International trends in the incidence of diabetes in young people

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https://github.com/jimb0w/YO

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Contents

1 Preface

The methods used in this analyses are drawn heavily/almost entirely from Bendix Carstensen (see [1, 2]).
To generate this document, the Stata package texdoc [3] was used, which is available from: http://repec.sowi.unibe.ch/stata/texdoc/ (accessed 14 November 2022). The final Stata do file and this pdf are available at: https://github.com/jimb0w/YO . The ordinal colour schemes used are *inferno* and *viridis* from the *viridis* package [4].

2 Crude rates

We start by examining crude incidence rates for each country. We will generate a table showing the overall counts for each country, then plots of the crude incidence of each type of diabetes by sex and year. Also, because the diabetes type definitions require two years of non-insulin use to be effective, we will drop all data from 2021 or later.

```
cd "/Users/jed/Documents/YO"
import delimited "Consortium young-onset diabetes_incidence v7.csv", varnames(1) clear
drop if cal >= 2021
bysort country (cal sex age) : egen lb = min(cal)
bysort country (cal sex age) : egen ub = max(cal)
tostring lb ub, replace
gen rang = lb+ "-" + ub
collapse (sum) inc_t1d inc_t2d inc_uncertaint pys_nondm, by(country sex rang)
tostring inc_t1d-inc_u, replace format(%15.0fc) force
tostring pys, force replace format(%15.0fc)
bysort country (sex) : replace rang = "" if _n == 2
bysort country (sex) : replace country = "" if _n == 2
order country rang
replace sex = "Female" if sex == "F"
replace sex = "Male" if sex == "M"
export delimited using T1.csv, delimiter(":") novarnames replace
```

Table 2.1: Incident diabetes cases and person-years of follow-up in people without diabetes for people aged 15-39, by country and sex.

Country	Period	Sex	Type 1 diabetes	Type 2 diabetes	Uncertain diabetes type	Person-years in people without diabetes
Australia	2005-2017	Female	3,817	18,910	10,347	39,967,776
		Male	5,357	23,862	5,692	40,607,882
Catalonia, Spain	2006-2020	Female	3,682	9,739	4,278	13,981,377
		Male	2,083	10,787	2,806	14,761,347
Denmark	2000-2020	Female	2,504	9,204	389	17,979,725
		Male	4,243	11,621	548	18,521,723
Finland	2000-2017	Female	1,834	8,719	3,765	14,448,475
		Male	3,389	9,616	2,935	15,147,484
Hungary	2014-2018	Female	658	5,700	706	7,593,313
		Male	1,265	4,999	1,319	7,937,813
Japan	2015-2018	Female	3,854	40,969	9,526	68,009,304
		Male	3,170	74,592	15,542	64,097,170
Scotland	2010-2020	Female	1,187	5,649	2,071	9,335,113
		Male	1,887	7,180	1,836	9,233,299
South Korea	2007-2019	Female	85	3,054	414	2,300,142
		Male	44	5,507	557	2,477,829

```
import delimited "Consortium young-onset diabetes_incidence v7.csv", varnames(1) clear
drop if cal >= 2021
collapse (sum) inc_t1d inc_t2d inc_uncertaint pys_nondm, by(country calendar_yr)
gen inc1 = 1000*inc_t1d/pys_nondm
gen inc2 = 1000*inc_t2d/pys_nondm
gen inc3 = 1000*inc_unc/pys_nondm
forval i = 1/8 {
if `i´ == 1 {
local c = "Australia"
```

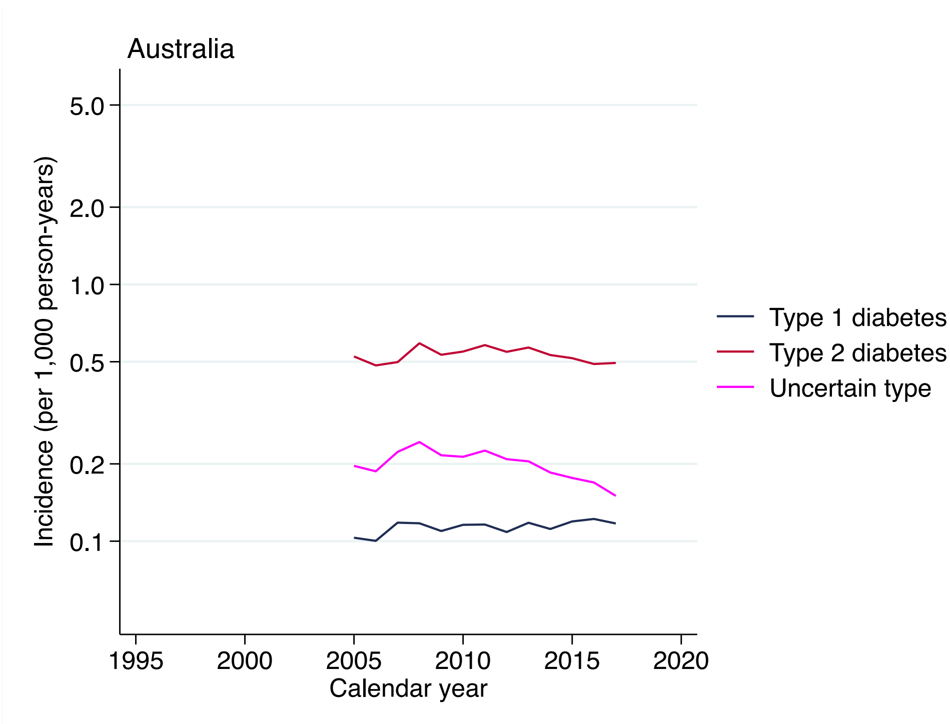

Figure 2.1: Crude incidence of diabetes in Australia among people aged 15-39 years, by diabetes type

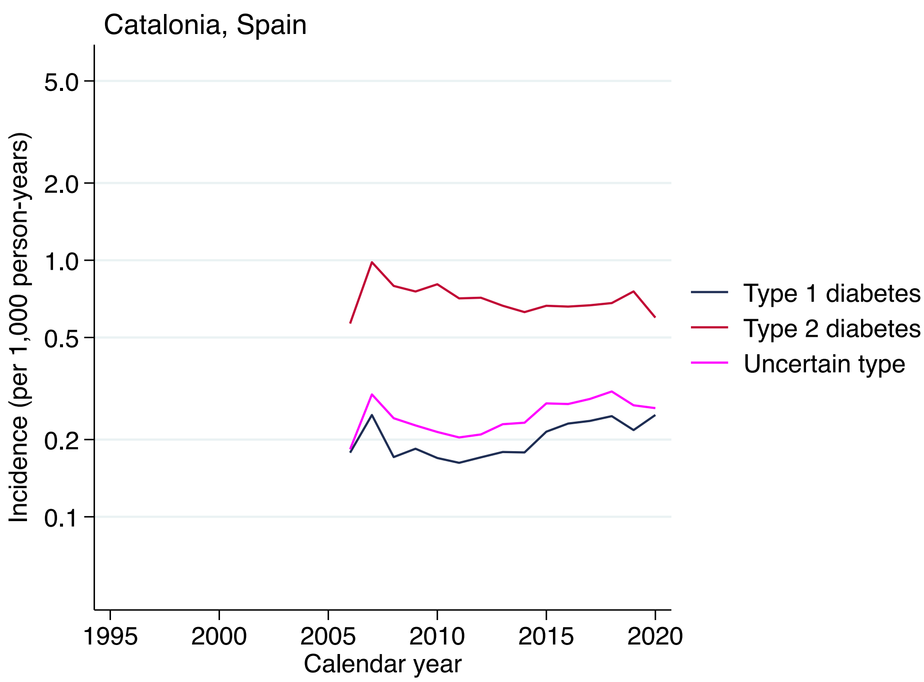

Figure 2.2: Crude incidence of diabetes in Catalonia, Spain among people aged 15-39 years, by diabetes type

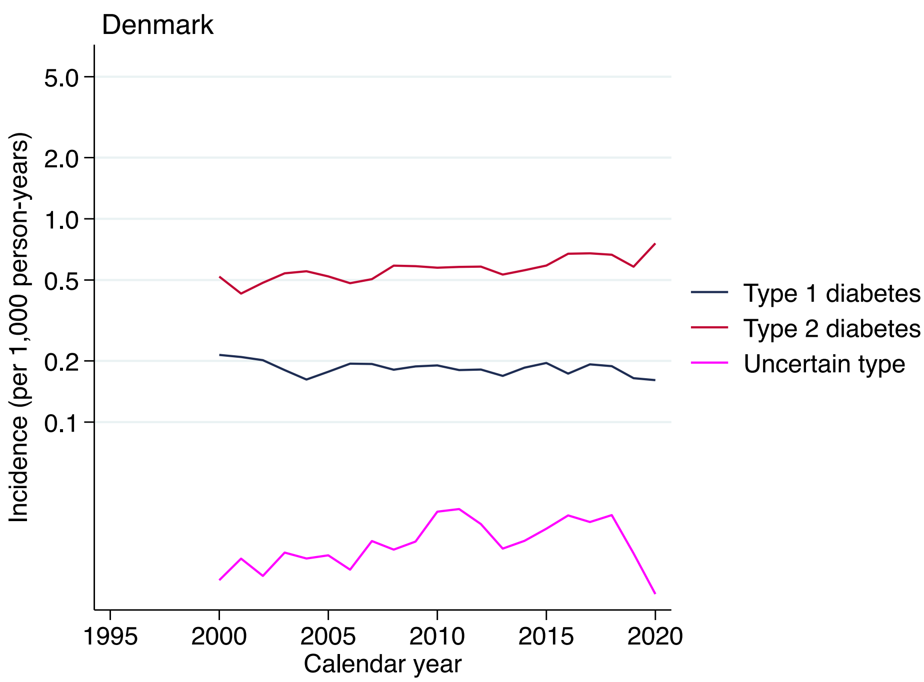

Figure 2.3: Crude incidence of diabetes in Denmark among people aged 15-39 years, by diabetes type

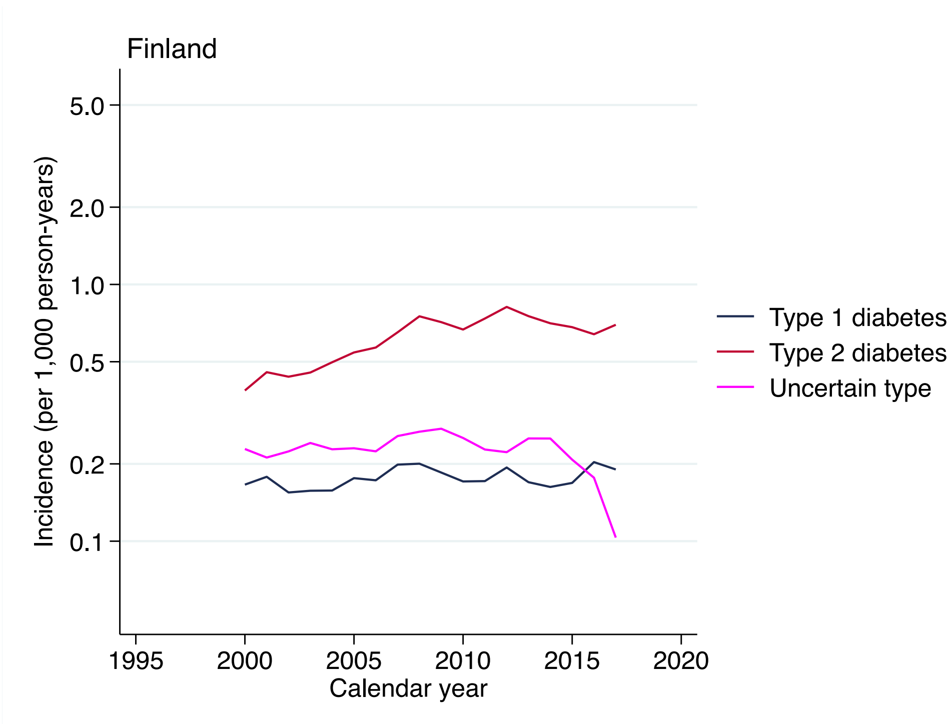

Figure 2.4: Crude incidence of diabetes in Finland among people aged 15-39 years, by diabetes type

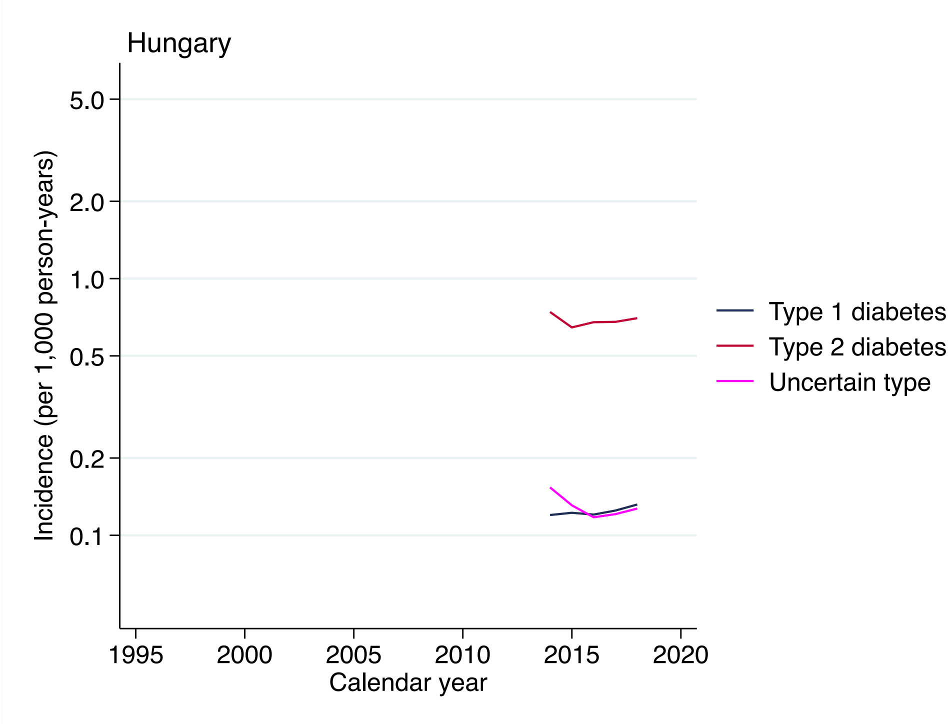

Figure 2.5: Crude incidence of diabetes in Hungary among people aged 15-39 years, by diabetes type

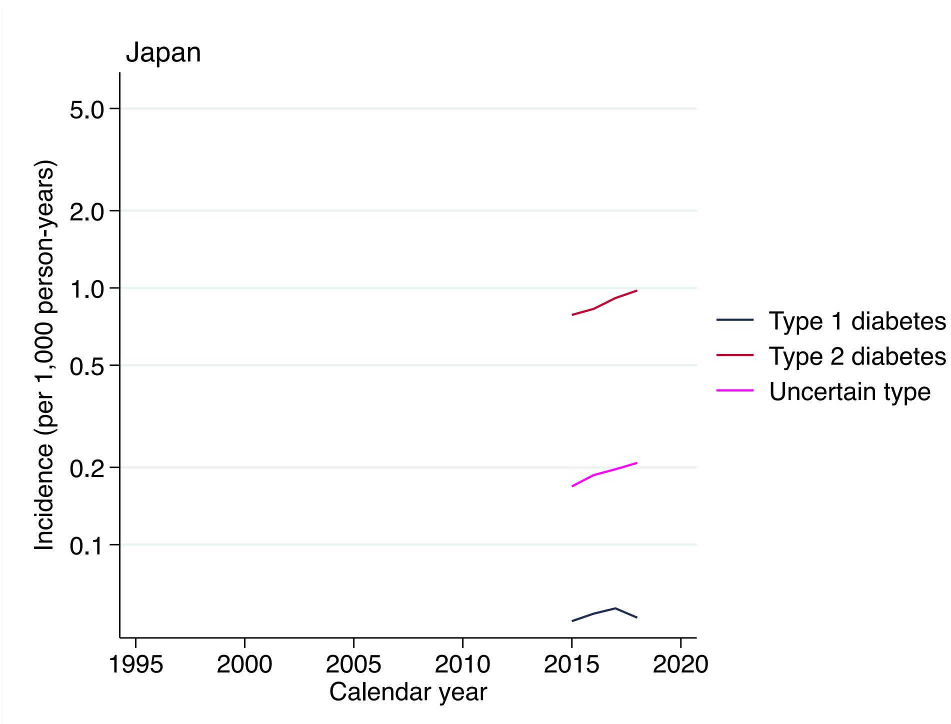

Figure 2.6: Crude incidence of diabetes in Japan among people aged 15-39 years, by diabetes type

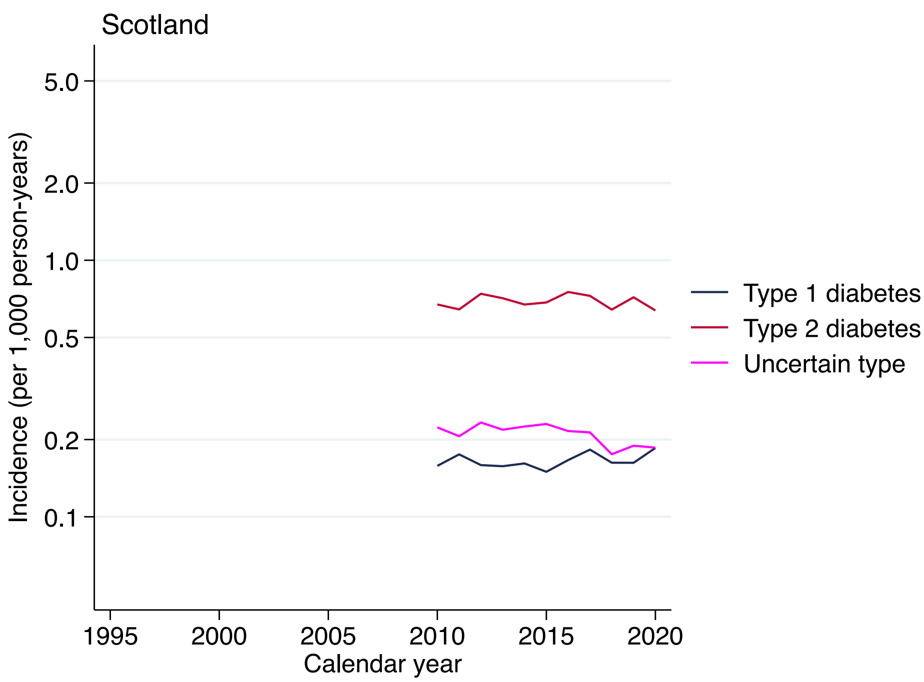

Figure 2.7: Crude incidence of diabetes in Scotland among people aged 15-39 years, by diabetes type

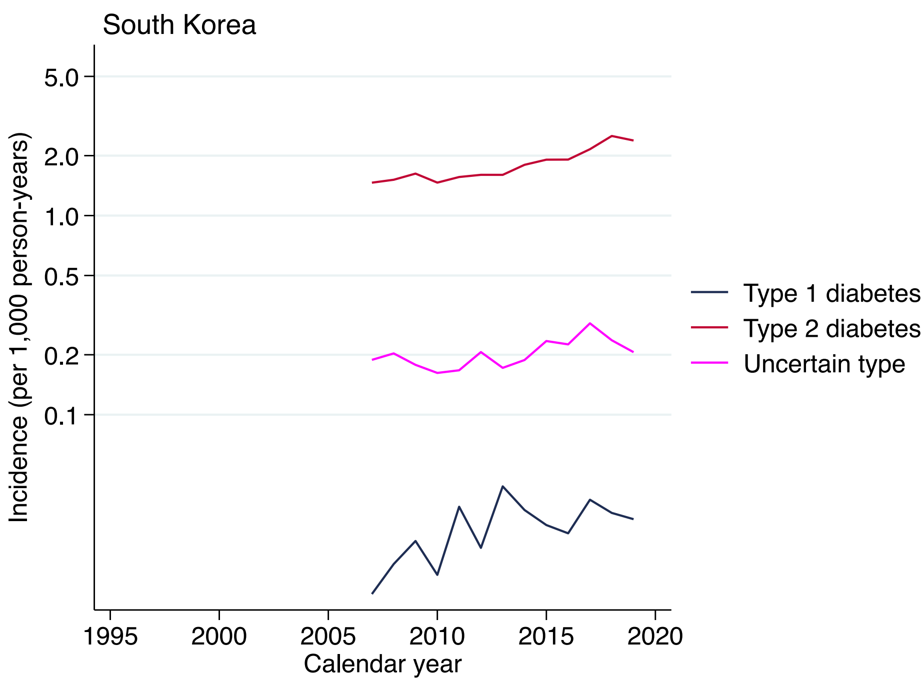

Figure 2.8: Crude incidence of diabetes in South Korea among people aged 15-39 years, by diabetes type

```
}
if `i´ == 2 {
local c = "Catalonia, Spain"
}
if `i´ == 3 {
local c = "Denmark"
}
if `i´ == 4 {
local c = "Finland"
}
if `i´ == 5 {
local c = "Hungary"
}
if `i´ == 6 {
local c = "Japan"
}
if `i´ == 7 {
local c = "Scotland"
}
if `i´ == 8 {
local c = "South Korea"
}
twoway ///
(line inc1 calendar if country == "`c´", color(dknavy)) ///
(line inc2 calendar if country == "`c´", color(cranberry)) ///
(line inc3 calendar if country == "`c´", color(magenta)) ///
, legend(symxsize(0.13cm) position(3) region(lcolor(white) color(none)) ///
order(1 "Type 1 diabetes" ///
2 "Type 2 diabetes" ///
3 "Uncertain type") ///
rows(3)) ///
graphregion(color(white)) ///
xlabel(1995(5)2020) ///
ylabel(0.1 0.2 0.5 1 2 5, angle(0) format(%9.1f)) ///
yscale(log range(0.05 6)) ///
ytitle("Incidence (per 1,000 person-years)") ///
xtitle("Calendar year") ///
title("`c´", placement(west) color(gs0) size(medium))
> rs, by diabetes type)
}


import delimited "Consortium young-onset diabetes_incidence v7.csv", varnames(1) clear
drop if cal >= 2021
collapse (sum) inc_t1d inc_t2d inc_uncertaint pys_nondm, by(country sex calendar_yr)
gen inc1 = 1000*inc_t1d/pys_nondm
gen inc2 = 1000*inc_t2d/pys_nondm
gen inc3 = 1000*inc_unc/pys_nondm
forval i = 1/8 {
if `i´ == 1 {
local c = "Australia"
}
if `i´ == 2 {
local c = "Catalonia, Spain"
}
if `i´ == 3 {
local c = "Denmark"
}
if `i´ == 4 {
local c = "Finland"
}
if `i´ == 5 {
local c = "Hungary"
}
if `i´ == 6 {
local c = "Japan"
}
if `i´ == 7 {
local c = "Scotland"
```

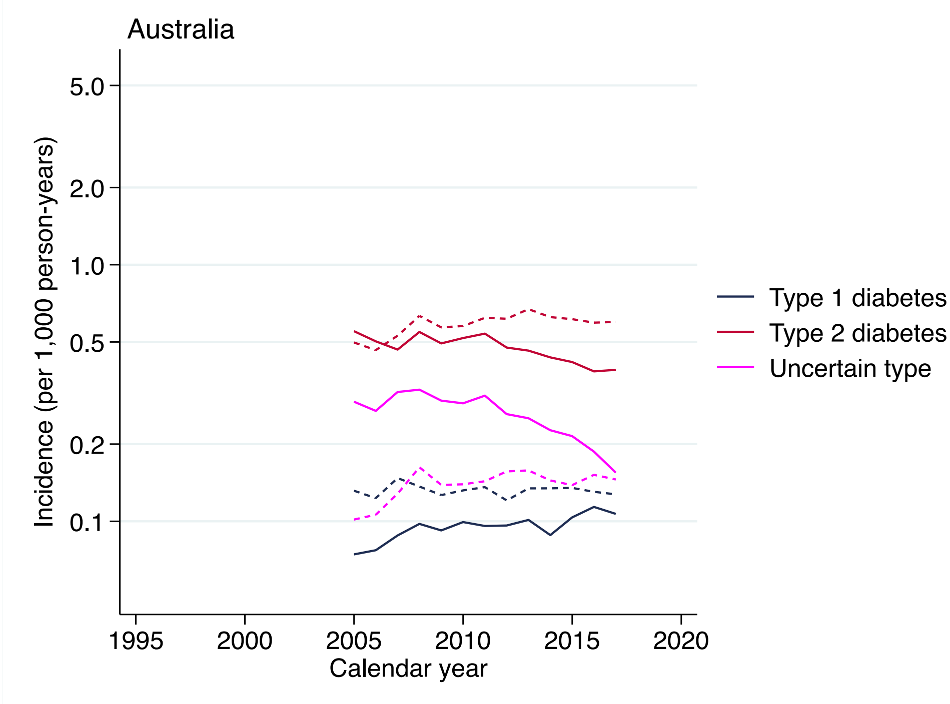

Figure 2.9: Crude incidence of diabetes in Australia among people aged 15-39 years, by diabetes type and sex. Females = solid connecting lines; males = dashed connecting lines.

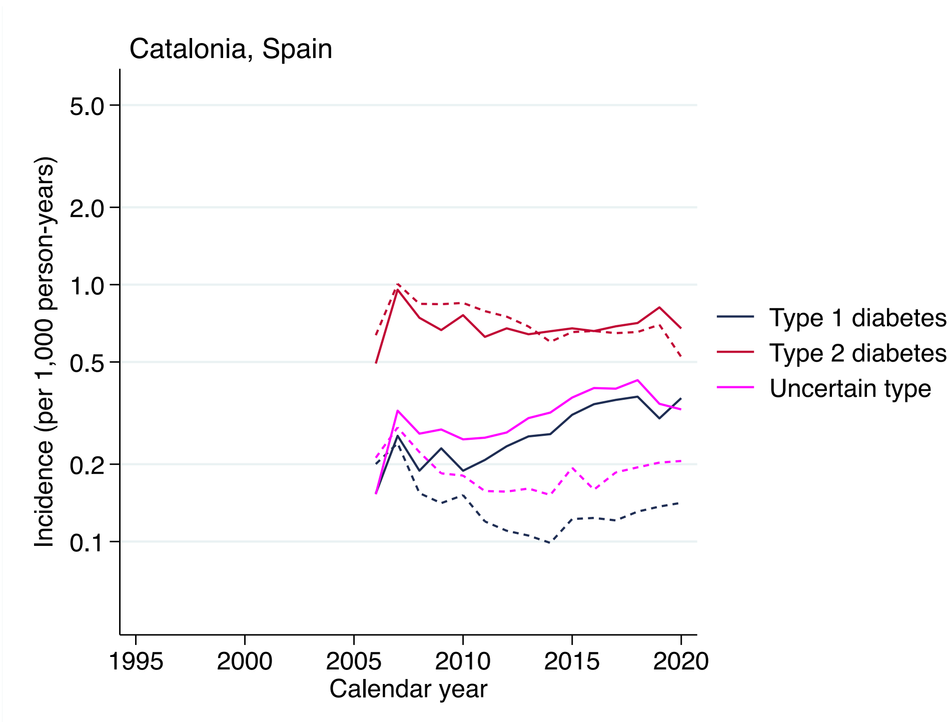

Figure 2.10: Crude incidence of diabetes in Catalonia, Spain among people aged 15-39 years, by diabetes type and sex. Females = solid connecting lines; males = dashed connecting lines.

