `paramed` (Emsley and Liu, 2013)† can only be used when L is not an intermediate confounder

† Now incorporated in version 18



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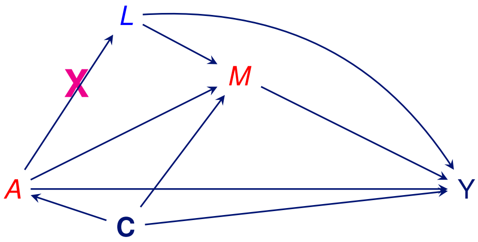

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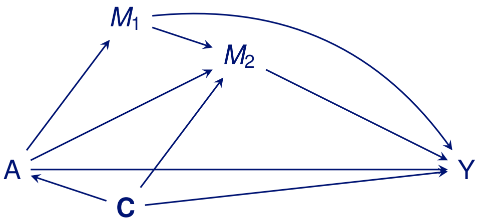
Vansteelandt & Daniel “Interventional effects for mediation analysis with multiple mediators”, *Epidemiology* 2017



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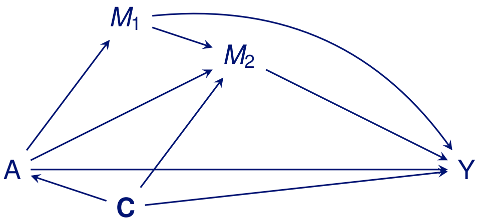

Micali *et al.* "Maternal Prepregnancy Weight Status and Adolescent Eating Disorder Behaviors", *Epidemiology* 2018

A: Prepregnancy maternal BMI

Y: Binge eating score at 13/14y

M_1: Childhood growth 8-12y

M_2: Maternal food avoidance at 8y

	Effect of Maternal overweight Mean difference	95% CI
Total	0.25	0.18, 0.32
Direct	-0.02	-0.08, 0.05
Indirect via growth	0.28	0.23, 0.33
Indirect via environment	-0.02	-0.04, -0.01

- Administrative databases
- High-dimensional covariates

- Linked administrative data sources increasingly available for:
  - comparative effectiveness research
  - policy evaluations
- Recognition of biases potentially affecting such research:
  - Confounding and measurement error
  - Selection bias
  - Lack of positivity
  - Immortal time bias
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- Aim: assess the impact of SEN provision on an unauthorised absences for children with a certain health needs
- Data: ECHILD, linked educational and health records across England
- Many challenges including high-dimensionality of confounders
- Results with/without (correct) lasso selection (using `telasso`)‡:

‡As developed by Chernozhukov (2018); Code to be deposited in GitHub

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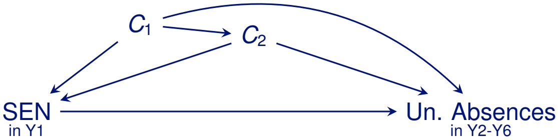

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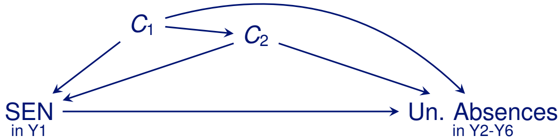

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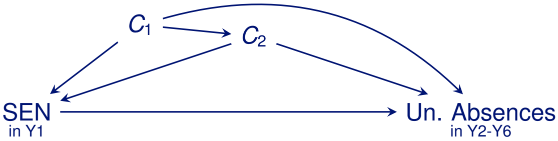

- Many challenges including high-dimensionality of confounders
- Results with/without (correct) lasso selection (using `telasso`)[‡]:

Effect of SEN in Y1	Rate Ratio	95% CI
Crude	1.22	1.11, 1.34
AIPW-lasso with int.	0.80	0.66, 0.95

[‡] As developed by Chernozhukov (2018); Code to be deposited in GitHub

Final thoughts . . .

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- Wonderful Stata community
- Cross-pollination of biostatisticians and econometricians
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Thank you for listening!