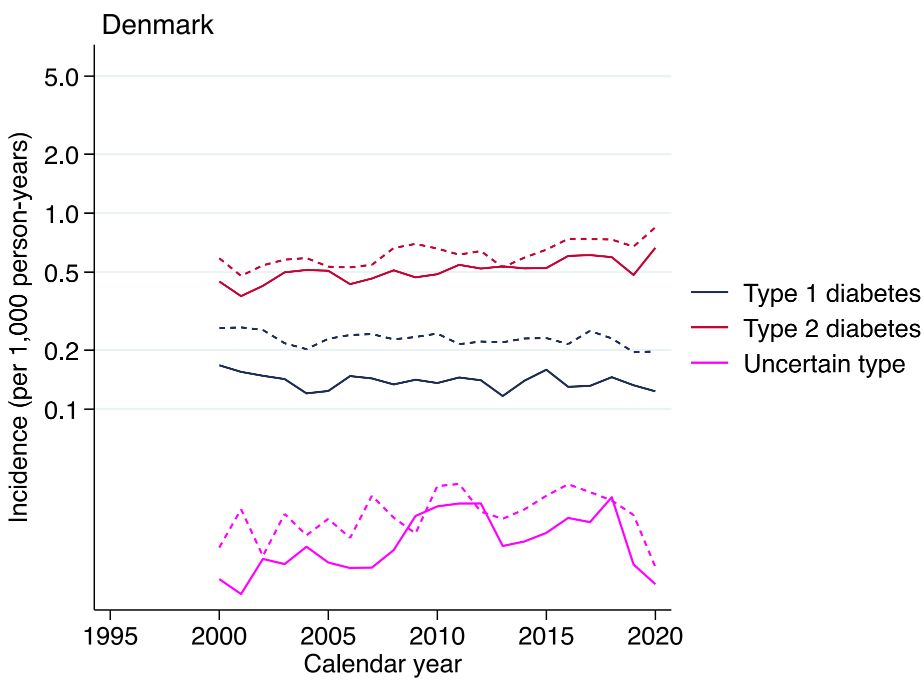

Figure 2.11: Crude incidence of diabetes in Denmark among people aged 15-39 years, by diabetes type and sex. Females = solid connecting lines; males = dashed connecting lines.

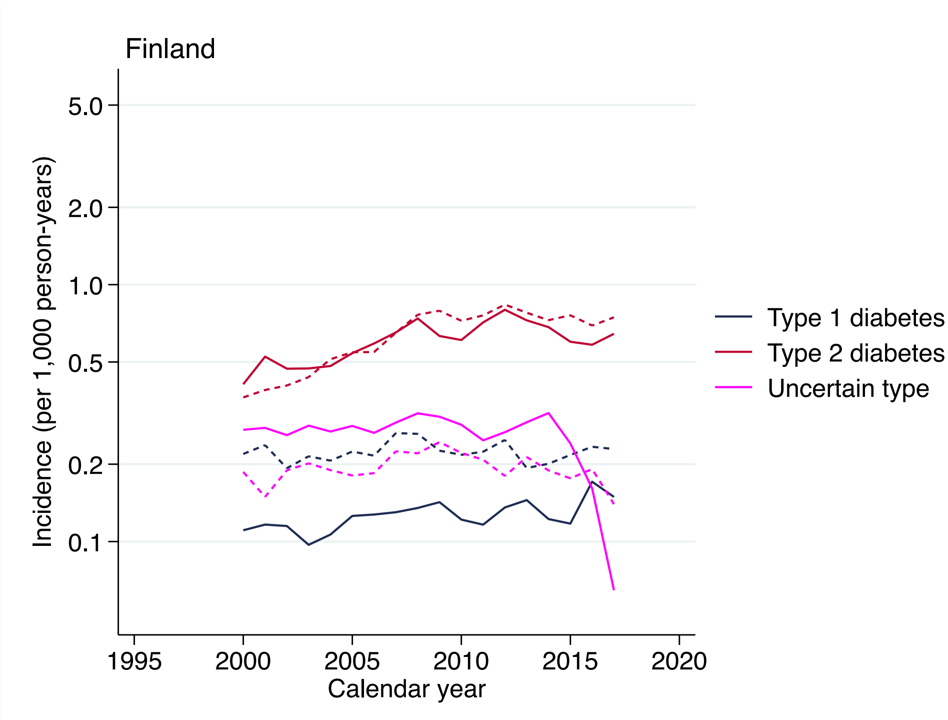

Figure 2.12: Crude incidence of diabetes in Finland among people aged 15-39 years, by diabetes type and sex. Females = solid connecting lines; males = dashed connecting lines.

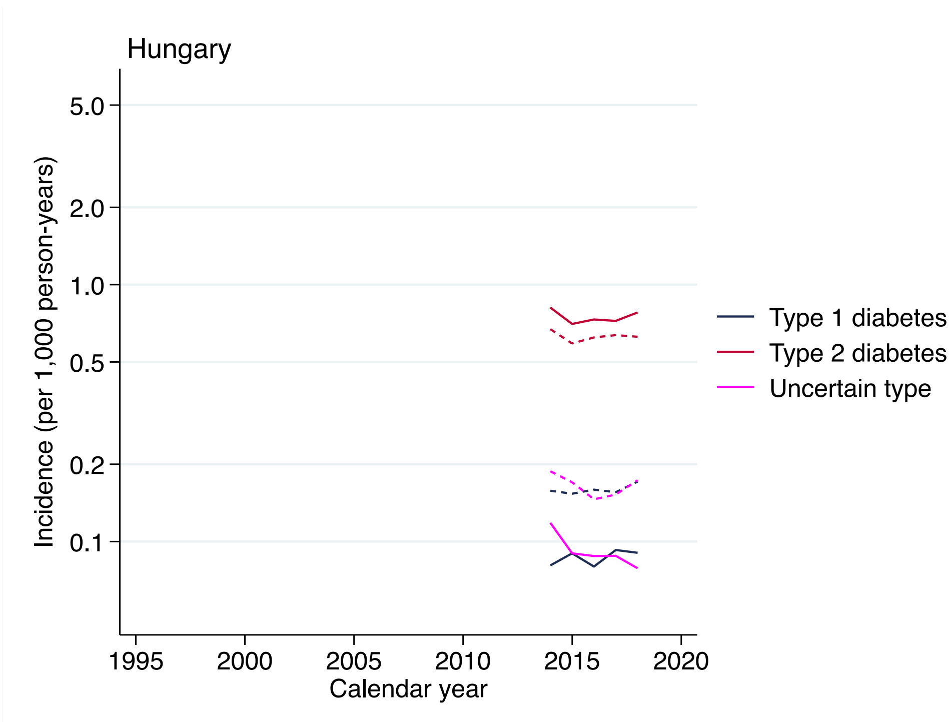

Figure 2.13: Crude incidence of diabetes in Hungary among people aged 15-39 years, by diabetes type and sex. Females = solid connecting lines; males = dashed connecting lines.

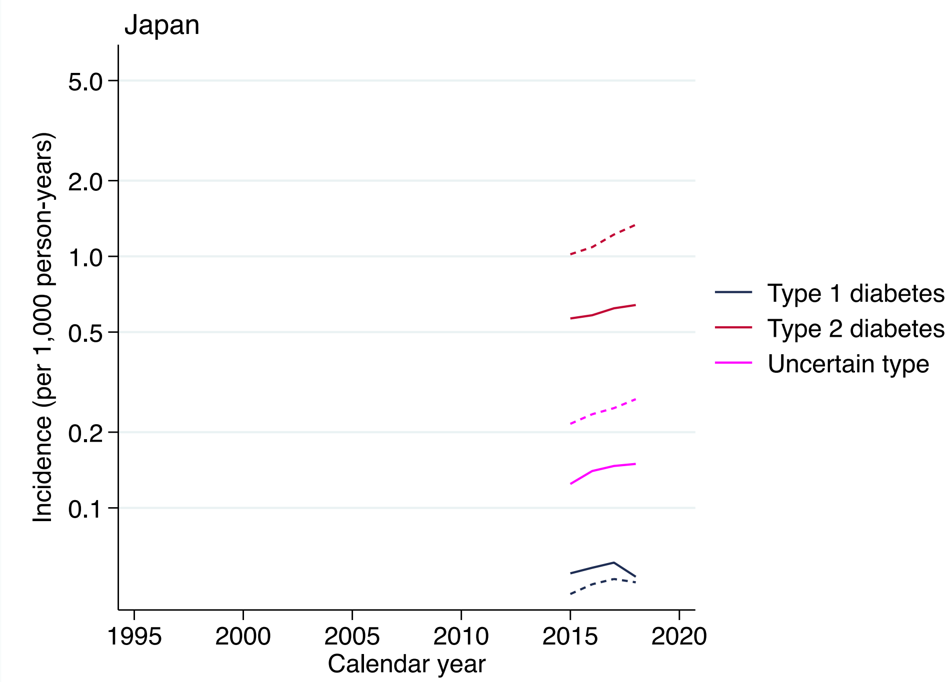

Figure 2.14: Crude incidence of diabetes in Japan among people aged 15-39 years, by diabetes type and sex. Females = solid connecting lines; males = dashed connecting lines.

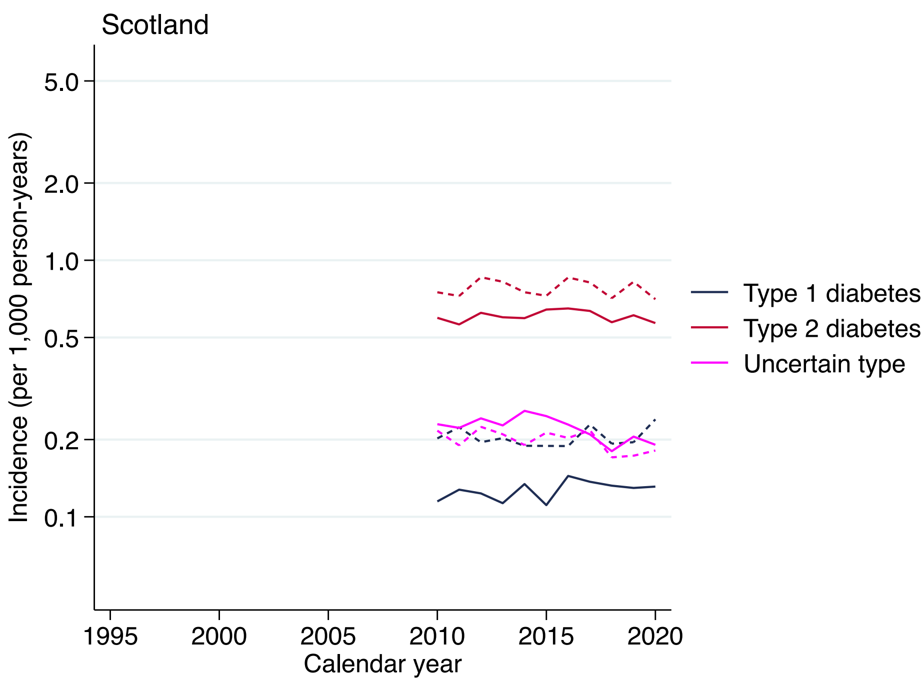

Figure 2.15: Crude incidence of diabetes in Scotland among people aged 15-39 years, by diabetes type and sex. Females = solid connecting lines; males = dashed connecting lines.

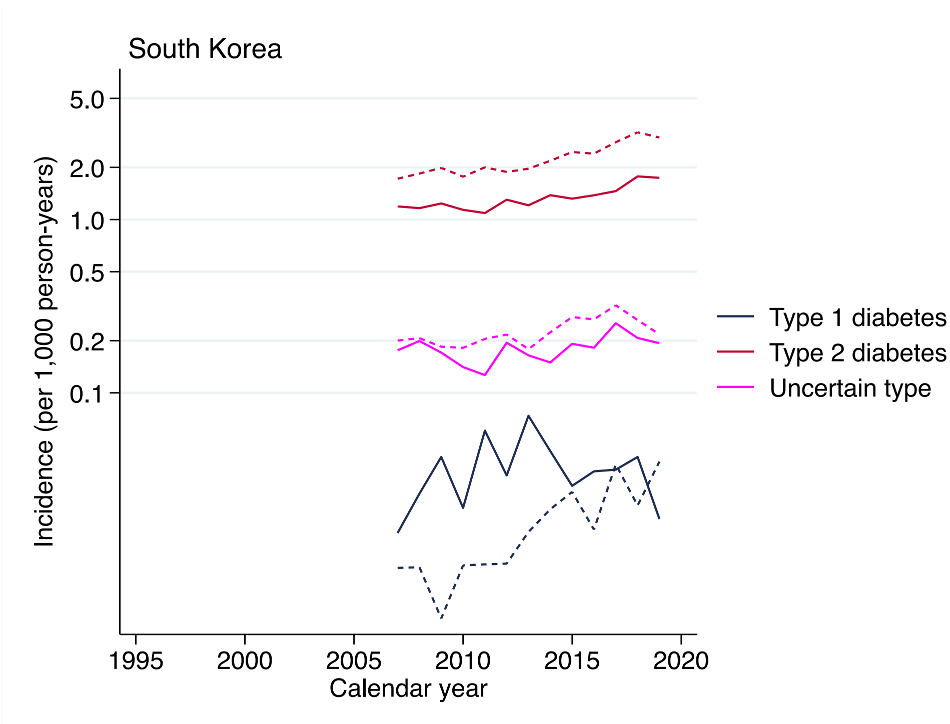

Figure 2.16: Crude incidence of diabetes in South Korea among people aged 15-39 years, by diabetes type and sex. Females = solid connecting lines; males = dashed connecting lines.

```
}
if `i´ == 8 {
local c = "South Korea"
}
twoway ///
(line inc1 calendar if country == "`c´" & sex == "F", color(dknavy)) ///
(line inc1 calendar if country == "`c´" & sex == "M", color(dknavy) lpattern(shortdash)) ///
(line inc2 calendar if country == "`c´" & sex == "F", color(cranberry)) ///
(line inc2 calendar if country == "`c´" & sex == "M", color(cranberry) lpattern(shortdash)) ///
(line inc3 calendar if country == "`c´" & sex == "F", color(magenta)) ///
(line inc3 calendar if country == "`c´" & sex == "M", color(magenta) lpattern(shortdash)) ///
, legend(symxsize(0.13cm) position(3) region(lcolor(white) color(none)) ///
order(1 "Type 1 diabetes" ///
3 "Type 2 diabetes" ///
5 "Uncertain type") ///
rows(3)) ///
graphregion(color(white)) ///
xlabel(1995(5)2020) ///
ylabel(0.1 0.2 0.5 1 2 5, angle(0) format(%9.1f)) ///
yscale(log range(0.05 6)) ///
ytitle("Incidence (per 1,000 person-years)") ///
xtitle("Calendar year") ///
title("`c´", placement(west) color(gs0) size(medium))
> rs, by diabetes type and sex. Females = solid connecting lines; males = dashed connecting lines.)
}
```

3 Age and sex-specific rates

For the analyses, we are going to use Carstensen's Age-Period-Cohort model [2] to estimate the age and sex-specific incidence of type 2 diabetes for each country. For this, we take the incidence and person-years in 5-year age groups, and fit a Poisson model with spline effects of age, period (calendar time; measured from 2010 (i.e., 2010 is set to 0)), and cohort (calendar time minus age). This is done separately for each country and sex. Moreover, because of the different years covered by each dataset, the knot locations are different for each country (and knot placement is as recommended by Harrell [5] for period and cohort effects).

Next, we check these models have fit the data appropriately by investigating the Pearson residuals. Then, we use this model to predict the incidence of diabetes by age and calendar time. These results are presented in figures showing the incidence of type 2 diabetes for each country.

```
forval i = 1/8 {
foreach ii in M F {
foreach iii in inc_t1d inc_t2d inc_uncertaint {
if `i´ == 1 {
local c = "Australia"
}
if `i´ == 2 {
local c = "Catalonia, Spain"
}
if `i´ == 3 {
local c = "Denmark"
}
if `i´ == 4 {
local c = "Finland"
}
if `i´ == 5 {
local c = "Hungary"
}
if `i´ == 6 {
local c = "Japan"
}
if `i´ == 7 {
local c = "Scotland"
}
if `i´ == 8 {
local c = "South Korea"
}
import delimited "Consortium young-onset diabetes_incidence v7.csv", varnames(1) clear
drop if cal >= 2021
if "`iii´" == "inc_t1d" {
drop if age_gp == "35-39"
}
keep if country == "`c´" & sex == "`ii´"
rename age_gp age
replace age = substr(age,1,2)
destring age, replace
replace age = age+2.5
replace calendar = calendar-2010
gen coh = calendar-age
centile(age), centile(5 35 65 95)
local A1 = r(c_1)
local A2 = r(c_2)
local A3 = r(c_3)
local A4 = r(c_4)
mkspline agesp = age, cubic knots(`A1´ `A2´ `A3´ `A4´)
su(calendar), detail
local rang = r(max)-r(min)
if `rang´ < 8 {
centile calendar, centile(25 75)
local CK1 = r(c_1)
```

```
local CK2 = r(c_2)
mkspline timesp = calendar, cubic knots(`CK1´ `CK2´)
}
else if inrange(`rang´,8,11.9) {
centile calendar, centile(10 50 90)
local CK1 = r(c_1)
local CK2 = r(c_2)
local CK3 = r(c_3)
mkspline timesp = calendar, cubic knots(`CK1´ `CK2´ `CK3´)
}
else if inrange(`rang´,12,15.9) {
centile calendar, centile(5 35 65 95)
local CK1 = r(c_1)
local CK2 = r(c_2)
local CK3 = r(c_3)
local CK3 = r(c_4)
mkspline timesp = calendar, cubic knots(`CK1´ `CK2´ `CK3´ `CK4´)
}
else {
centile calendar, centile(5 27.5 50 72.5 95)
local CK1 = r(c_1)
local CK2 = r(c_2)
local CK3 = r(c_3)
local CK3 = r(c_4)
local CK3 = r(c_5)
mkspline timesp = calendar, cubic knots(`CK1´ `CK2´ `CK3´ `CK4´ `CK5´)
}
centile(coh), centile(5 35 65 95)
local CO1 = r(c_1)
local CO2 = r(c_2)
local CO3 = r(c_3)
local CO4 = r(c_4)
mkspline cohsp = coh, cubic knots(`CO1´ `CO2´ `CO3´ `CO4´)
poisson `iii´ agesp* timesp* cohsp*, exposure(pys)
predict pred
save APC_pred_`i´_`ii´_`iii´, replace
keep age calendar pys
expand 50
replace pys=pys/50
bysort cal age : replace age = round(age+((_n/10)-2.6),0.1)
sort age cal
expand 10
sort age cal
bysort age cal : replace cal = cal+(_n/10)-0.1
replace pys = pys/10
gen coh = calendar-age
mkspline agesp = age, cubic knots(`A1´ `A2´ `A3´ `A4´)
if `rang´ < 7.99 {
mkspline timesp = calendar, cubic knots(`CK1´ `CK2´)
}
else if inrange(`rang´,8,11.99) {
mkspline timesp = calendar, cubic knots(`CK1´ `CK2´ `CK3´)
}
else if inrange(`rang´,12,15.99) {
mkspline timesp = calendar, cubic knots(`CK1´ `CK2´ `CK3´ `CK4´)
}
else {
mkspline timesp = calendar, cubic knots(`CK1´ `CK2´ `CK3´ `CK4´ `CK5´)
}
mkspline cohsp = coh, cubic knots(`CO1´ `CO2´ `CO3´ `CO4´)
predict _Rate, ir
predict errr, stdp
replace _Rate = _Rate*1000
gen lb = exp(ln(_Rate)-1.96*errr)
gen ub = exp(ln(_Rate)+1.96*errr)
gen country = "`c´"
gen sex = "`ii´"
gen OC = "`iii´"
```

```
replace cal = cal+2010
tostring age, replace force format(%9.1f)
destring age, replace
save APC_Rate_`i´_`ii´_`iii´, replace
}
}
}
forval i = 1/8 {
foreach ii in M F {
foreach iii in inc_t1d inc_t2d inc_uncertaint {
if `i´ == 1 {
local c = "Australia"
}
if `i´ == 2 {
local c = "Catalonia, Spain"
}
if `i´ == 3 {
local c = "Denmark"
}
if `i´ == 4 {
local c = "Finland"
}
if `i´ == 5 {
local c = "Hungary"
}
if `i´ == 6 {
local c = "Japan"
}
if `i´ == 7 {
local c = "Scotland"
}
if `i´ == 8 {
local c = "South Korea"
}
if "`ii´" == "M" {
local s = "Males"
use viridis, clear
local col1 = var6[6]
local col2 = var6[5]
local col3 = var6[4]
local col4 = var6[3]
local col5 = var6[2]
}
else {
local s = "Females"
use inferno, clear
local col1 = var6[6]
local col2 = var6[5]
local col3 = var6[4]
local col4 = var6[3]
local col5 = var6[2]
}
if "`iii´" == "inc_t1d" {
local oc = "Type 1 diabetes"
}
else if "`iii´" == "inc_t2d" {
local oc = "Type 2 diabetes"
}
else {
local oc = "Uncertain diabetes type"
}
use APC_pred_`i´_`ii´_`iii´, clear
gen res = (`iii´-pred)/sqrt(pred)
twoway ///
(scatter res age, col(black)) ///
, legend(off) ///
graphregion(color(white)) ///
ylabel(, format(%9.0f) grid angle(0)) ///
```

```
ytitle("Pearson residuals", margin(a+2)) ///
xtitle("Age (years)") ///
title("`c´ - `oc´ - `s´", placement(west) color(black) size(medium))
graph save CRJ_1_`i´_`ii´_`iii´, replace
twoway ///
(scatter res cal, col(black)) ///
, legend(off) ///
graphregion(color(white)) ///
ylabel(, format(%9.0f) grid angle(0)) ///
ytitle("Pearson residuals", margin(a+2)) ///
xtitle("Calendar time (years)") ///
title("`c´ - `oc´ - `s´", placement(west) color(black) size(medium))
graph save CRJ_2_`i´_`ii´_`iii´, replace
twoway ///
(scatter res coh, col(black)) ///
, legend(off) ///
graphregion(color(white)) ///
ylabel(, format(%9.0f) grid angle(0)) ///
ytitle("Pearson residuals", margin(a+2)) ///
xtitle("Cohort (years)") ///
title("`c´ - `oc´ - `s´", placement(west) color(black) size(medium))
graph save CRJ_3_`i´_`ii´_`iii´, replace
use APC_Rate_`i´_`ii´_`iii´, clear
twoway ///
(rarea ub lb calendar if age == 15, color("`col1´%30") fintensity(inten80) lwidth(none)) ///
(line _Rate calendar if age == 15, color("`col1´") lpattern(solid)) ///
(rarea ub lb calendar if age == 20, color("`col2´%30") fintensity(inten80) lwidth(none)) ///
(line _Rate calendar if age == 20, color("`col2´") lpattern(solid)) ///
(rarea ub lb calendar if age == 25, color("`col3´%30") fintensity(inten80) lwidth(none)) ///
(line _Rate calendar if age == 25, color("`col3´") lpattern(solid)) ///
(rarea ub lb calendar if age == 30, color("`col4´%30") fintensity(inten80) lwidth(none)) ///
(line _Rate calendar if age == 30, color("`col4´") lpattern(solid)) ///
(rarea ub lb calendar if age == 35, color("`col5´%30") fintensity(inten80) lwidth(none)) ///
(line _Rate calendar if age == 35, color("`col5´") lpattern(solid)) ///
, legend(symxsize(0.13cm) position(3) region(lcolor(white) color(none)) ///
order(10 "35" ///
8 "30" ///
6 "25" ///
4 "20" ///
2 "15") ///
cols(1)) ///
graphregion(color(white)) ///
ylabel(0.002 "0.002" ///
0.005 "0.005" ///
0.01 "0.01" ///
0.02 "0.02" ///
0.05 "0.05" ///
0.1 "0.1" ///
0.2 "0.2" ///
0.5 "0.5" ///
1.0 "1.0" ///
2.0 "2.0" ///
5.0 "5.0", format(%9.3f) grid angle(0)) ///
yscale(range(0.001 5.05) log) ///
xscale(range(1995 2020)) ///
xlabel(1995(5)2020, nogrid) ///
ytitle("Incidence (per 1,000 person-years)", margin(a+2)) ///
xtitle("Calendar year") ///
title("`c´ - `oc´ - `s´", placement(west) color(black) size(medium))
graph save "Graph" Escape_`i´_`ii´_`iii´, replace
egen calmin = min(calendar)
egen calmen = mean(calendar)
replace calmen = round(calmen,1)
egen calmax = max(calendar)
replace calmax = calmax-0.9
local cmn = calmin[1]
local cmu = calmen[1]
local cmx = calmax[1]
```

```
if "`iii´" == "inc_t1d" {
local ylab = "0(0.2)0.8"
local yft = "%9.2f"
}
if "`iii´" == "inc_t2d" {
local ylab = "0(1)10"
local yft = "%9.0f"
}
if "`iii´" == "inc_uncertaint" {
local ylab = "0(0.2)0.8"
local yft = "%9.1f"
}
twoway ///
(rarea ub lb age if calendar == calmin, color("`col1´%30") fintensity(inten80) lwidth(none)) ///
(line _Rate age if calendar == calmin, color("`col1´") lpattern(solid)) ///
(rarea ub lb age if calendar == calmen, color("`col3´%30") fintensity(inten80) lwidth(none)) ///
(line _Rate age if calendar == calmen, color("`col3´") lpattern(solid)) ///
(rarea ub lb age if calendar == calmax, color("`col5´%30") fintensity(inten80) lwidth(none)) ///
(line _Rate age if calendar == calmax, color("`col5´") lpattern(solid)) ///
, legend(symxsize(0.13cm) position(3) region(lcolor(white) color(none)) ///
order(2 "`cmn´" ///
4 "`cmu´" ///
6 "`cmx´") ///
cols(1)) ///
graphregion(color(white)) ///
ylabel(`ylab´, format(`yft´) grid angle(0)) ///
xscale(range(15 40)) ///
xlabel(15(5)40, nogrid) ///
ytitle("Incidence (per 1,000 person-years)", margin(a+2)) ///
xtitle("Age (years)") ///
title("`c´ - `oc´ - `s´", placement(west) color(black) size(medium))
graph save "Graph" TTFATF_`i´_`ii´_`iii´, replace
}
}
}


forval i = 1/8 {
if `i´ == 1 {
local c = "Australia"
}
if `i´ == 2 {
local c = "Catalonia, Spain"
}
if `i´ == 3 {
local c = "Denmark"
}
if `i´ == 4 {
local c = "Finland"
}
if `i´ == 5 {
local c = "Hungary"
}
if `i´ == 6 {
local c = "Japan"
}
if `i´ == 7 {
local c = "Scotland"
}
if `i´ == 8 {
local c = "South Korea"
}
graph combine ///
CRJ_1_`i´_F_inc_t1d.gph ///
CRJ_2_`i´_F_inc_t1d.gph ///
CRJ_3_`i´_F_inc_t1d.gph ///
CRJ_1_`i´_M_inc_t1d.gph ///
CRJ_2_`i´_M_inc_t1d.gph ///
CRJ_3_`i´_M_inc_t1d.gph ///
```

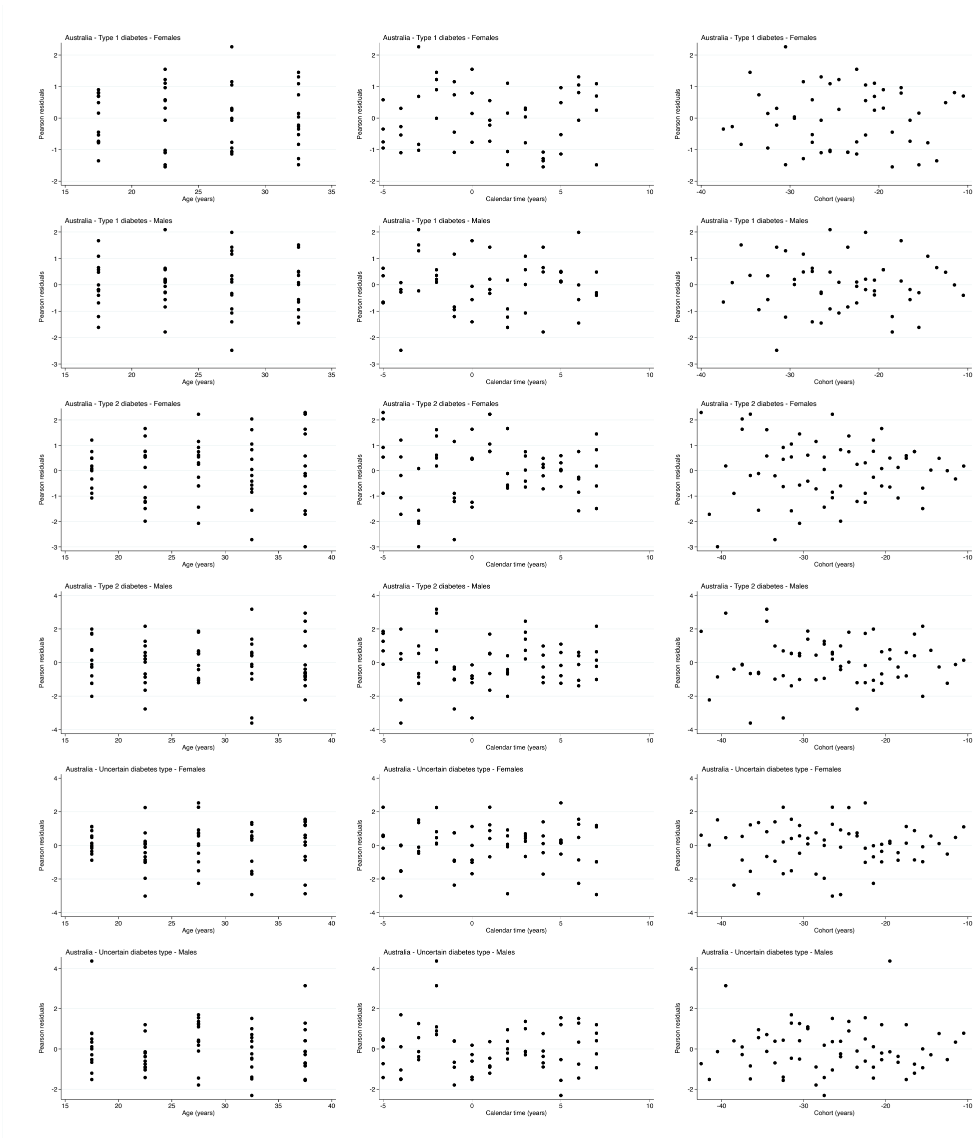

Figure 3.1: Pearson residuals for the age-period-cohort model in Australia, by diabetes type and sex

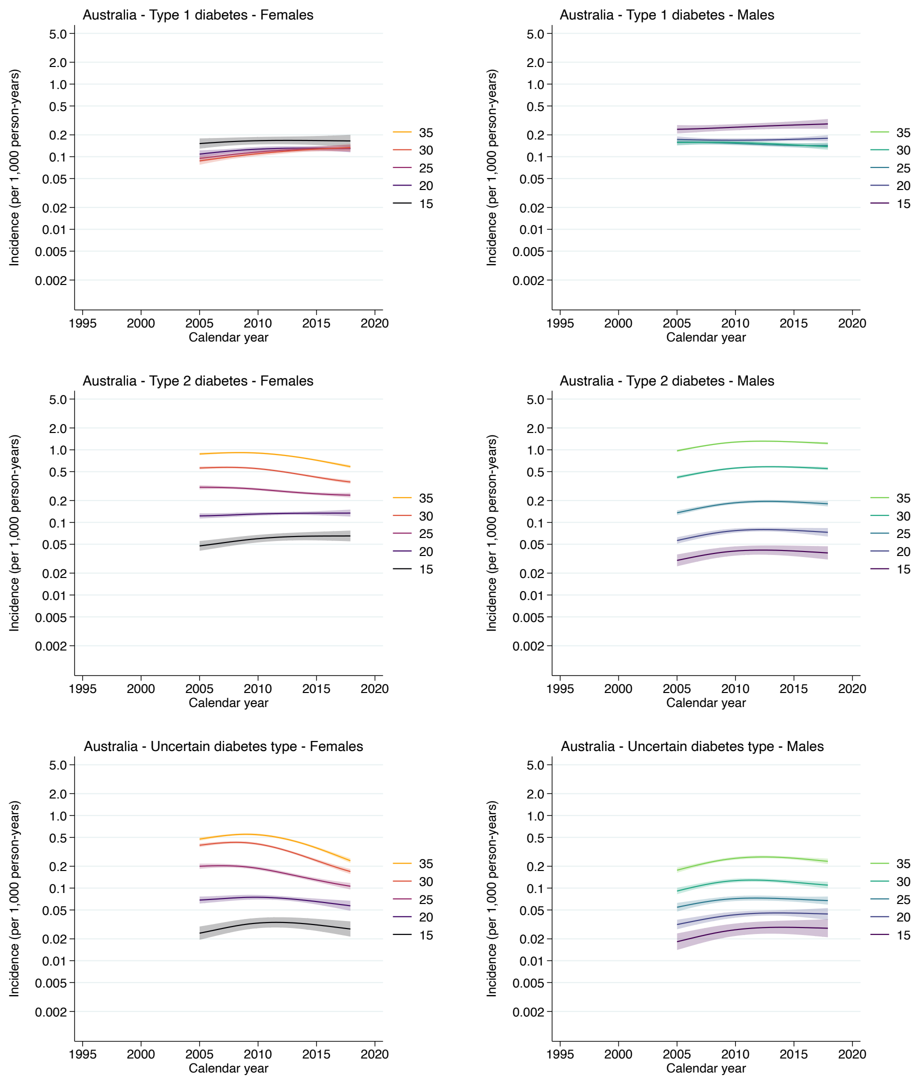

Figure 3.2: Incidence of diabetes in Australia for people aged 15, 20, 25, 30, and 35 years, by diabetes type and sex

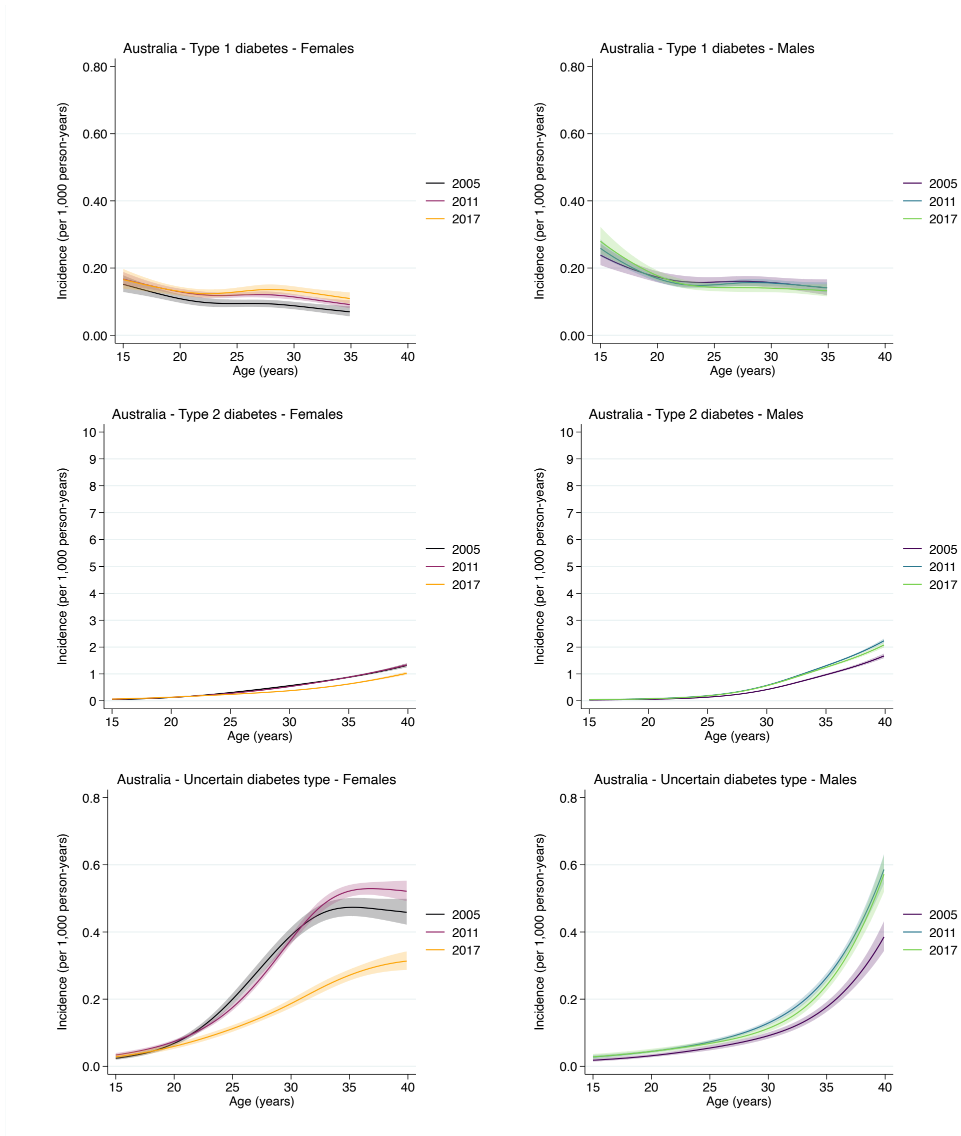

Figure 3.3: Incidence of diabetes in Australia by age for the first, middle, and last calendar year of follow-up, by diabetes type and sex

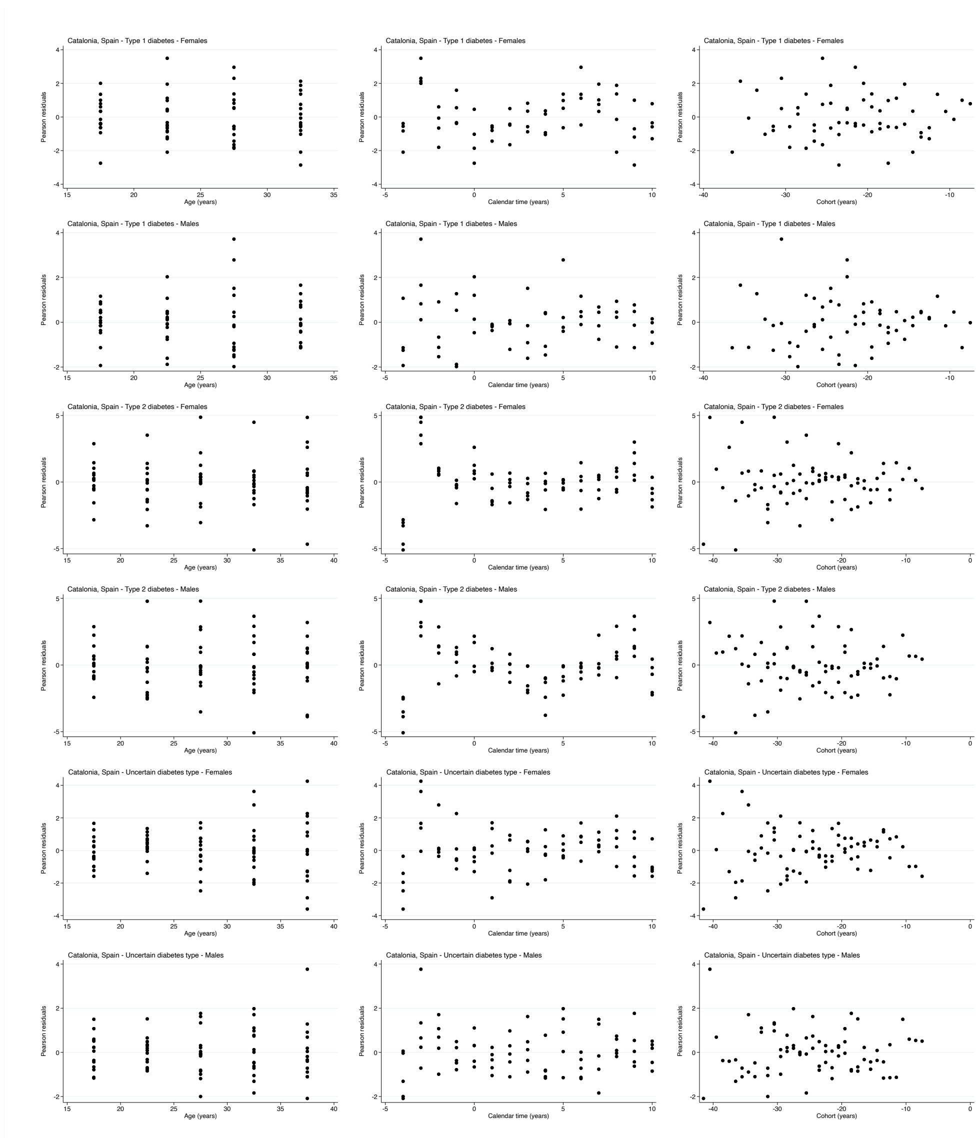

Figure 3.4: Pearson residuals for the age-period-cohort model in Catalonia, Spain, by diabetes type and sex

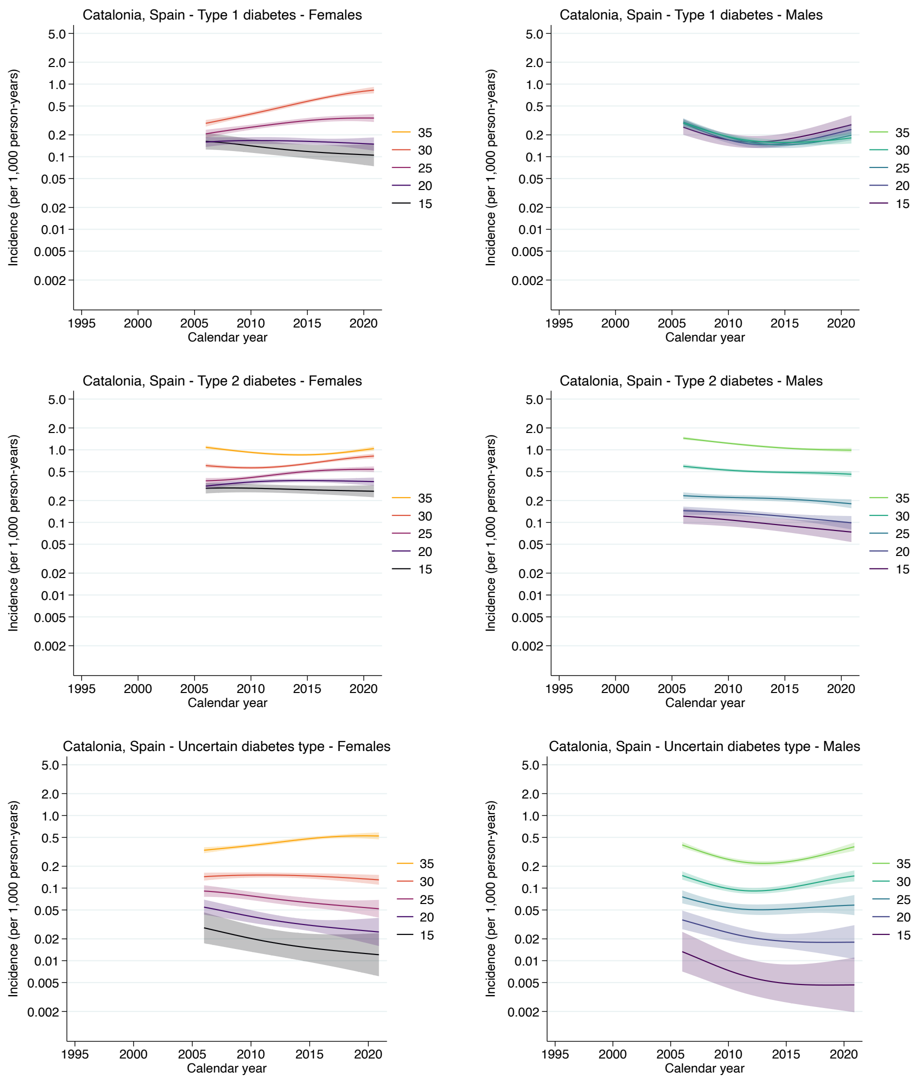

Figure 3.5: Incidence of diabetes in Catalonia, Spain for people aged 15, 20, 25, 30, and 35 years, by diabetes type and sex

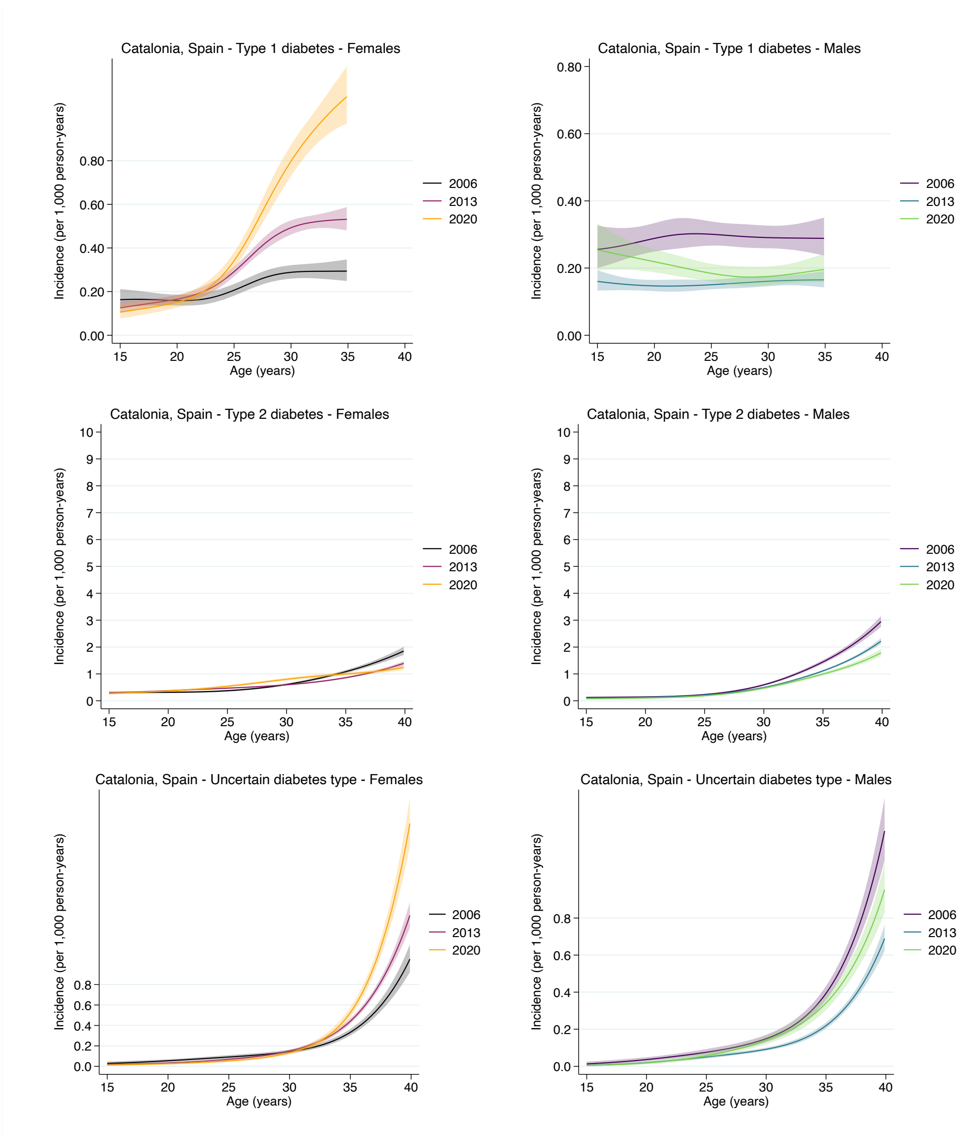

Figure 3.6: Incidence of diabetes in Catalonia, Spain by age for the first, middle, and last calendar year of follow-up, by diabetes type and sex

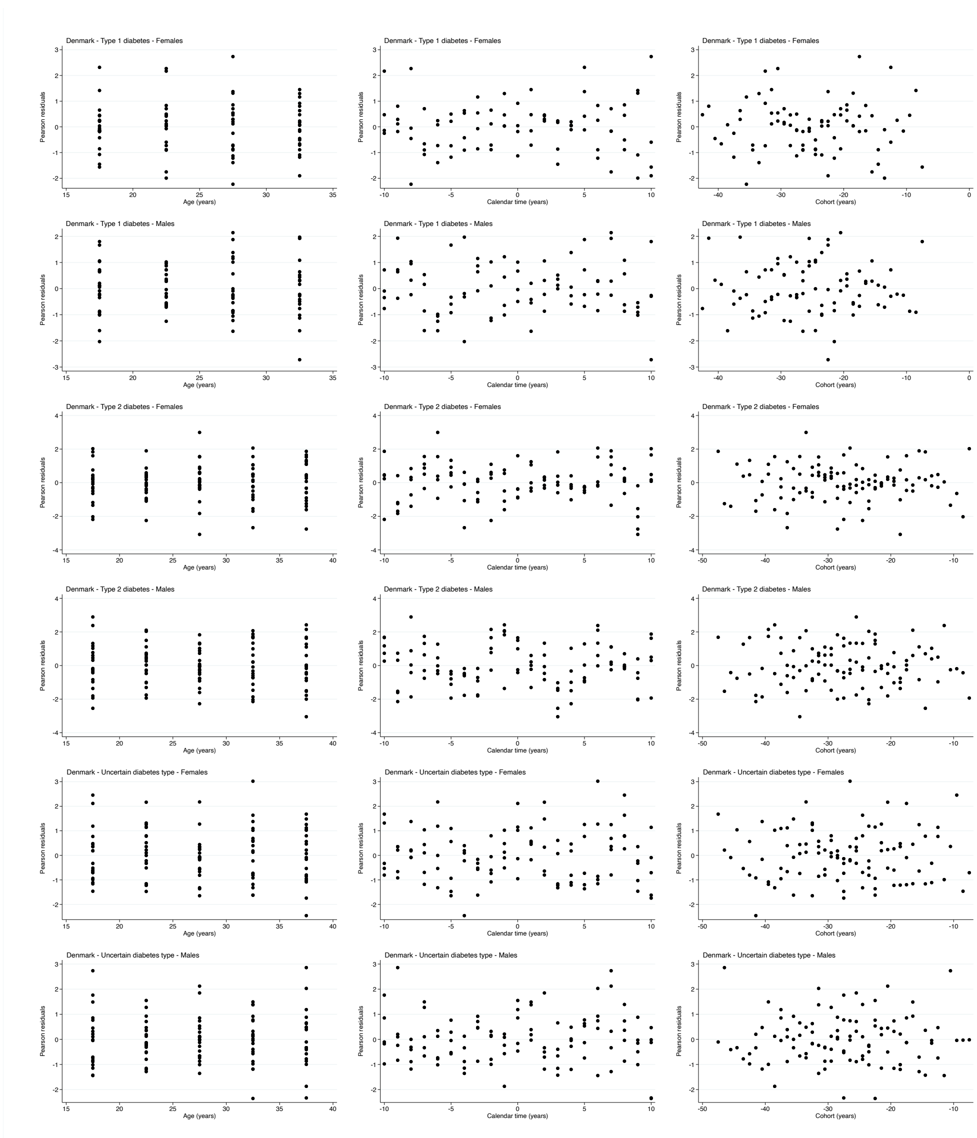

Figure 3.7: Pearson residuals for the age-period-cohort model in Denmark, by diabetes type and sex

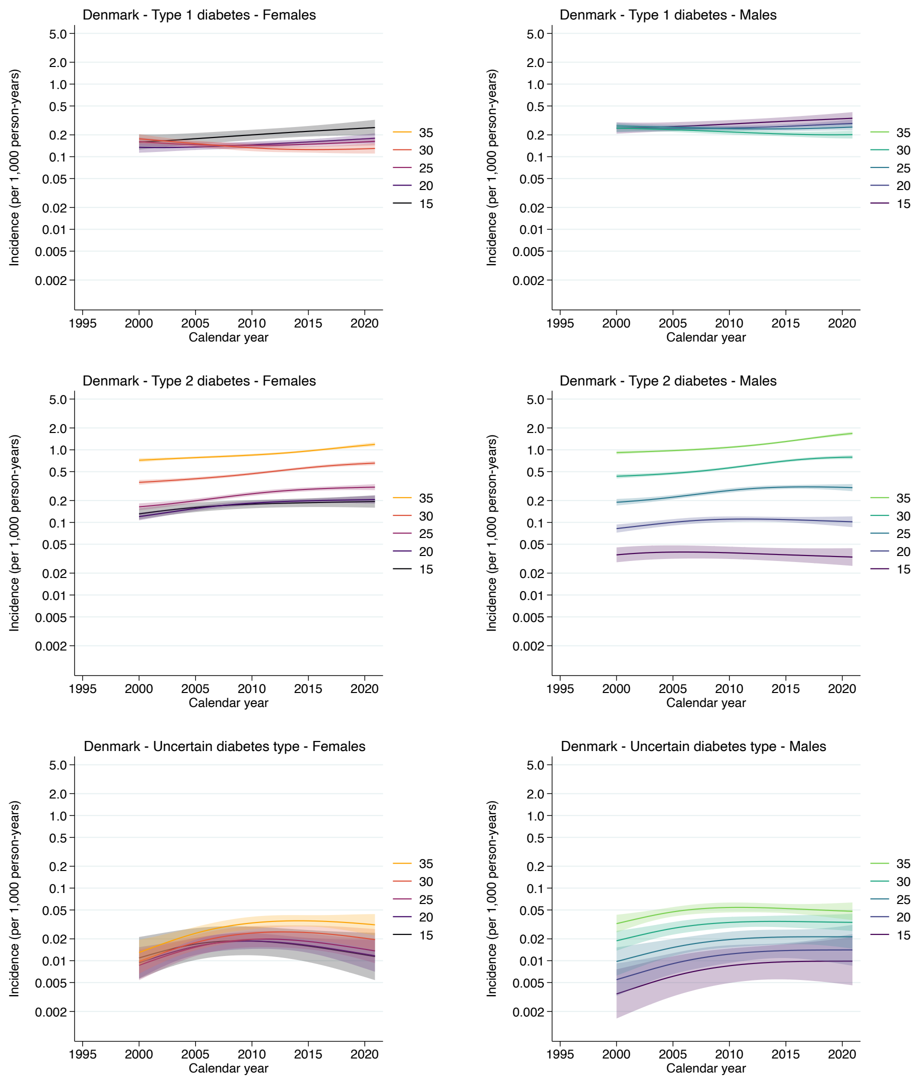

Figure 3.8: Incidence of diabetes in Denmark for people aged 15, 20, 25, 30, and 35 years, by diabetes type and sex

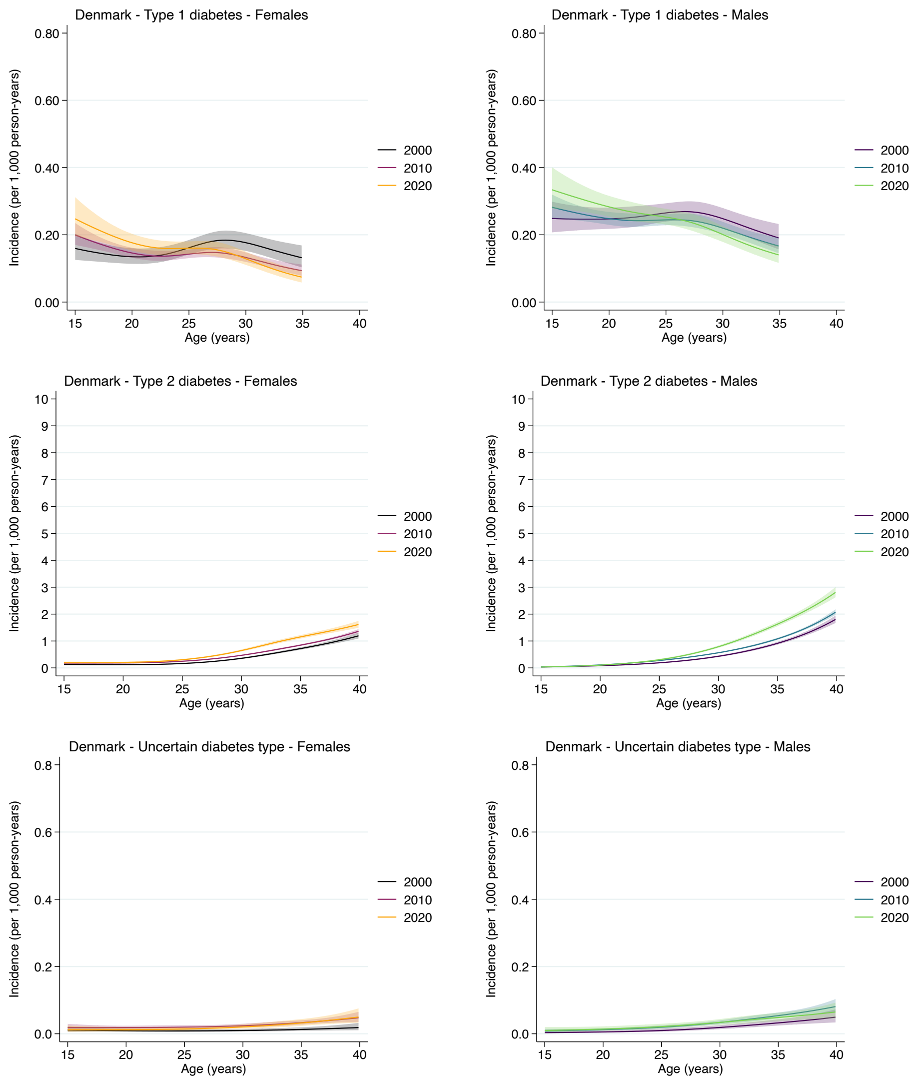

Figure 3.9: Incidence of diabetes in Denmark by age for the first, middle, and last calendar year of follow-up, by diabetes type and sex

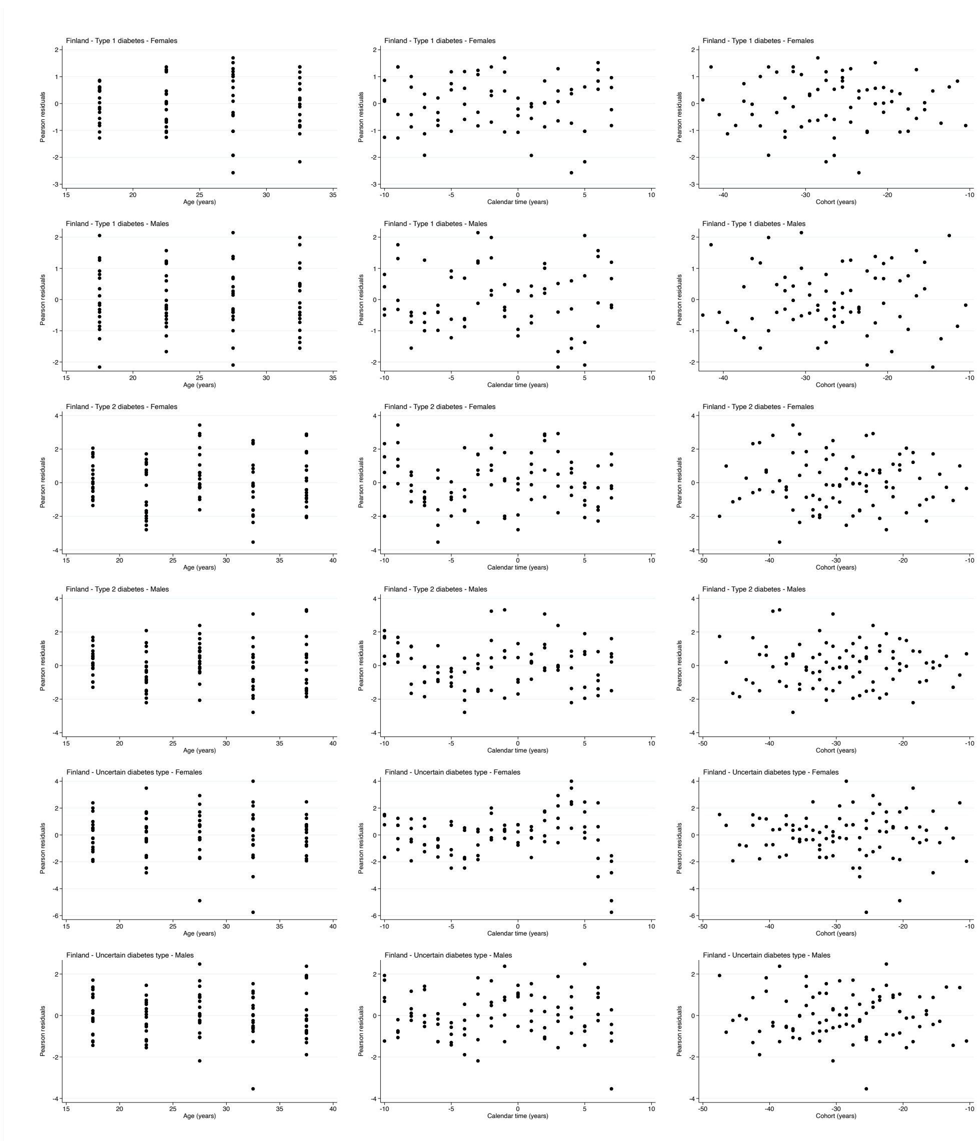

Figure 3.10: Pearson residuals for the age-period-cohort model in Finland, by diabetes type and sex

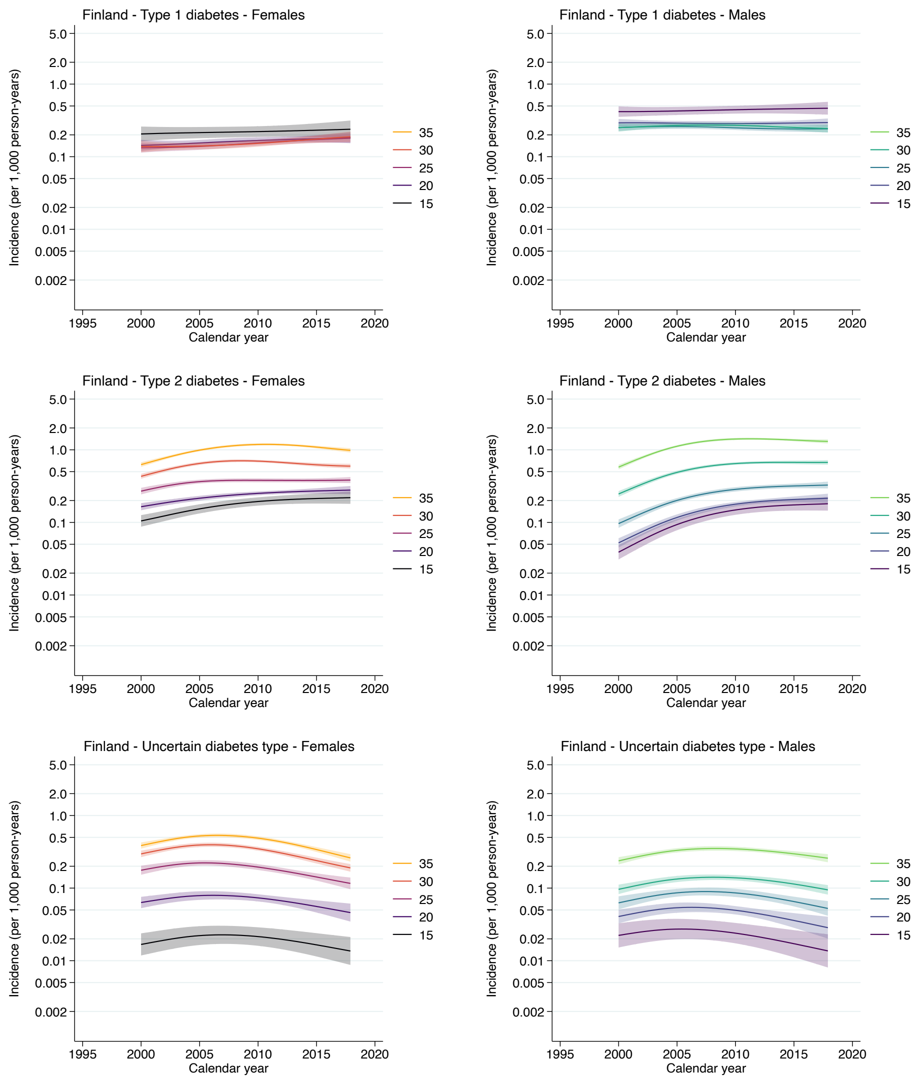

Figure 3.11: Incidence of diabetes in Finland for people aged 15, 20, 25, 30, and 35 years, by diabetes type and sex

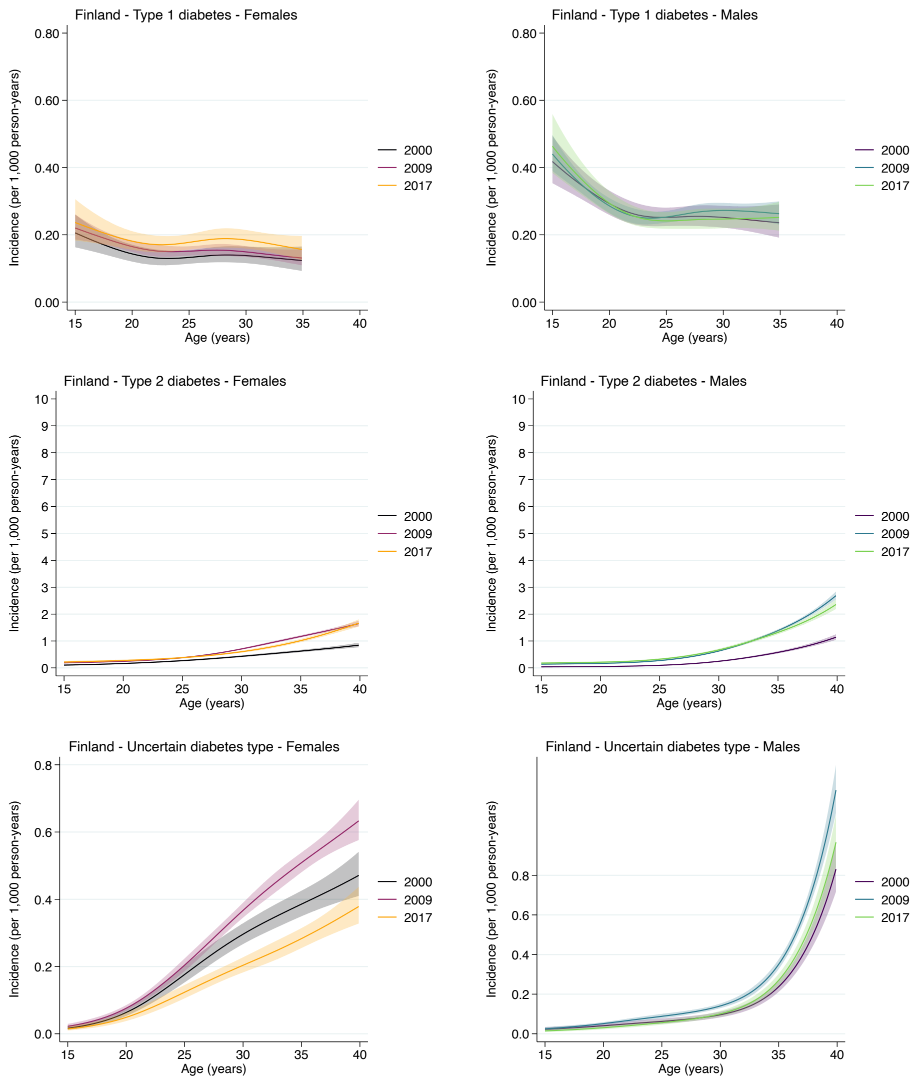

Figure 3.12: Incidence of diabetes in Finland by age for the first, middle, and last calendar year of follow-up, by diabetes type and sex

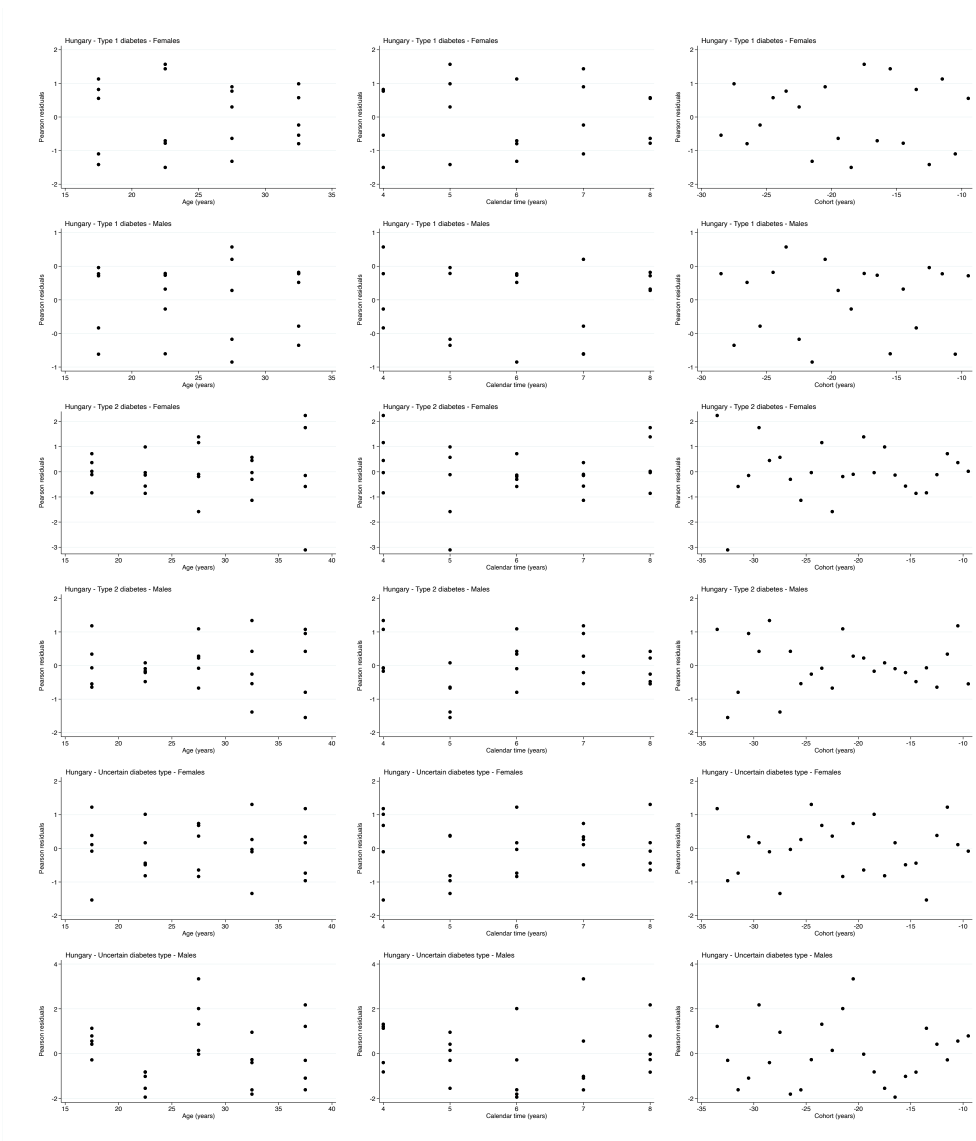

Figure 3.13: Pearson residuals for the age-period-cohort model in Hungary, by diabetes type and sex

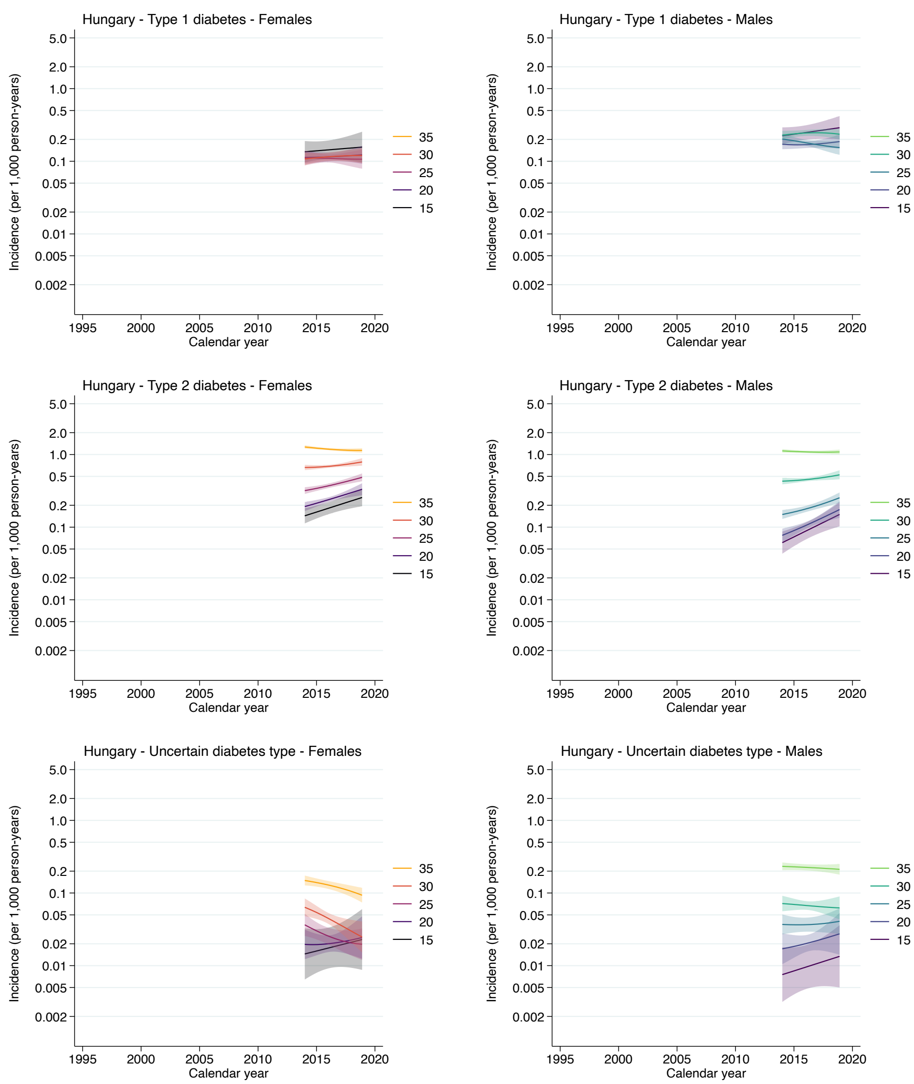

Figure 3.14: Incidence of diabetes in Hungary for people aged 15, 20, 25, 30, and 35 years, by diabetes type and sex

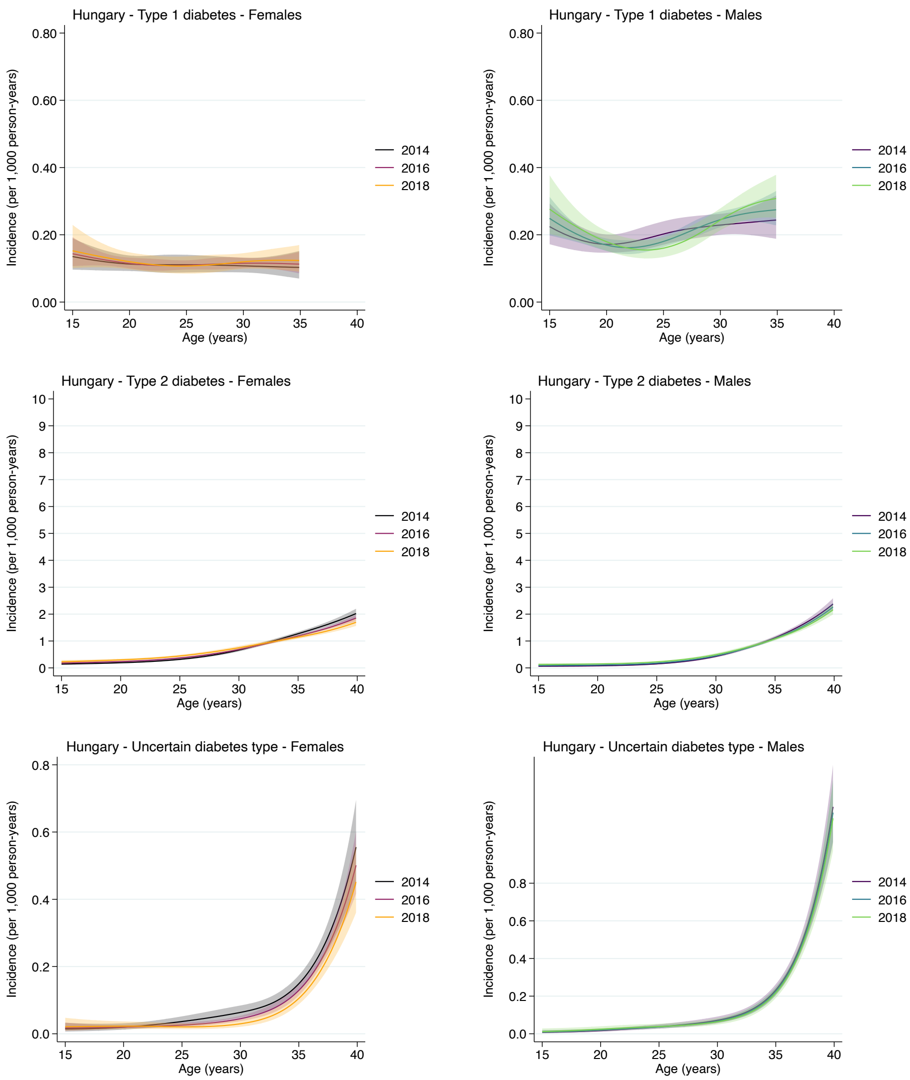

Figure 3.15: Incidence of diabetes in Hungary by age for the first, middle, and last calendar year of follow-up, by diabetes type and sex

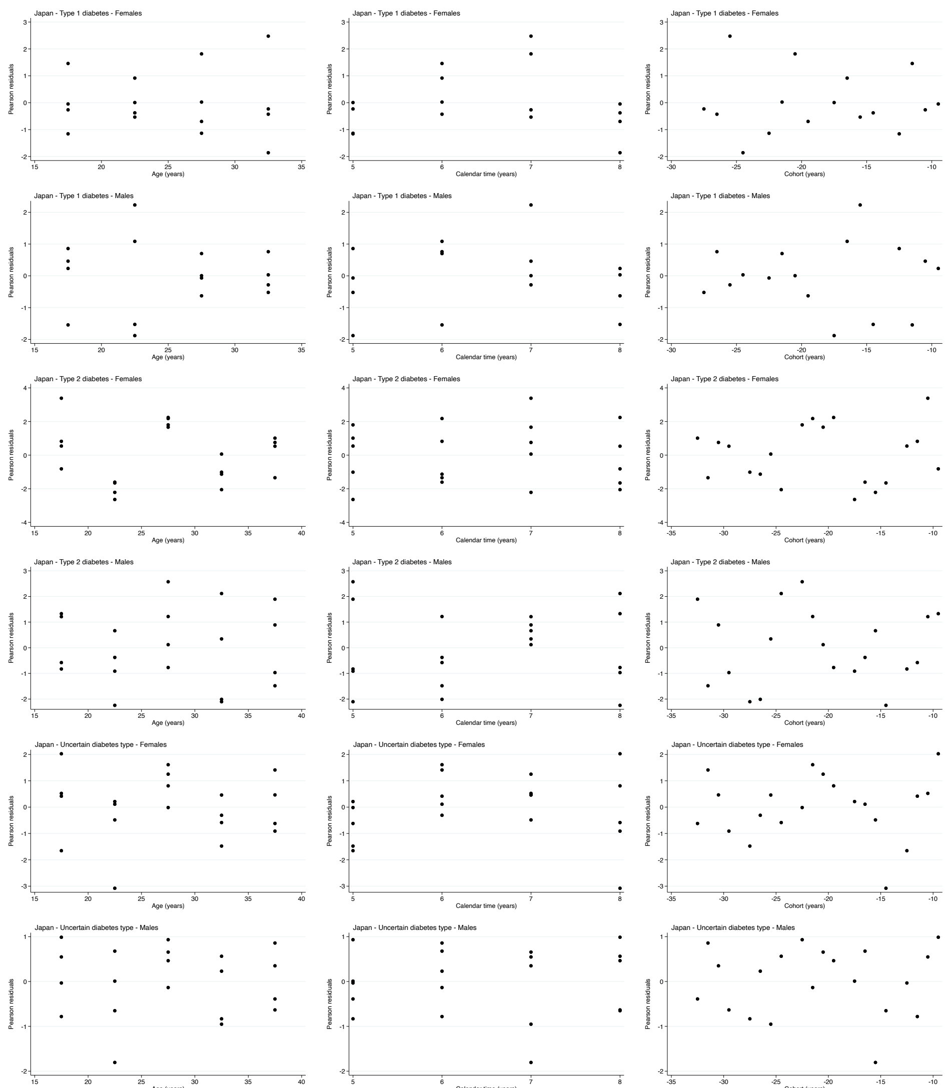

Figure 3.16: Pearson residuals for the age-period-cohort model in Japan, by diabetes type and sex

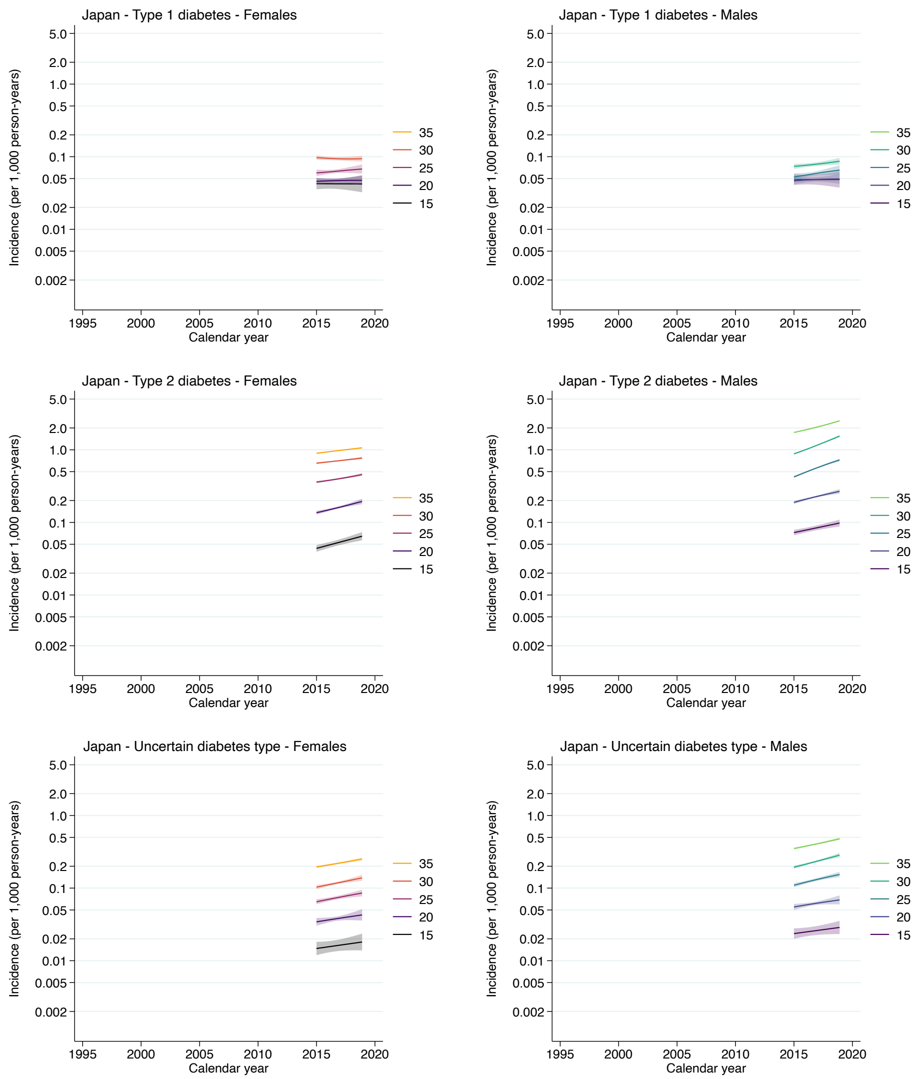

Figure 3.17: Incidence of diabetes in Japan for people aged 15, 20, 25, 30, and 35 years, by diabetes type and sex

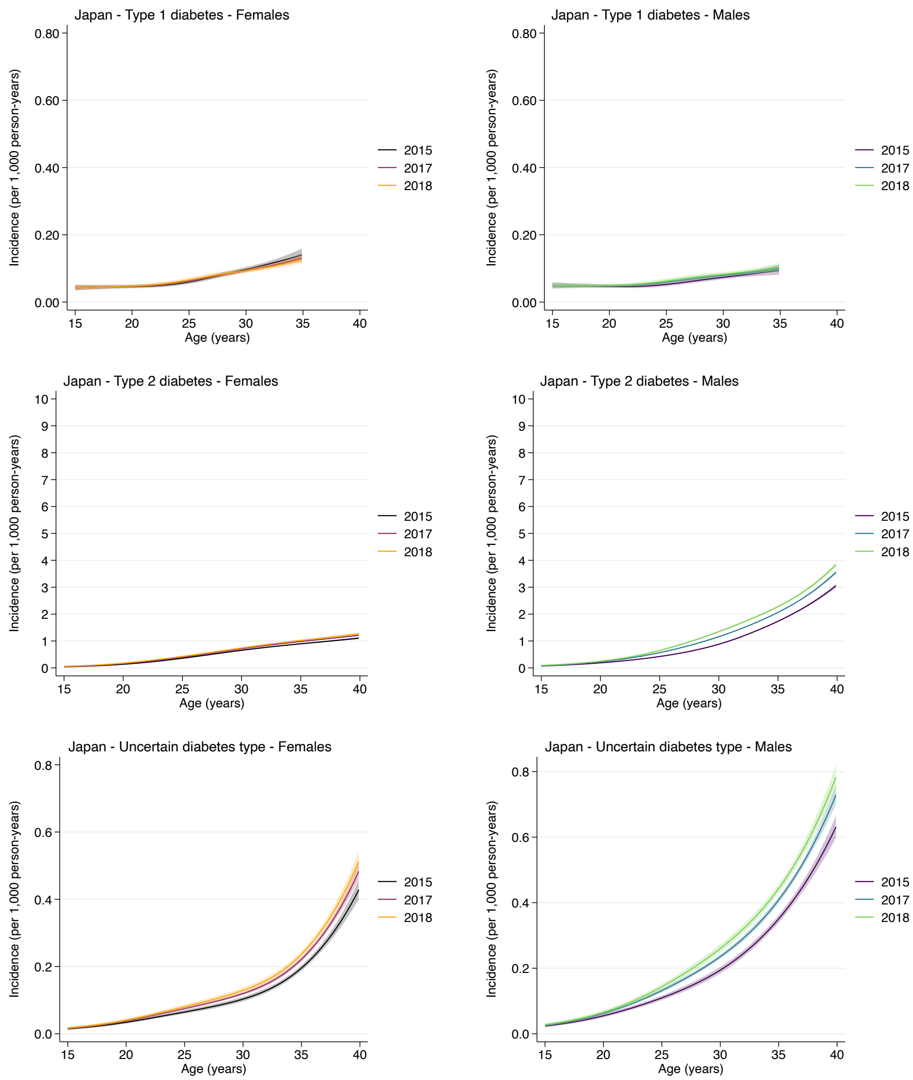

Figure 3.18: Incidence of diabetes in Japan by age for the first, middle, and last calendar year of follow-up, by diabetes type and sex

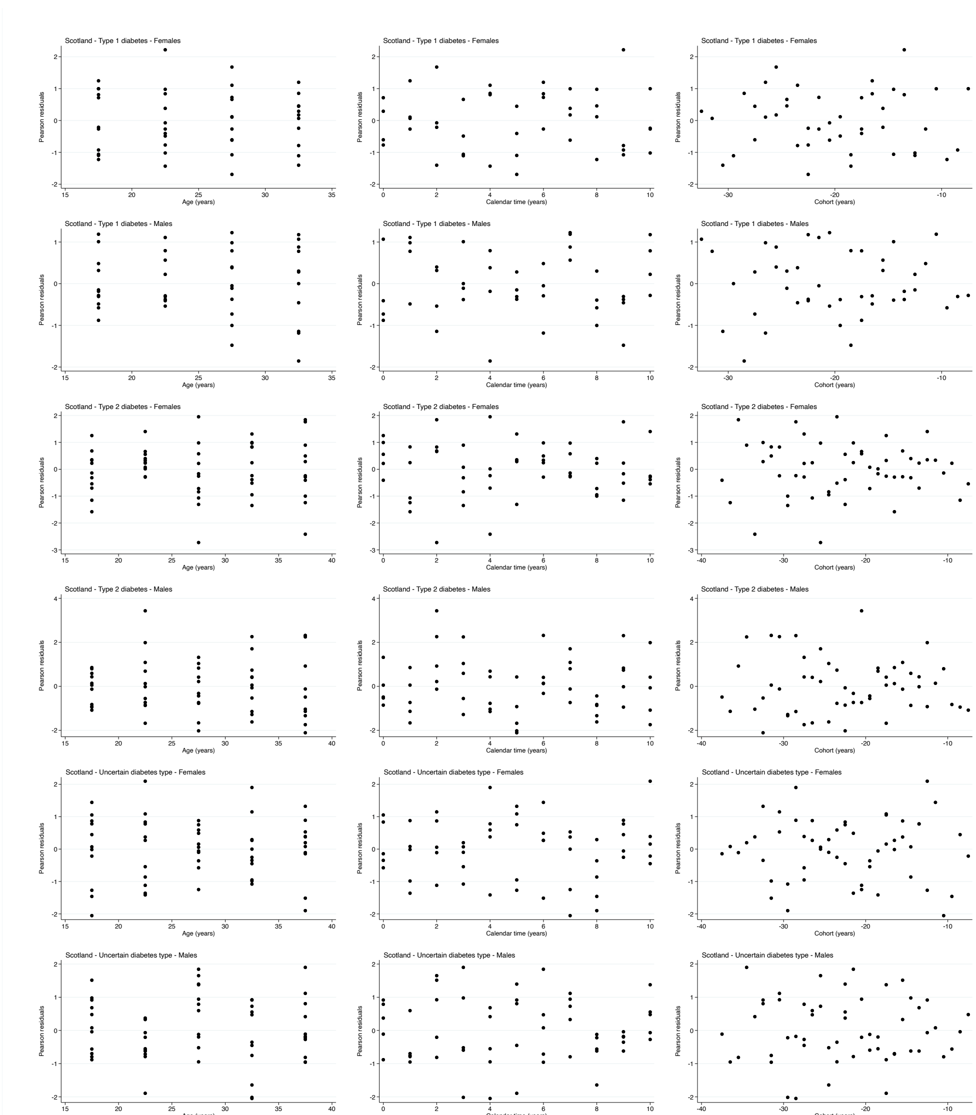

Figure 3.19: Pearson residuals for the age-period-cohort model in Scotland, by diabetes type and sex

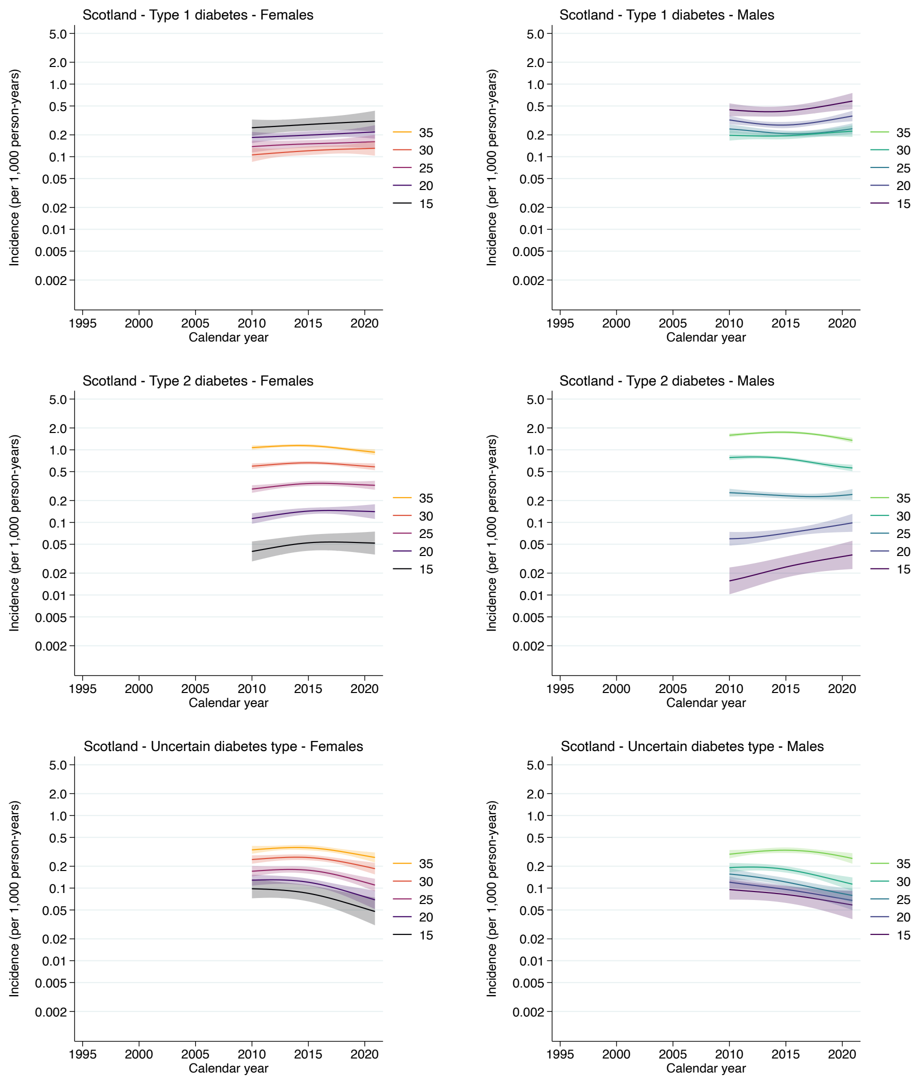

Figure 3.20: Incidence of diabetes in Scotland for people aged 15, 20, 25, 30, and 35 years, by diabetes type and sex

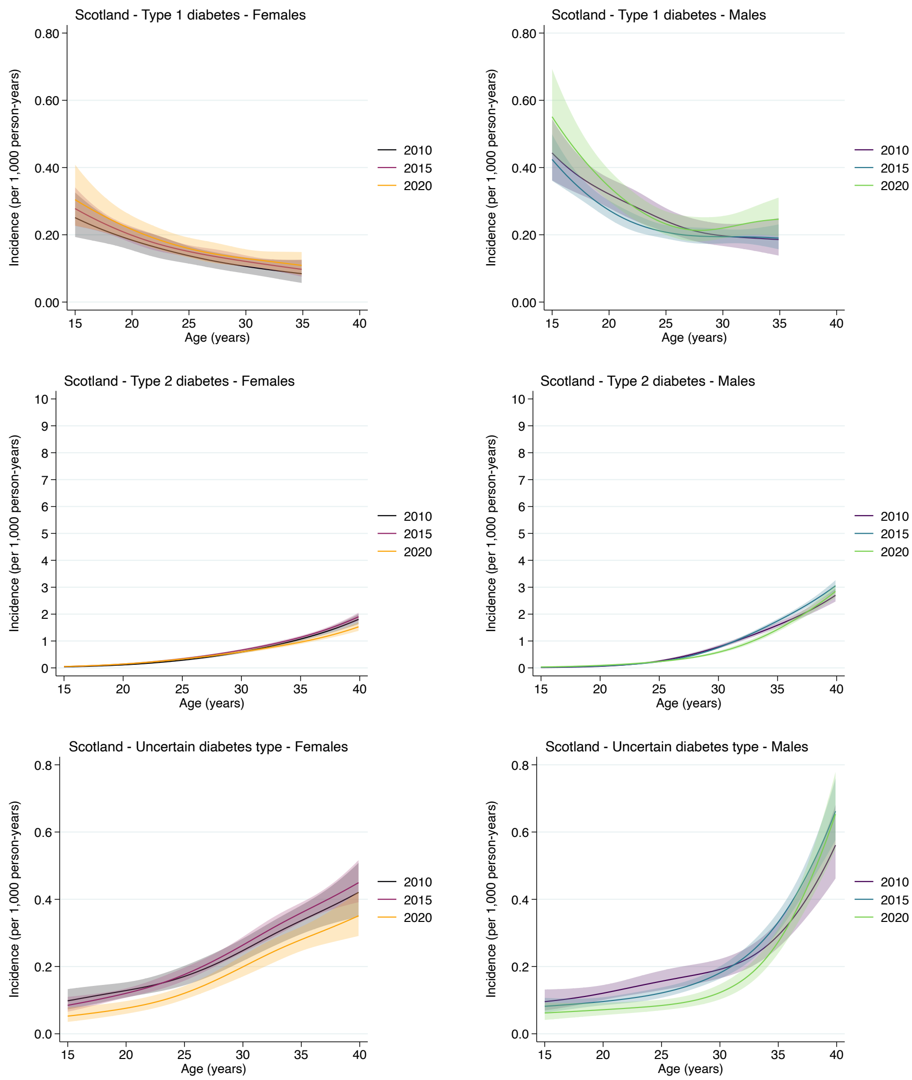

Figure 3.21: Incidence of diabetes in Scotland by age for the first, middle, and last calendar year of follow-up, by diabetes type and sex

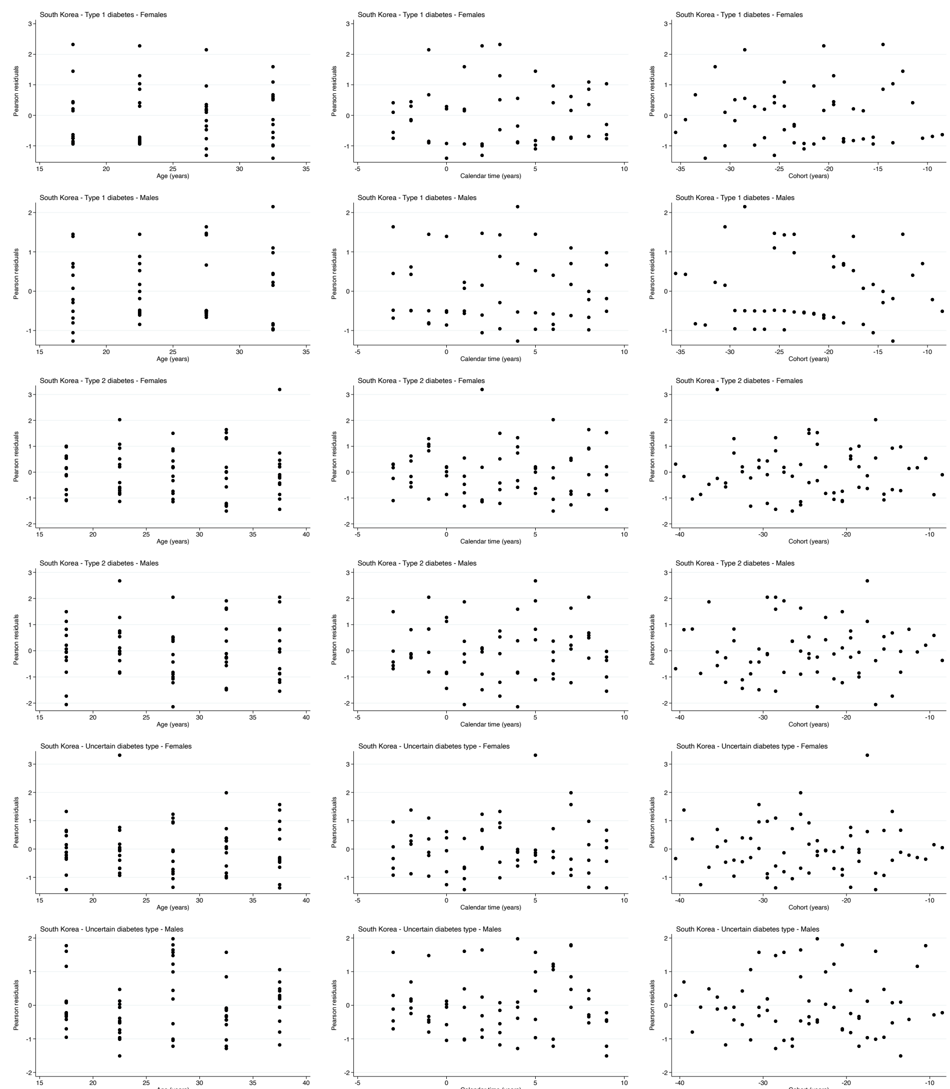

Figure 3.22: Pearson residuals for the age-period-cohort model in South Korea, by diabetes type and sex

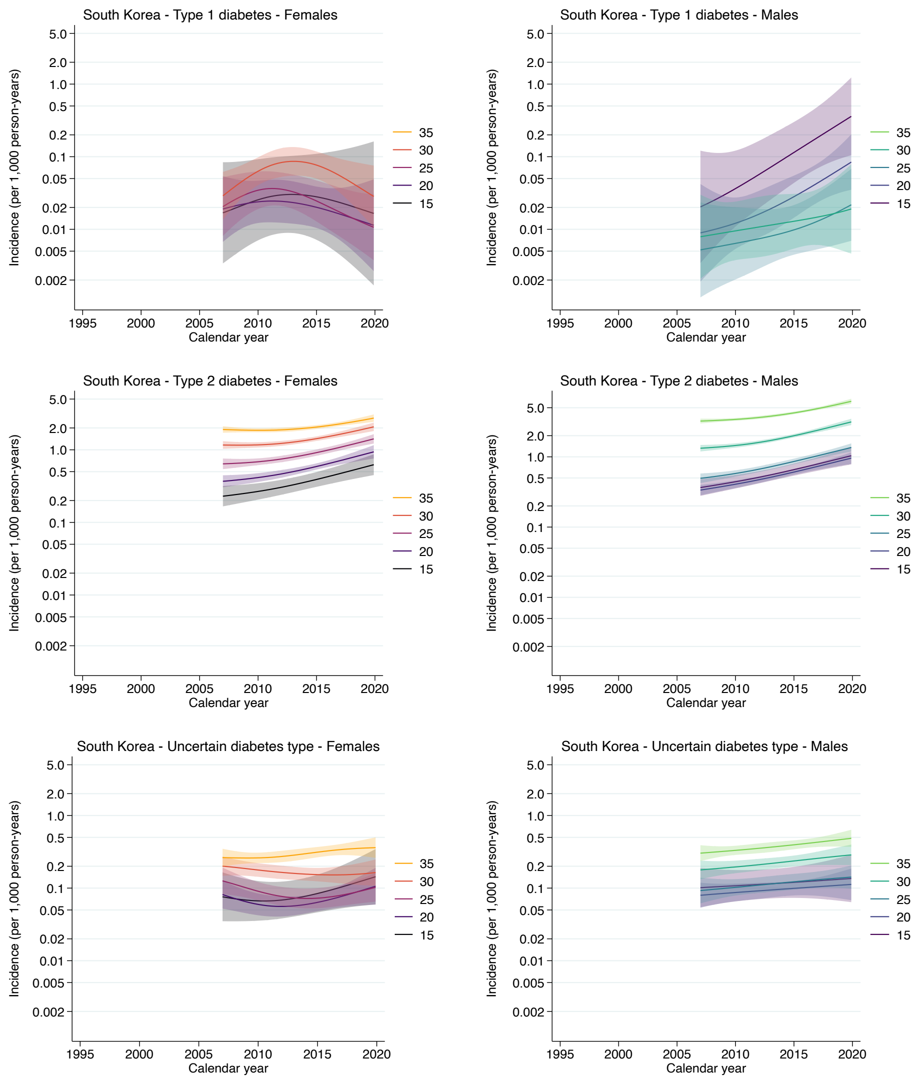

Figure 3.23: Incidence of diabetes in South Korea for people aged 15, 20, 25, 30, and 35 years, by diabetes type and sex

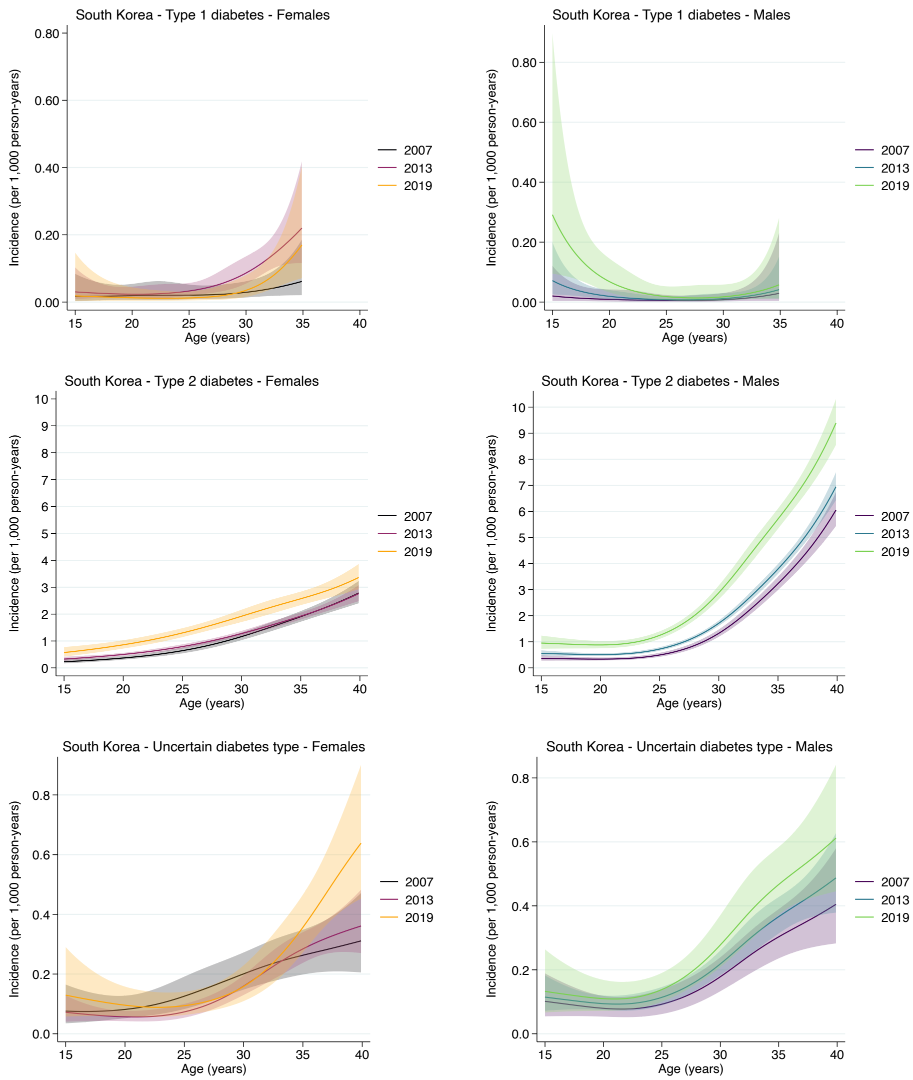

Figure 3.24: Incidence of diabetes in South Korea by age for the first, middle, and last calendar year of follow-up, by diabetes type and sex

```
CRJ_1_`i´_F_inc_t2d.gph ///
CRJ_2_`i´_F_inc_t2d.gph ///
CRJ_3_`i´_F_inc_t2d.gph ///
CRJ_1_`i´_M_inc_t2d.gph ///
CRJ_2_`i´_M_inc_t2d.gph ///
CRJ_3_`i´_M_inc_t2d.gph ///
CRJ_1_`i´_F_inc_uncertaint.gph ///
CRJ_2_`i´_F_inc_uncertaint.gph ///
CRJ_3_`i´_F_inc_uncertaint.gph ///
CRJ_1_`i´_M_inc_uncertaint.gph ///
CRJ_2_`i´_M_inc_uncertaint.gph ///
CRJ_3_`i´_M_inc_uncertaint.gph ///
, altshrink cols(3) xsize(3.5) graphregion(color(white))
> y diabetes type and sex)
graph combine ///
Escape_`i´_F_inc_t1d.gph ///
Escape_`i´_M_inc_t1d.gph ///
Escape_`i´_F_inc_t2d.gph ///
Escape_`i´_M_inc_t2d.gph ///
Escape_`i´_F_inc_uncertaint.gph ///
Escape_`i´_M_inc_uncertaint.gph ///
, altshrink rows(3) xsize(3.5) graphregion(color(white))
> , and 35 years, by diabetes type and sex)
graph combine ///
TTFATF_`i´_F_inc_t1d.gph ///
TTFATF_`i´_M_inc_t1d.gph ///
TTFATF_`i´_F_inc_t2d.gph ///
TTFATF_`i´_M_inc_t2d.gph ///
TTFATF_`i´_F_inc_uncertaint.gph ///
TTFATF_`i´_M_inc_uncertaint.gph ///
, altshrink rows(3) xsize(3.5) graphregion(color(white))
> and last calendar year of follow-up, by diabetes type and sex)
}
```

To make comparison between countries easier, we will plot all curves for age 25 on the same graph (and 20 and 30, to see if there is any difference depending on the age selected; figures 3.25 - 3.27).

For these plots, we no longer use an ordinal colour scheme. We're using rainbow.

```
forval age = 20(5)30 {
foreach ii in M F {
foreach iii in inc_t1d inc_t2d inc_uncertaint {
if "`ii´" == "M" {
local s = "Males"
}
else {
local s = "Females"
}
if "`iii´" == "inc_t1d" {
local oc = "Type 1 diabetes"
}
else if "`iii´" == "inc_t2d" {
local oc = "Type 2 diabetes"
}
else {
local oc = "Uncertain diabetes type"
}
local col1 = "0 0 255"
local col2 = "75 0 130"
local col3 = "255 0 255"
local col4 = "255 0 0"
local col5 = "255 125 0"
local col6 = "0 125 0"
local col7 = "0 175 255"
local col8 = "0 0 0"
clear
forval i = 1/8 {
```

```
append using APC_Rate_`i´_`ii´_`iii´
}
keep if age == `age´
preserve
bysort country : keep if _n == 1
forval i = 1/8 {
local C`i´ = country[`i´]
}
restore
twoway ///
(rarea ub lb calendar if country == "`C1´", color("`col1´%30") fintensity(inten80) lwidth(none)) ///
(line _Rate calendar if country == "`C1´", color("`col1´") lpattern(solid)) ///
(rarea ub lb calendar if country == "`C2´", color("`col2´%30") fintensity(inten80) lwidth(none)) ///
(line _Rate calendar if country == "`C2´", color("`col2´") lpattern(solid)) ///
(rarea ub lb calendar if country == "`C3´", color("`col3´%30") fintensity(inten80) lwidth(none)) ///
(line _Rate calendar if country == "`C3´", color("`col3´") lpattern(solid)) ///
(rarea ub lb calendar if country == "`C4´", color("`col4´%30") fintensity(inten80) lwidth(none)) ///
(line _Rate calendar if country == "`C4´", color("`col4´") lpattern(solid)) ///
(rarea ub lb calendar if country == "`C5´", color("`col5´%30") fintensity(inten80) lwidth(none)) ///
(line _Rate calendar if country == "`C5´", color("`col5´") lpattern(solid)) ///
(rarea ub lb calendar if country == "`C6´", color("`col6´%30") fintensity(inten80) lwidth(none)) ///
(line _Rate calendar if country == "`C6´", color("`col6´") lpattern(solid)) ///
(rarea ub lb calendar if country == "`C7´", color("`col7´%30") fintensity(inten80) lwidth(none)) ///
(line _Rate calendar if country == "`C7´", color("`col7´") lpattern(solid)) ///
(rarea ub lb calendar if country == "`C8´", color("`col8´%30") fintensity(inten80) lwidth(none)) ///
(line _Rate calendar if country == "`C8´", color("`col8´") lpattern(solid)) ///
, legend(symxsize(0.13cm) position(3) region(lcolor(white) color(none)) ///
order(2 "`C1´" ///
4 "`C2´" ///
6 "`C3´" ///
8 "`C4´" ///
10 "`C5´" ///
12 "`C6´" ///
14 "`C7´" ///
16 "`C8´") ///
cols(1)) ///
graphregion(color(white)) ///
ylabel(0.002 "0.002" ///
0.005 "0.005" ///
0.01 "0.01" ///
0.02 "0.02" ///
0.05 "0.05" ///
0.1 "0.1" ///
0.2 "0.2" ///
0.5 "0.5" ///
1.0 "1.0" ///
2.0 "2.0" ///
5.0 "5.0", format(%9.3f) grid angle(0)) ///
yscale(range(0.001 5.05) log) ///
xscale(range(1995 2020)) ///
xlabel(1995(5)2020, nogrid) ///
ytitle("Incidence (per 1,000 person-years)", margin(a+2)) ///
xtitle("Calendar year") ///
title("`oc´ - `s´", placement(west) color(black) size(medium))
graph save "Graph" Alive_`ii´_`iii´_`age´, replace
}
}
}


graph combine ///
Alive_F_inc_t1d_20.gph ///
Alive_M_inc_t1d_20.gph ///
Alive_F_inc_t2d_20.gph ///
Alive_M_inc_t2d_20.gph ///
Alive_F_inc_uncertaint_20.gph ///
Alive_M_inc_uncertaint_20.gph ///
, altshrink rows(3) xsize(4) graphregion(color(white))
> ype and sex)
```

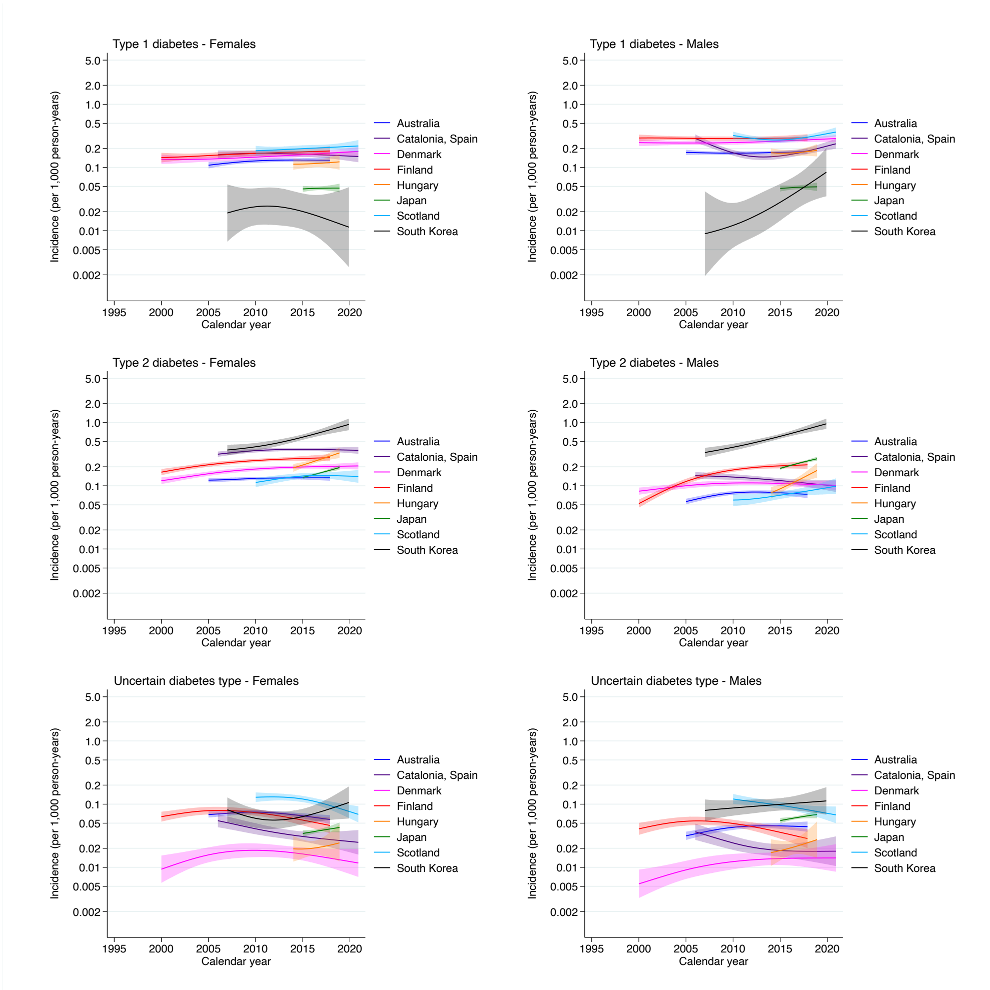

Figure 3.25: Incidence of diabetes for people aged 20 years, by diabetes type and sex

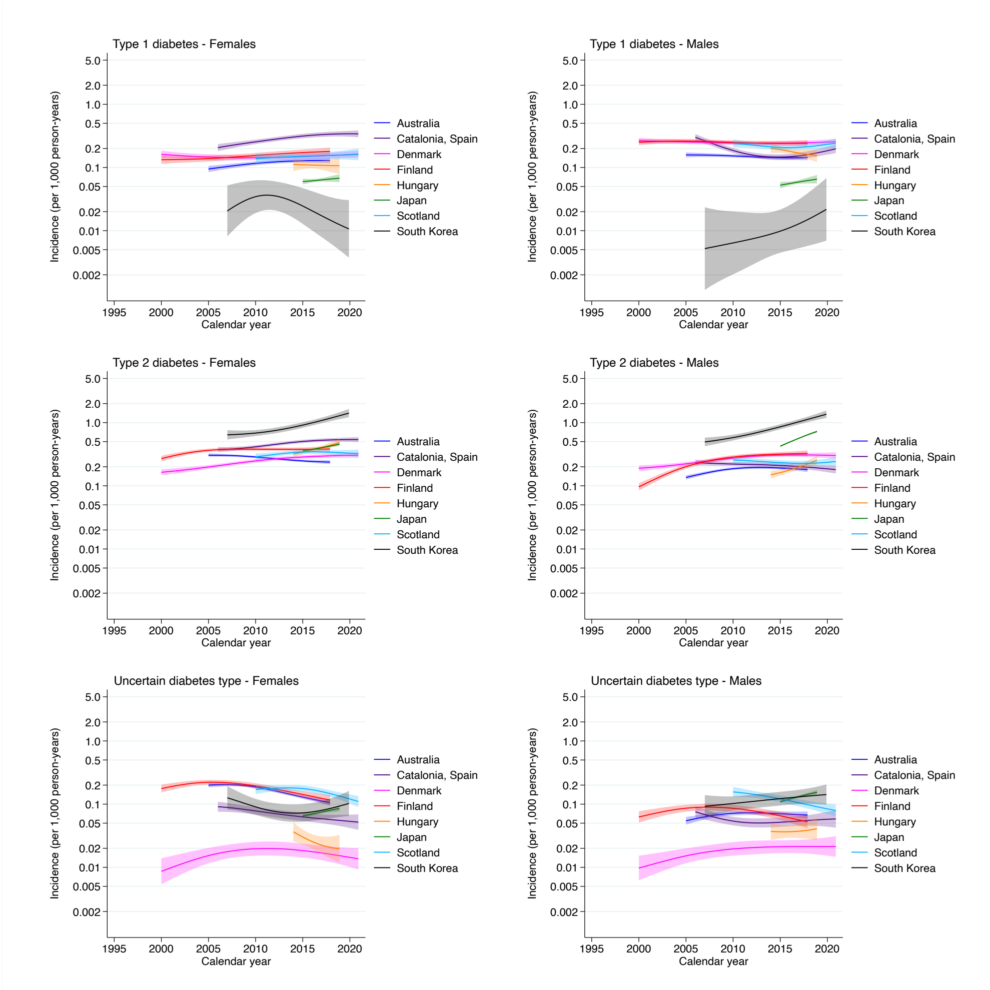

Figure 3.26: Incidence of diabetes for people aged 25 years, by diabetes type and sex

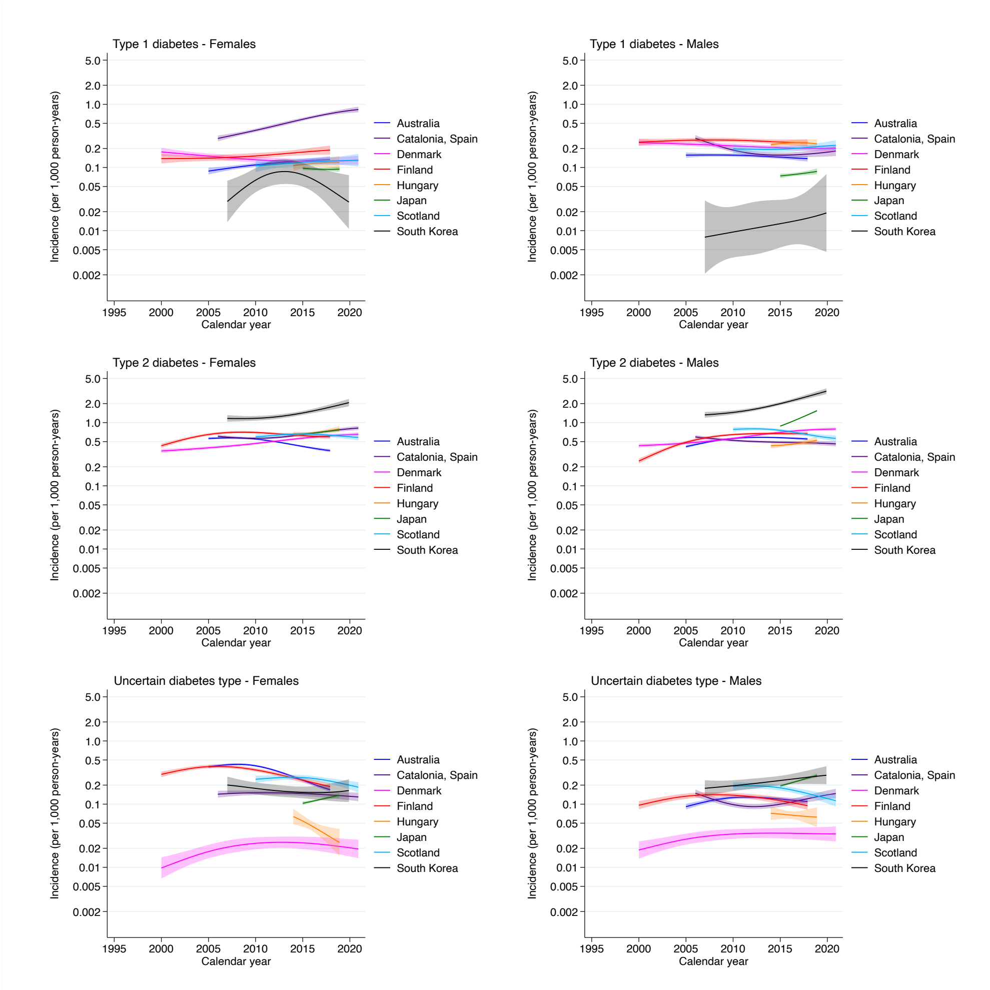

Figure 3.27: Incidence of diabetes for people aged 30 years, by diabetes type and sex

```
graph combine ///
Alive_F_inc_t1d_25.gph ///
Alive_M_inc_t1d_25.gph ///
Alive_F_inc_t2d_25.gph ///
Alive_M_inc_t2d_25.gph ///
Alive_F_inc_uncertaint_25.gph ///
Alive_M_inc_uncertaint_25.gph ///
, altshrink rows(3) xsize(4) graphregion(color(white))
> ype and sex)
graph combine ///
Alive_F_inc_t1d_30.gph ///
Alive_M_inc_t1d_30.gph ///
Alive_F_inc_t2d_30.gph ///
Alive_M_inc_t2d_30.gph ///
Alive_F_inc_uncertaint_30.gph ///
Alive_M_inc_uncertaint_30.gph ///
, altshrink rows(3) xsize(4) graphregion(color(white))
> ype and sex)
```

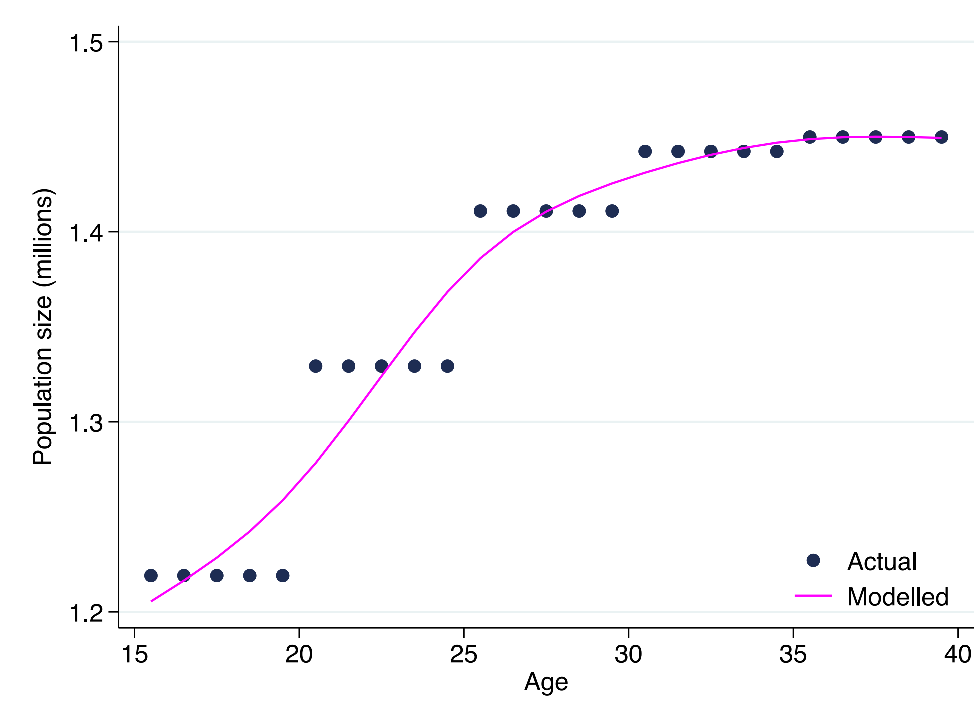

Figure 4.1: European standard population in 2010

4 Age-standardized rates

Additionally, we will age-standardise the incidence rates to the European population in 2010. This will be done using the same Age-Period-Cohort models described above. In this analysis, we will take the predicted rates from these models (in single years) and use these in direct standardisation. However, to do this, we first need to convert the European standard population (available only in 5-year age groups) to 1-year age groups (using linear regression).

```
import delimited "Consortium young-onset diabetes_incidence v7.csv", varnames(1) clear
drop if cal >= 2021
keep if _n<=5
keep age_gp esp2010
rename age_gp age
replace age = substr(age,1,2)
destring age, replace
expand 5
replace esp2010=esp2010/5
bysort age : replace age = age+_n-0.5
mkspline agesp = age, cubic knots(15(5)40)
reg esp2010 agesp*
predict A
preserve
replace esp2010 = esp2010/1000000
replace A = A/1000000
twoway ///
(scatter esp2010 age, col(dknavy)) ///
(line A age, col(magenta)) ///
, legend(symxsize(0.13cm) position(4) ring(0) region(lcolor(white) color(none)) ///
order(1 "Actual" ///
2 "Modelled") ///
```

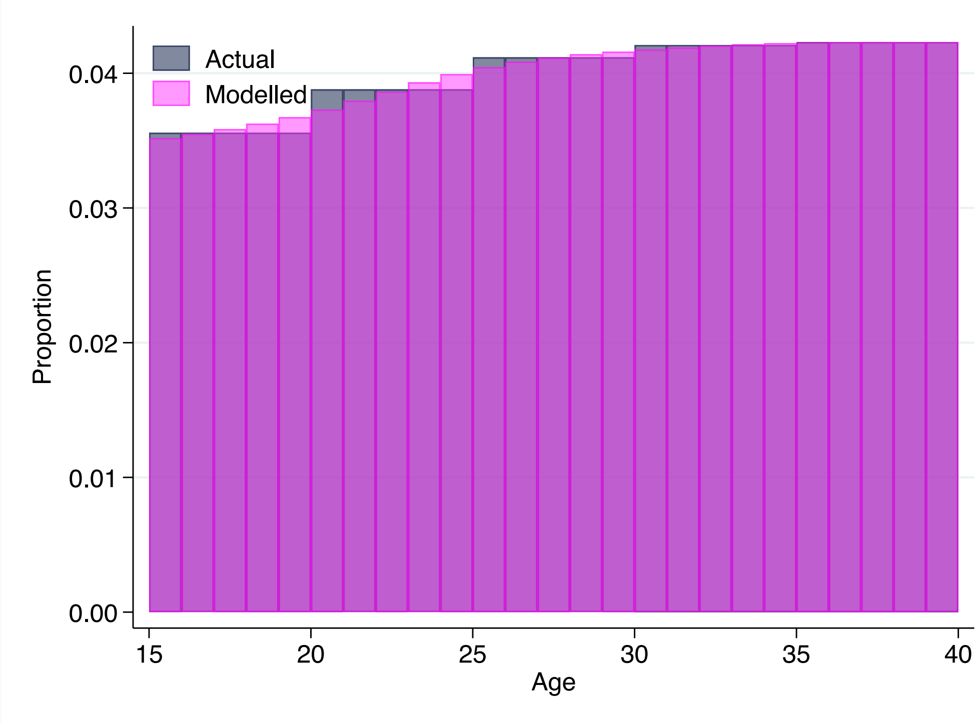

Figure 4.2: European standard population proportions in 2010

```
cols(1)) ///
graphregion(color(white)) ///
ylabel(1.2(0.1)1.5, format(%9.1f) angle(0)) ///
ytitle("Population size (millions)") xtitle("Age")
restore
su(esp2010)
gen esp2010prop = esp2010/r(sum)
su(A)
gen B = A/r(sum)
twoway ///
(bar esp2010prop age, color(dknavy%70)) ///
(bar B age, color(magenta%50)) ///
, legend(symxsize(0.13cm) position(11) ring(0) region(lcolor(white) color(none)) ///
order(1 "Actual" ///
2 "Modelled") ///
cols(1)) ///
ylabel(0(0.01)0.04, angle(0) format(%9.2f)) ///
graphregion(color(white)) ///
ytitle("Proportion") xtitle("Age")
keep age B
replace age = age-0.5
save refpop, replace
import delimited "Consortium young-onset diabetes_incidence v7.csv", varnames(1) clear
drop if cal >= 2021
keep if _n<=5
keep age_gp esp2010
rename age_gp age
replace age = substr(age,1,2)
destring age, replace
expand 5
replace esp2010=esp2010/5
bysort age : replace age = age+_n-0.5
mkspline agesp = age, cubic knots(15(5)40)
```

```
reg esp2010 agesp*
predict A
replace esp2010 = esp2010/1000000
replace A = A/1000000
drop if age > 35
su(esp2010)
gen esp2010prop = esp2010/r(sum)
su(A)
gen B = A/r(sum)
keep age B
replace age = age-0.5
save refpop1, replace
```

With that, we can calculate and plot the age-standardized rates. Note: the method used to calculate the confidence intervals is the same as the Stata command dstdize, and it assumes that the person-years are the same for each single age within the 5-year age group (which, if the populations we sample from are anything like the European population, is a safe assumption (figure 4.2, and is unlikely to affect the calculated error even if included)).

```
quietly {
forval i = 1/8 {
foreach ii in M F {
foreach iii in inc_t1d inc_t2d inc_uncertaint {
if `i´ == 1 {
local c = "Australia"
}
if `i´ == 2 {
local c = "Catalonia, Spain"
}
if `i´ == 3 {
local c = "Denmark"
}
if `i´ == 4 {
local c = "Finland"
}
if `i´ == 5 {
local c = "Hungary"
}
if `i´ == 6 {
local c = "Japan"
}
if `i´ == 7 {
local c = "Scotland"
}
if `i´ == 8 {
local c = "South Korea"
}
import delimited "Consortium young-onset diabetes_incidence v7.csv", varnames(1) clear
drop if cal >= 2021
if "`iii´" == "inc_t1d" {
drop if age_gp == "35-39"
}
keep if country == "`c´" & sex == "`ii´"
rename age_gp age
replace age = substr(age,1,2)
destring age, replace
replace age = age+2.5
replace calendar = calendar-2010
gen coh = calendar-age
centile(age), centile(5 35 65 95)
local A1 = r(c_1)
local A2 = r(c_2)
local A3 = r(c_3)
local A4 = r(c_4)
mkspline agesp = age, cubic knots(`A1´ `A2´ `A3´ `A4´)
su(calendar), detail
local rang = r(max)-r(min)
if `rang´ < 8 {
centile calendar, centile(25 75)
local CK1 = r(c_1)
local CK2 = r(c_2)
mkspline timesp = calendar, cubic knots(`CK1´ `CK2´)
}
else if inrange(`rang´,8,11.9) {
centile calendar, centile(10 50 90)
local CK1 = r(c_1)
local CK2 = r(c_2)
local CK3 = r(c_3)
mkspline timesp = calendar, cubic knots(`CK1´ `CK2´ `CK3´)
```

```
}
else if inrange(`rang´,12,15.9) {
centile calendar, centile(5 35 65 95)
local CK1 = r(c_1)
local CK2 = r(c_2)
local CK3 = r(c_3)
local CK3 = r(c_4)
mkspline timesp = calendar, cubic knots(`CK1´ `CK2´ `CK3´ `CK4´)
}
else {
centile calendar, centile(5 27.5 50 72.5 95)
local CK1 = r(c_1)
local CK2 = r(c_2)
local CK3 = r(c_3)
local CK3 = r(c_4)
local CK3 = r(c_5)
mkspline timesp = calendar, cubic knots(`CK1´ `CK2´ `CK3´ `CK4´ `CK5´)
}
centile(coh), centile(5 35 65 95)
local CO1 = r(c_1)
local CO2 = r(c_2)
local CO3 = r(c_3)
local CO4 = r(c_4)
mkspline cohsp = coh, cubic knots(`CO1´ `CO2´ `CO3´ `CO4´)
poisson `iii´ agesp* timesp* cohsp*, exposure(pys)
keep age calendar pys
expand 5
replace pys=pys/5
bysort cal age : replace age = age+_n-3.5
sort age cal
gen coh = calendar-age
mkspline agesp = age, cubic knots(`A1´ `A2´ `A3´ `A4´)
if `rang´ < 7.99 {
mkspline timesp = calendar, cubic knots(`CK1´ `CK2´)
}
else if inrange(`rang´,8,11.99) {
mkspline timesp = calendar, cubic knots(`CK1´ `CK2´ `CK3´)
}
else if inrange(`rang´,12,15.99) {
mkspline timesp = calendar, cubic knots(`CK1´ `CK2´ `CK3´ `CK4´)
}
else {
mkspline timesp = calendar, cubic knots(`CK1´ `CK2´ `CK3´ `CK4´ `CK5´)
}
mkspline cohsp = coh, cubic knots(`CO1´ `CO2´ `CO3´ `CO4´)
predict _Rate, ir
replace cal = cal+2010
keep cal age pys _Rate
if "`iii´" == "inc_t1d" {
merge m:1 age using refpop1
}
else {
merge m:1 age using refpop
}
drop _merge
gen double expdeath = _Rate*B
bysort cal : egen double expdeath1 = sum(expdeath)
gen stdrate = 1000*expdeath1
gen SEC1 = ((B^2)*(_Rate*(1-_Rate)))/pys_nondm
bysort cal : egen double SEC2 = sum(SEC1)
gen double SE = sqrt(SEC2)
gen lb = 1000*(expdeath1-1.96*SE)
gen ub = 1000*(expdeath1+1.96*SE)
bysort cal (age) : keep if _n == 1
noisily count if lb < 0
keep cal stdrate lb ub
gen country = "`c´"
gen sex = "`ii´"
```

```
gen OC = "`iii´"
save STD_Rate_`i´_`ii´_`iii´, replace
}
}
}
}
foreach ii in M F {
foreach iii in inc_t1d {
if "`ii´" == "M" {
local s = "Males"
}
else {
local s = "Females"
}
if "`iii´" == "inc_t1d" {
local oc = "Type 1 diabetes"
}
else if "`iii´" == "inc_t2d" {
local oc = "Type 2 diabetes"
}
else {
local oc = "Uncertain diabetes type"
}
local col1 = "0 0 255"
local col2 = "75 0 130"
local col3 = "255 0 255"
local col4 = "255 0 0"
local col5 = "255 125 0"
local col6 = "0 125 0"
local col7 = "0 175 255"
local col8 = "0 0 0"
clear
forval i = 1/7 {
append using STD_Rate_`i´_`ii´_`iii´
}
preserve
bysort country : keep if _n == 1
forval i = 1/7 {
local C`i´ = country[`i´]
}
restore
if "`ii´" == "F" & "`iii´" == "inc_t2d" {
twoway ///
(rarea ub lb calendar if country == "`C1´", color("`col1´%30") fintensity(inten80) lwidth(none)) ///
(line stdrate calendar if country == "`C1´", color("`col1´") lpattern(solid)) ///
(rarea ub lb calendar if country == "`C2´", color("`col2´%30") fintensity(inten80) lwidth(none)) ///
(line stdrate calendar if country == "`C2´", color("`col2´") lpattern(solid)) ///
(rarea ub lb calendar if country == "`C3´", color("`col3´%30") fintensity(inten80) lwidth(none)) ///
(line stdrate calendar if country == "`C3´", color("`col3´") lpattern(solid)) ///
(rarea ub lb calendar if country == "`C4´", color("`col4´%30") fintensity(inten80) lwidth(none)) ///
(line stdrate calendar if country == "`C4´", color("`col4´") lpattern(solid)) ///
(rarea ub lb calendar if country == "`C5´", color("`col5´%30") fintensity(inten80) lwidth(none)) ///
(line stdrate calendar if country == "`C5´", color("`col5´") lpattern(solid)) ///
(rarea ub lb calendar if country == "`C6´", color("`col6´%30") fintensity(inten80) lwidth(none)) ///
(line stdrate calendar if country == "`C6´", color("`col6´") lpattern(solid)) ///
(rarea ub lb calendar if country == "`C7´", color("`col7´%30") fintensity(inten80) lwidth(none)) ///
(line stdrate calendar if country == "`C7´", color("`col7´") lpattern(solid)) ///
, legend(symxsize(0.13cm) position(4) ring(0) region(lcolor(white) color(none)) ///
order(2 "`C1´" ///
4 "`C2´" ///
6 "`C3´" ///
8 "`C4´" ///
10 "`C5´" ///
12 "`C6´" ///
14 "`C7´") ///
cols(2)) ///
graphregion(color(white)) ///
ylabel(0.005 "0.005" ///
```

```
0.01 "0.01" ///
0.02 "0.02" ///
0.05 "0.05" ///
0.1 "0.1" ///
0.2 "0.2" ///
0.5 "0.5" ///
1.0 "1.0" ///
2.0 "2.0" ///
5.0 "5.0", format(%9.3f) grid angle(0)) ///
yscale(range(0.004 5.05) log) ///
xscale(range(1995 2020)) ///
xlabel(1995(5)2020, nogrid) ///
ytitle("Incidence (per 1,000 person-years)", margin(a+2)) ///
xtitle("Calendar year") ///
title("`oc´ - `s´", placement(west) color(black) size(medium))
}
else {
twoway ///
(rarea ub lb calendar if country == "`C1´", color("`col1´%30") fintensity(inten80) lwidth(none)) ///
(line stdrate calendar if country == "`C1´", color("`col1´") lpattern(solid)) ///
(rarea ub lb calendar if country == "`C2´", color("`col2´%30") fintensity(inten80) lwidth(none)) ///
(line stdrate calendar if country == "`C2´", color("`col2´") lpattern(solid)) ///
(rarea ub lb calendar if country == "`C3´", color("`col3´%30") fintensity(inten80) lwidth(none)) ///
(line stdrate calendar if country == "`C3´", color("`col3´") lpattern(solid)) ///
(rarea ub lb calendar if country == "`C4´", color("`col4´%30") fintensity(inten80) lwidth(none)) ///
(line stdrate calendar if country == "`C4´", color("`col4´") lpattern(solid)) ///
(rarea ub lb calendar if country == "`C5´", color("`col5´%30") fintensity(inten80) lwidth(none)) ///
(line stdrate calendar if country == "`C5´", color("`col5´") lpattern(solid)) ///
(rarea ub lb calendar if country == "`C6´", color("`col6´%30") fintensity(inten80) lwidth(none)) ///
(line stdrate calendar if country == "`C6´", color("`col6´") lpattern(solid)) ///
(rarea ub lb calendar if country == "`C7´", color("`col7´%30") fintensity(inten80) lwidth(none)) ///
(line stdrate calendar if country == "`C7´", color("`col7´") lpattern(solid)) ///
, legend(off) ///
graphregion(color(white)) ///
ylabel(0.005 "0.005" ///
0.01 "0.01" ///
0.02 "0.02" ///
0.05 "0.05" ///
0.1 "0.1" ///
0.2 "0.2" ///
0.5 "0.5" ///
1.0 "1.0" ///
2.0 "2.0" ///
5.0 "5.0", format(%9.3f) grid angle(0)) ///
yscale(range(0.004 5.05) log) ///
xscale(range(1995 2020)) ///
xlabel(1995(5)2020, nogrid) ///
ytitle("Incidence (per 1,000 person-years)", margin(a+2)) ///
xtitle("Calendar year") ///
title("`oc´ - `s´", placement(west) color(black) size(medium))
}
graph save "Graph" Alive_`ii´_`iii´_STD, replace
}
}
foreach ii in M F {
foreach iii in inc_t2d inc_uncertaint {
if "`ii´" == "M" {
local s = "Males"
}
else {
local s = "Females"
}
if "`iii´" == "inc_t1d" {
local oc = "Type 1 diabetes"
}
else if "`iii´" == "inc_t2d" {
local oc = "Type 2 diabetes"
}
```

```
else {
local oc = "Uncertain diabetes type"
}
local col1 = "0 0 255"
local col2 = "75 0 130"
local col3 = "255 0 255"
local col4 = "255 0 0"
local col5 = "255 125 0"
local col6 = "0 125 0"
local col7 = "0 175 255"
local col8 = "0 0 0"
clear
forval i = 1/8 {
append using STD_Rate_`i´_`ii´_`iii´
}
preserve
bysort country : keep if _n == 1
forval i = 1/8 {
local C`i´ = country[`i´]
}
restore
if "`ii´" == "F" & "`iii´" == "inc_t2d" {
twoway ///
(rarea ub lb calendar if country == "`C1´", color("`col1´%30") fintensity(inten80) lwidth(none)) ///
(line stdrate calendar if country == "`C1´", color("`col1´") lpattern(solid)) ///
(rarea ub lb calendar if country == "`C2´", color("`col2´%30") fintensity(inten80) lwidth(none)) ///
(line stdrate calendar if country == "`C2´", color("`col2´") lpattern(solid)) ///
(rarea ub lb calendar if country == "`C3´", color("`col3´%30") fintensity(inten80) lwidth(none)) ///
(line stdrate calendar if country == "`C3´", color("`col3´") lpattern(solid)) ///
(rarea ub lb calendar if country == "`C4´", color("`col4´%30") fintensity(inten80) lwidth(none)) ///
(line stdrate calendar if country == "`C4´", color("`col4´") lpattern(solid)) ///
(rarea ub lb calendar if country == "`C5´", color("`col5´%30") fintensity(inten80) lwidth(none)) ///
(line stdrate calendar if country == "`C5´", color("`col5´") lpattern(solid)) ///
(rarea ub lb calendar if country == "`C6´", color("`col6´%30") fintensity(inten80) lwidth(none)) ///
(line stdrate calendar if country == "`C6´", color("`col6´") lpattern(solid)) ///
(rarea ub lb calendar if country == "`C7´", color("`col7´%30") fintensity(inten80) lwidth(none)) ///
(line stdrate calendar if country == "`C7´", color("`col7´") lpattern(solid)) ///
(rarea ub lb calendar if country == "`C8´", color("`col8´%30") fintensity(inten80) lwidth(none)) ///
(line stdrate calendar if country == "`C8´", color("`col8´") lpattern(solid)) ///
, legend(symxsize(0.13cm) position(4) ring(0) region(lcolor(white) color(none)) ///
order(2 "`C1´" ///
4 "`C2´" ///
6 "`C3´" ///
8 "`C4´" ///
10 "`C5´" ///
12 "`C6´" ///
14 "`C7´" ///
16 "`C8´") ///
cols(2)) ///
graphregion(color(white)) ///
ylabel(0.005 "0.005" ///
0.01 "0.01" ///
0.02 "0.02" ///
0.05 "0.05" ///
0.1 "0.1" ///
0.2 "0.2" ///
0.5 "0.5" ///
1.0 "1.0" ///
2.0 "2.0" ///
5.0 "5.0", format(%9.3f) grid angle(0)) ///
yscale(range(0.004 5.05) log) ///
xscale(range(1995 2020)) ///
xlabel(1995(5)2020, nogrid) ///
ytitle("Incidence (per 1,000 person-years)", margin(a+2)) ///
xtitle("Calendar year") ///
title("`oc´ - `s´", placement(west) color(black) size(medium))
}
else {
```

```
twoway ///
(rarea ub lb calendar if country == "`C1´", color("`col1´%30") fintensity(inten80) lwidth(none)) ///
(line stdrate calendar if country == "`C1´", color("`col1´") lpattern(solid)) ///
(rarea ub lb calendar if country == "`C2´", color("`col2´%30") fintensity(inten80) lwidth(none)) ///
(line stdrate calendar if country == "`C2´", color("`col2´") lpattern(solid)) ///
(rarea ub lb calendar if country == "`C3´", color("`col3´%30") fintensity(inten80) lwidth(none)) ///
(line stdrate calendar if country == "`C3´", color("`col3´") lpattern(solid)) ///
(rarea ub lb calendar if country == "`C4´", color("`col4´%30") fintensity(inten80) lwidth(none)) ///
(line stdrate calendar if country == "`C4´", color("`col4´") lpattern(solid)) ///
(rarea ub lb calendar if country == "`C5´", color("`col5´%30") fintensity(inten80) lwidth(none)) ///
(line stdrate calendar if country == "`C5´", color("`col5´") lpattern(solid)) ///
(rarea ub lb calendar if country == "`C6´", color("`col6´%30") fintensity(inten80) lwidth(none)) ///
(line stdrate calendar if country == "`C6´", color("`col6´") lpattern(solid)) ///
(rarea ub lb calendar if country == "`C7´", color("`col7´%30") fintensity(inten80) lwidth(none)) ///
(line stdrate calendar if country == "`C7´", color("`col7´") lpattern(solid)) ///
(rarea ub lb calendar if country == "`C8´", color("`col8´%30") fintensity(inten80) lwidth(none)) ///
(line stdrate calendar if country == "`C8´", color("`col8´") lpattern(solid)) ///
, legend(off) ///
graphregion(color(white)) ///
ylabel(0.005 "0.005" ///
0.01 "0.01" ///
0.02 "0.02" ///
0.05 "0.05" ///
0.1 "0.1" ///
0.2 "0.2" ///
0.5 "0.5" ///
1.0 "1.0" ///
2.0 "2.0" ///
5.0 "5.0", format(%9.3f) grid angle(0)) ///
yscale(range(0.004 5.05) log) ///
xscale(range(1995 2020)) ///
xlabel(1995(5)2020, nogrid) ///
ytitle("Incidence (per 1,000 person-years)", margin(a+2)) ///
xtitle("Calendar year") ///
title("`oc´ - `s´", placement(west) color(black) size(medium))
}
graph save "Graph" Alive_`ii´_`iii´_STD, replace
}
}


graph combine ///
Alive_F_inc_t1d_STD.gph ///
Alive_M_inc_t1d_STD.gph ///
Alive_F_inc_t2d_STD.gph ///
Alive_M_inc_t2d_STD.gph ///
Alive_F_inc_uncertaint_STD.gph ///
Alive_M_inc_uncertaint_STD.gph ///
, altshrink rows(3) xsize(3.3) graphregion(color(white))
> rs, by diabetes type and sex. ///
South Korea is excluded from type 1 diabetes due to insufficent numbers.)
```

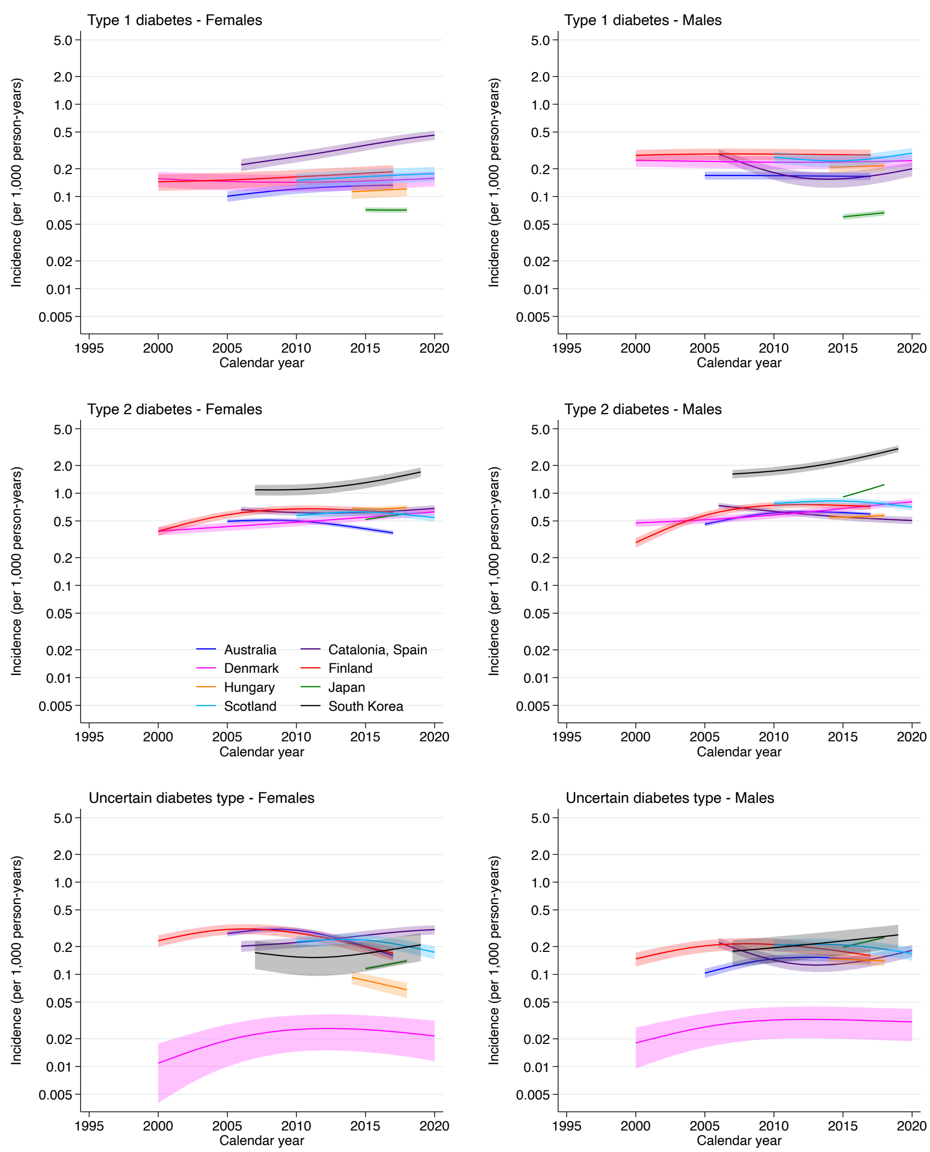

Figure 4.3: Age-standardized incidence of diabetes for people aged 15-39 years, by diabetes type and sex. South Korea is excluded from type 1 diabetes due to insufficent numbers.

5 Average Annual Percent Changes

As a summary metric, we will also estimate the average annual percent change in incidence - overall, and by sex. For this, we use a different model with a spline effect of age, but only a (log-)linear effect of calendar time. This means we are assuming the effect of time is constant throughout follow-up, which we already know is false for a few countries (e.g., Australia; figure 3.26).

```
forval i = 1/8 {
forval ii = 0/2 {
forval iii = 1/3 {
if `i´ == 1 {
local c = "Australia"
}
if `i´ == 2 {
local c = "Catalonia, Spain"
}
if `i´ == 3 {
local c = "Denmark"
}
if `i´ == 4 {
local c = "Finland"
}
if `i´ == 5 {
local c = "Hungary"
}
if `i´ == 6 {
local c = "Japan"
}
if `i´ == 7 {
local c = "Scotland"
}
if `i´ == 8 {
local c = "South Korea"
}
import delimited "Consortium young-onset diabetes_incidence v7.csv", varnames(1) clear
drop if cal >= 2021
if `iii´ == 1 {
drop if age_gp == "35-39"
}
keep if country == "`c´"
if `ii´ == 1 {
keep if sex == "M"
}
if `ii´ == 2 {
keep if sex == "F"
}
rename age_gp age
replace age = substr(age,1,2)
destring age, replace
replace age = age+2.5
su(calendar), detail
local lb = r(min)
local ub = r(max)
replace calendar = calendar-2010
gen coh = calendar-age
centile(age), centile(5 35 65 95)
local A1 = r(c_1)
local A2 = r(c_2)
local A3 = r(c_3)
local A4 = r(c_4)
mkspline agesp = age, cubic knots(`A1´ `A2´ `A3´ `A4´)
if `iii´ == 1 {
poisson inc_t1d calendar agesp*, exposure(pys)
}
```

```
if `iii´ == 2 {
poisson inc_t2d calendar agesp*, exposure(pys)
}
if `iii´ == 3 {
poisson inc_uncertaint calendar agesp*, exposure(pys)
}
matrix A_`i´_`ii´_`iii´ = (`lb´,`ub´,`i´,`ii´,`iii´,r(table)[1,1], r(table)[5,1], r(table)[6,1])
}
}
matrix A_`i´ = (A_`i´_0_1,A_`i´_0_2,A_`i´_0_3\ ///
A_`i´_1_1,A_`i´_1_2,A_`i´_1_3\ ///
A_`i´_2_1,A_`i´_2_2,A_`i´_2_3)
}
matrix A = (A_1\A_2\A_3\A_4\A_5\A_6\A_7\A_8)
clear
svmat A
gen country=""
bysort A3 (A2) : replace country = "Australia" if A3 == 1 & _n == 1
bysort A3 (A2) : replace country = "Catalonia, Spain" if A3 == 2 & _n == 1
bysort A3 (A2) : replace country = "Denmark" if A3 == 3 & _n == 1
bysort A3 (A2) : replace country = "Finland" if A3 == 4 & _n == 1
bysort A3 (A2) : replace country = "Hungary" if A3 == 5 & _n == 1
bysort A3 (A2) : replace country = "Japan" if A3 == 6 & _n == 1
bysort A3 (A2) : replace country = "Scotland" if A3 == 7 & _n == 1
bysort A3 (A2) : replace country = "South Korea" if A3 == 8 & _n == 1
tostring A1 A2, replace format(%9.0f)
bysort A3 (A2) : gen time = A1+"-"+A2 if _n == 1
gen sex = "Overall" if A4 == 0
replace sex = "Males" if A4 == 1
replace sex = "Females" if A4 == 2
drop A9-A13 A17-A21
foreach var of varlist A6-A24 {
replace `var´ = 100*(exp(`var´)-1)
}
tostring A6-A24, replace force format(%9.2f)
gen T1 = A6 + " (" + A7 + ", " + A8 + ")"
gen T2 = A14 + " (" + A15 + ", " + A16 + ")"
gen T3 = A22 + " (" + A23 + ", " + A24 + ")"
keep country time sex T1 T2 T3
export delimited using APCs.csv, delimiter(":") novarnames replace
```

It's also worth looking at variation in the incidence rates by age, as some of the figures in section 3 suggested a greater increase in type 2 diabetes at younger ages. For this, we will use two models: the first includes the interaction between a spline effect of age and a log-linear effect of calendar time (plotted in the left panels of the combined figures), whereas the second includes a spline effect of age and the product of log-linear effects of age and calendar time (plotted on the right in the figures).

```
quietly {
forval i = 1/8 {
foreach ii in M F {
foreach iii in inc_t1d inc_t2d inc_uncertaint {
if `i´ == 1 {
local c = "Australia"
}
if `i´ == 2 {
local c = "Catalonia, Spain"
}
if `i´ == 3 {
local c = "Denmark"
}
if `i´ == 4 {
local c = "Finland"
}
if `i´ == 5 {
local c = "Hungary"
```

Table 5.1: Average annual percent change in the incidence of diabetes, by country, sex, and diabetes type. Adjusted for age.

Country	Period	Sex	Type 1 diabetes	Type 2 diabetes	Uncertain diabetes type
Australia	2005-2017	Overall	0.78 (0.23, 1.33)	-0.12 (-0.37, 0.13)	-2.14 (-2.54, -1.73)
		Males	-0.29 (-1.00, 0.43)	1.80 (1.46, 2.15)	2.20 (1.49, 2.92)
		Females	2.31 (1.44, 3.19)	-2.48 (-2.85, -2.11)	-4.46 (-4.95, -3.96)
Catalonia, Spain	2006-2020	Overall	2.92 (2.31, 3.54)	-1.48 (-1.80, -1.16)	1.58 (1.02, 2.15)
		Males	-3.12 (-4.10, -2.13)	-2.78 (-3.23, -2.34)	-1.59 (-2.46, -0.72)
		Females	6.31 (5.51, 7.12)	-0.03 (-0.49, 0.44)	3.60 (2.87, 4.34)
Denmark	2000-2020	Overall	-0.12 (-0.55, 0.31)	2.59 (2.36, 2.82)	2.39 (1.31, 3.47)
		Males	-0.17 (-0.71, 0.38)	2.77 (2.46, 3.07)	2.10 (0.70, 3.52)
		Females	-0.07 (-0.77, 0.64)	2.39 (2.04, 2.73)	2.81 (1.13, 4.52)
Finland	2000-2017	Overall	0.53 (0.01, 1.06)	3.36 (3.07, 3.65)	-1.00 (-1.45, -0.54)
		Males	-0.04 (-0.69, 0.61)	4.24 (3.83, 4.64)	0.22 (-0.46, 0.92)
		Females	1.58 (0.69, 2.49)	2.40 (1.99, 2.81)	-1.94 (-2.54, -1.34)
Hungary	2014-2018	Overall	1.27 (-1.88, 4.51)	0.25 (-1.08, 1.60)	-3.29 (-6.23, -0.25)
		Males	0.89 (-2.96, 4.89)	0.56 (-1.40, 2.55)	-1.16 (-4.87, 2.69)
		Females	1.79 (-3.55, 7.43)	0.02 (-1.80, 1.88)	-7.21 (-11.96, -2.19)
Japan	2015-2018	Overall	1.31 (-0.80, 3.45)	8.52 (7.96, 9.08)	7.70 (6.51, 8.91)
		Males	3.47 (0.29, 6.76)	10.52 (9.80, 11.23)	8.28 (6.76, 9.83)
		Females	-0.41 (-3.19, 2.45)	4.95 (4.04, 5.87)	6.70 (4.79, 8.63)
Scotland	2010-2020	Overall	1.29 (0.16, 2.43)	-0.70 (-1.24, -0.16)	-2.27 (-3.23, -1.29)
		Males	0.95 (-0.48, 2.41)	-0.81 (-1.53, -0.09)	-2.02 (-3.42, -0.60)
		Females	1.76 (-0.06, 3.61)	-0.56 (-1.37, 0.26)	-2.47 (-3.78, -1.13)
South Korea	2007-2019	Overall	6.05 (1.18, 11.15)	4.81 (4.22, 5.41)	2.99 (1.27, 4.73)
		Males	15.86 (6.34, 26.22)	5.40 (4.66, 6.15)	3.52 (1.25, 5.84)
		Females	1.82 (-3.85, 7.83)	3.69 (2.71, 4.68)	2.25 (-0.35, 4.91)

```
}
if `i´ == 6 {
local c = "Japan"
}
if `i´ == 7 {
local c = "Scotland"
}
if `i´ == 8 {
local c = "South Korea"
}
import delimited "Consortium young-onset diabetes_incidence v7.csv", varnames(1) clear
drop if cal >= 2021
if "`iii´" == "inc_t1d" {
drop if age_gp == "35-39"
}
keep if country == "`c´" & sex == "`ii´"
rename age_gp age
replace age = substr(age,1,2)
destring age, replace
replace age = age+2.5
replace calendar = calendar-2010
centile(age), centile(5 35 65 95)
local A1 = r(c_1)
local A2 = r(c_2)
local A3 = r(c_3)
local A4 = r(c_4)
mkspline agesp = age, cubic knots(`A1´ `A2´ `A3´ `A4´)
preserve
clear
set obs 251
```

```
gen age = (_n/10)+14.9
mkspline agesp = age, cubic knots(`A1´ `A2´ `A3´ `A4´)
forval a = 1/251 {
local A1`a´ = agesp1[`a´]
local A2`a´ = agesp2[`a´]
local A3`a´ = agesp3[`a´]
}
restore
poisson `iii´ c.agesp*##c.cal , exposure(pys)
matrix A = (.,.,.,.)
forval a = 1/251 {
margins, dydx(cal) at(agesp1==`A1`a´´ agesp2==`A2`a´´ agesp3==`A3`a´´) atmeans predict(xb)
matrix A = (A\(`a´/10)+14.9,r(table)[1,1],r(table)[5,1],r(table)[6,1])
}
preserve
clear
svmat A
drop if A1==.
replace A2 = 100*(exp(A2)-1)
replace A3 = 100*(exp(A3)-1)
replace A4 = 100*(exp(A4)-1)
rename A1 age
rename A2 apc
rename A3 lb
rename A4 ub
gen country = "`c´"
gen sex = "`ii´"
gen OC = "`iii´"
save APC_age_`i´_`ii´_`iii´_1, replace
restore
poisson `iii´ c.agesp* c.age##c.cal , exposure(pys)
matrix A = (.,.,.,.)
forval a = 1/251 {
margins, dydx(cal) at(age==`A1`a´´ agesp1==`A1`a´´ agesp2==`A2`a´´ agesp3==`A3`a´´) atmeans predict(
> xb)
matrix A = (A\(`a´/10)+14.9,r(table)[1,1],r(table)[5,1],r(table)[6,1])
}
clear
svmat A
drop if A1==.
replace A2 = 100*(exp(A2)-1)
replace A3 = 100*(exp(A3)-1)
replace A4 = 100*(exp(A4)-1)
rename A1 age
rename A2 apc
rename A3 lb
rename A4 ub
gen country = "`c´"
gen sex = "`ii´"
gen OC = "`iii´"
save APC_age_`i´_`ii´_`iii´_2, replace
}
}
}
}


forval i = 1/8 {
foreach iii in inc_t1d inc_t2d inc_uncertaint {
if `i´ == 1 {
local c = "Australia"
}
if `i´ == 2 {
local c = "Catalonia, Spain"
}
if `i´ == 3 {
local c = "Denmark"
}
if `i´ == 4 {
```

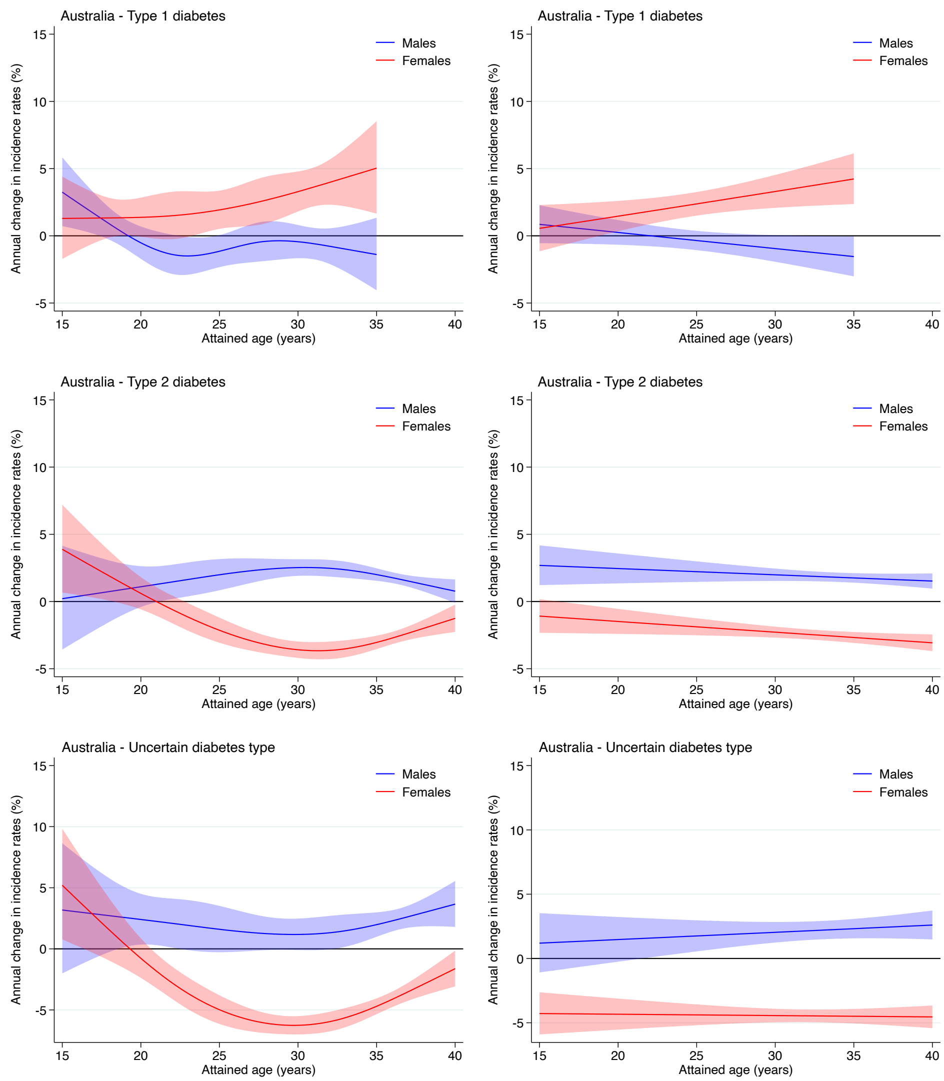

Figure 5.1: Annual percent change in the incidence of diabetes in Australia by age, by diabetes type and sex. Values are predicted from a Poisson model with a spline effect of attained age, a log-linear effect of calendar time, and an interaction between age and calendar time. The left panels use a spline term for age in the interaction, the right panels use the product of age and calendar time in the interaction.

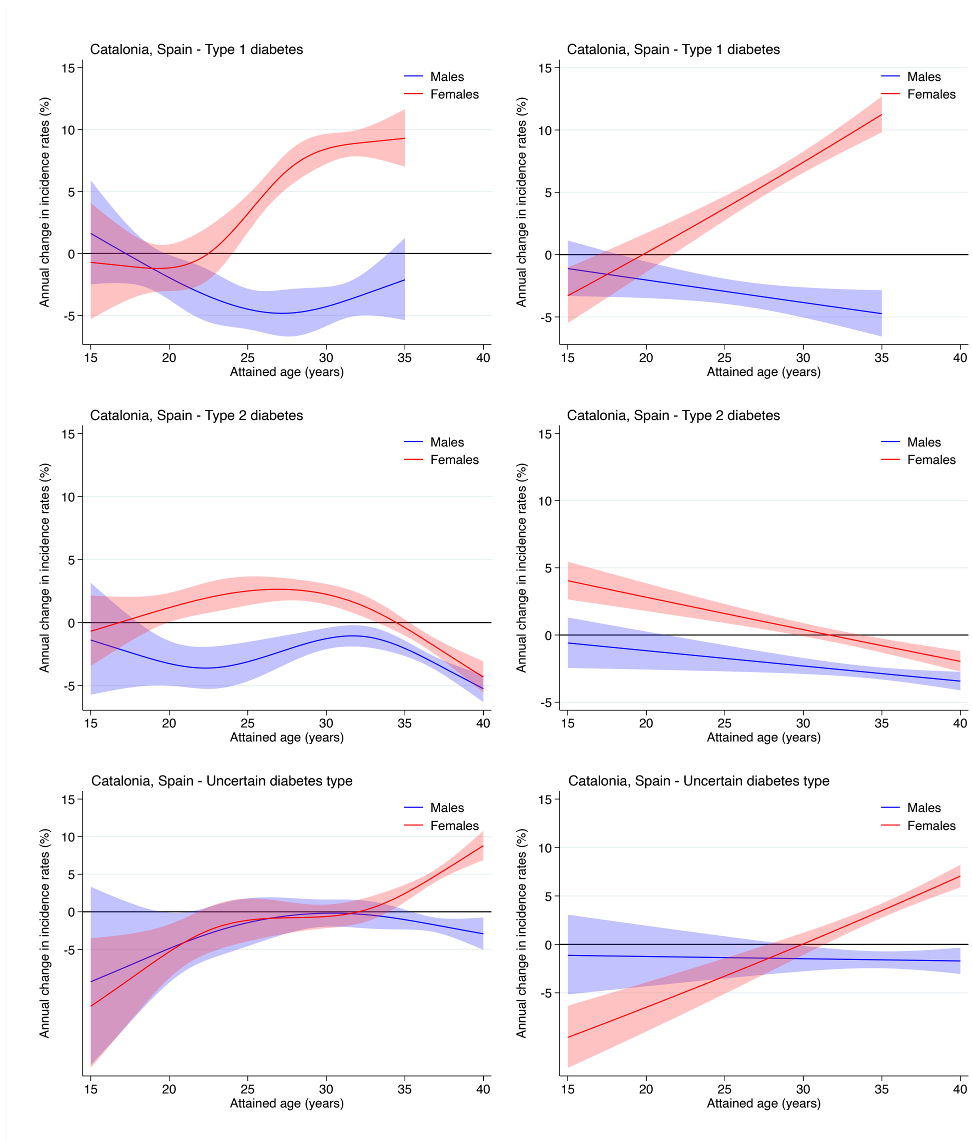

Figure 5.2: Annual percent change in the incidence of diabetes in Catalonia, Spain by age, by diabetes type and sex. Values are predicted from a Poisson model with a spline effect of attained age, a log-linear effect of calendar time, and an interaction between age and calendar time. The left panels use a spline term for age in the interaction, the right panels use the product of age and calendar time in the interaction.

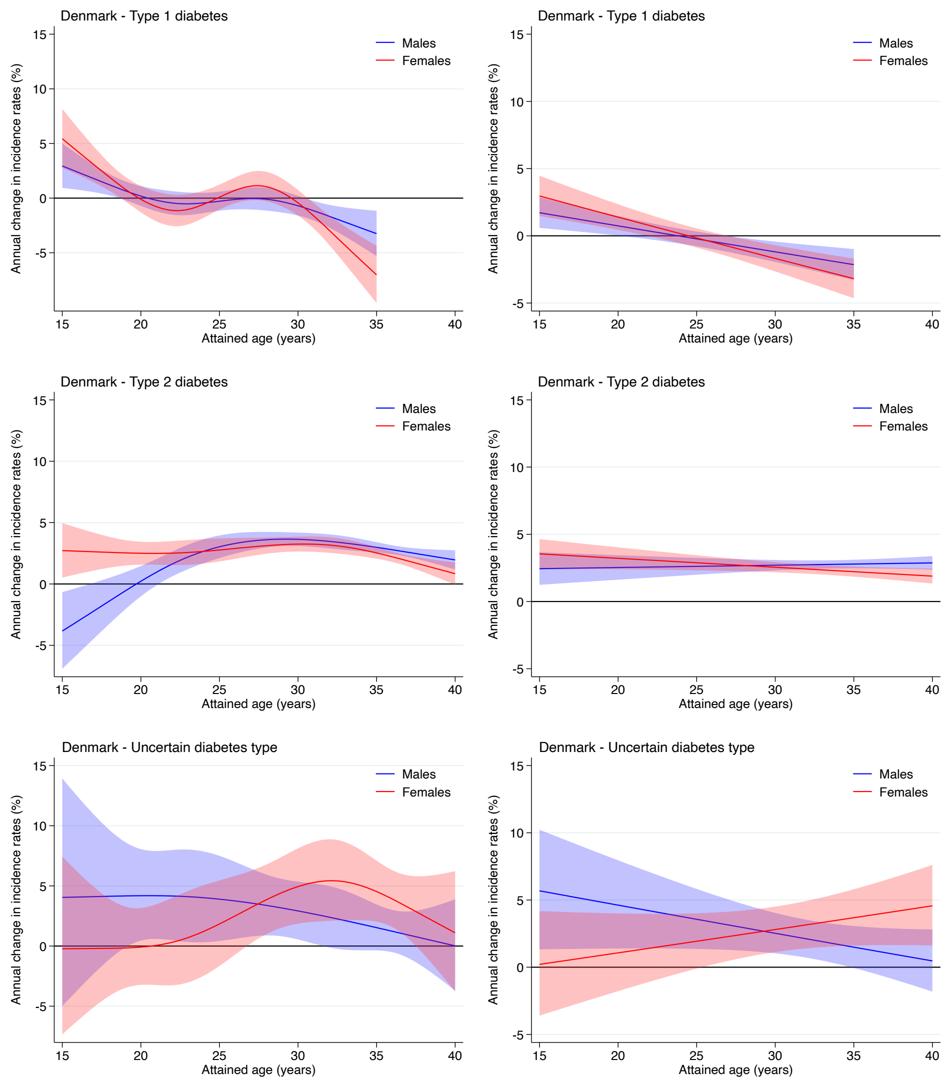

Figure 5.3: Annual percent change in the incidence of diabetes in Denmark by age, by diabetes type and sex. Values are predicted from a Poisson model with a spline effect of attained age, a log-linear effect of calendar time, and an interaction between age and calendar time. The left panels use a spline term for age in the interaction, the right panels use the product of age and calendar time in the interaction.

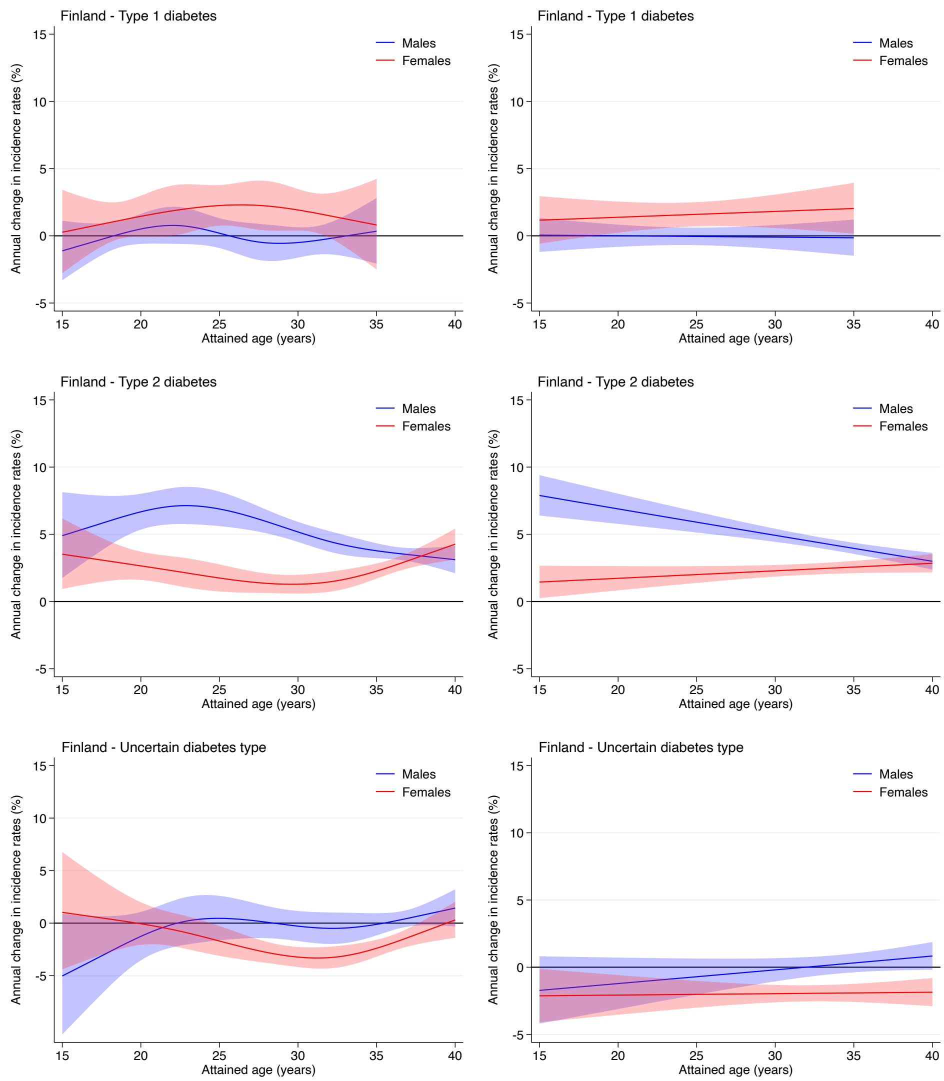

Figure 5.4: Annual percent change in the incidence of diabetes in Finland by age, by diabetes type and sex. Values are predicted from a Poisson model with a spline effect of attained age, a log-linear effect of calendar time, and an interaction between age and calendar time. The left panels use a spline term for age in the interaction, the right panels use the product of age and calendar time in the interaction.

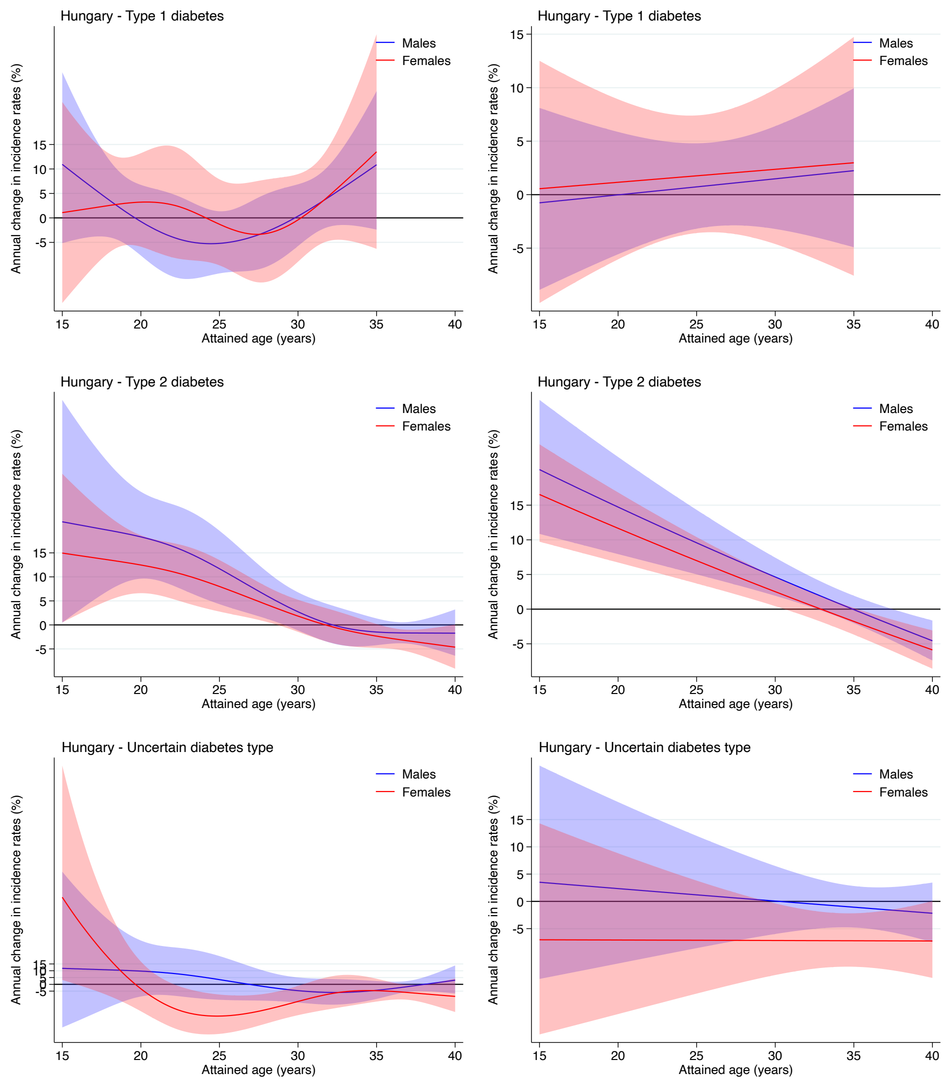

Figure 5.5: Annual percent change in the incidence of diabetes in Hungary by age, by diabetes type and sex. Values are predicted from a Poisson model with a spline effect of attained age, a log-linear effect of calendar time, and an interaction between age and calendar time. The left panels use a spline term for age in the interaction, the right panels use the product of age and calendar time in the interaction.

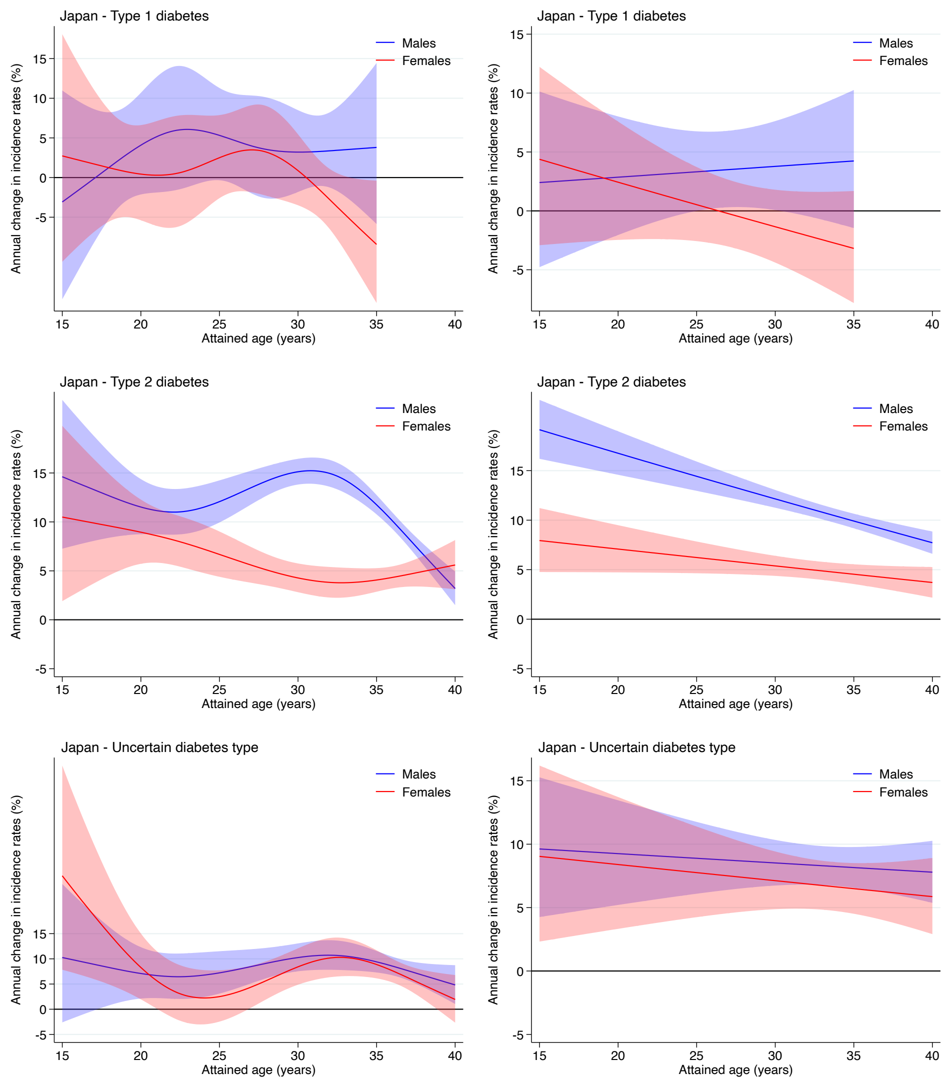

Figure 5.6: Annual percent change in the incidence of diabetes in Japan by age, by diabetes type and sex. Values are predicted from a Poisson model with a spline effect of attained age, a log-linear effect of calendar time, and an interaction between age and calendar time. The left panels use a spline term for age in the interaction, the right panels use the product of age and calendar time in the interaction.

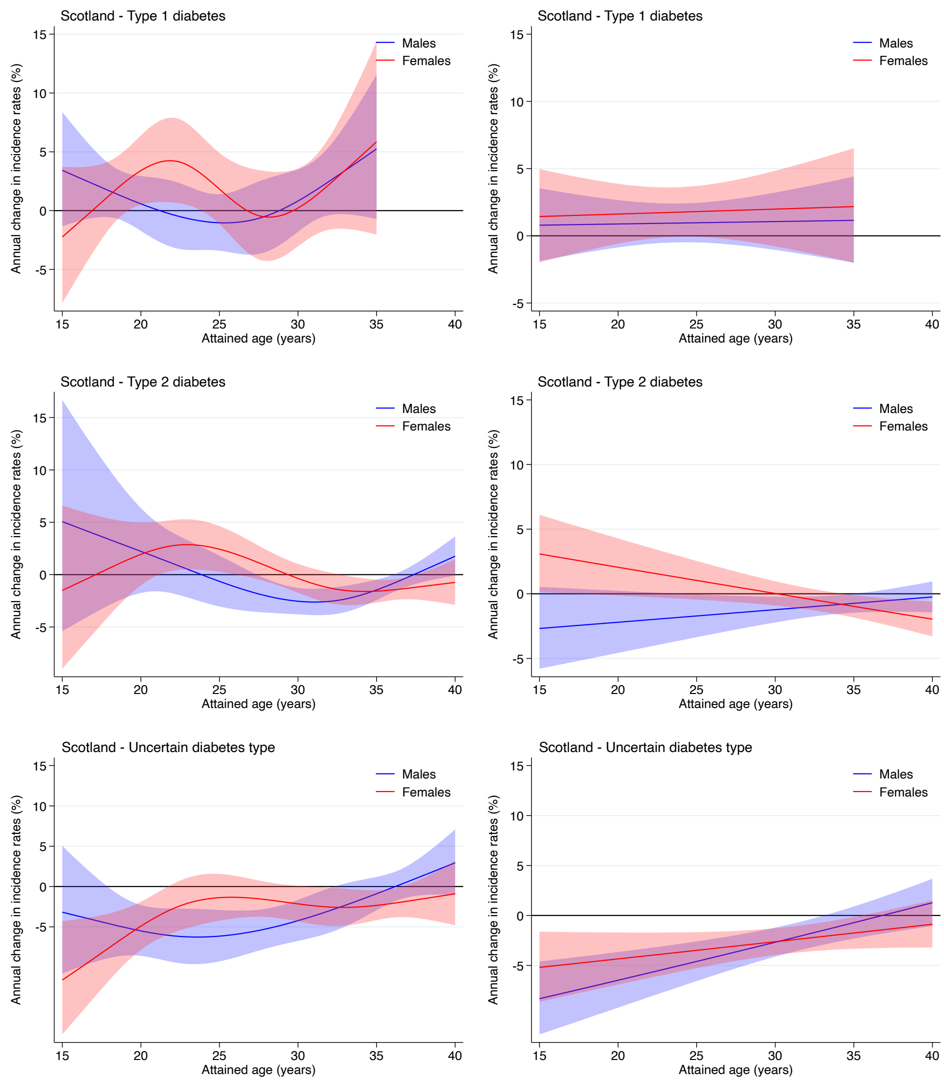

Figure 5.7: Annual percent change in the incidence of diabetes in Scotland by age, by diabetes type and sex. Values are predicted from a Poisson model with a spline effect of attained age, a log-linear effect of calendar time, and an interaction between age and calendar time. The left panels use a spline term for age in the interaction, the right panels use the product of age and calendar time in the interaction.

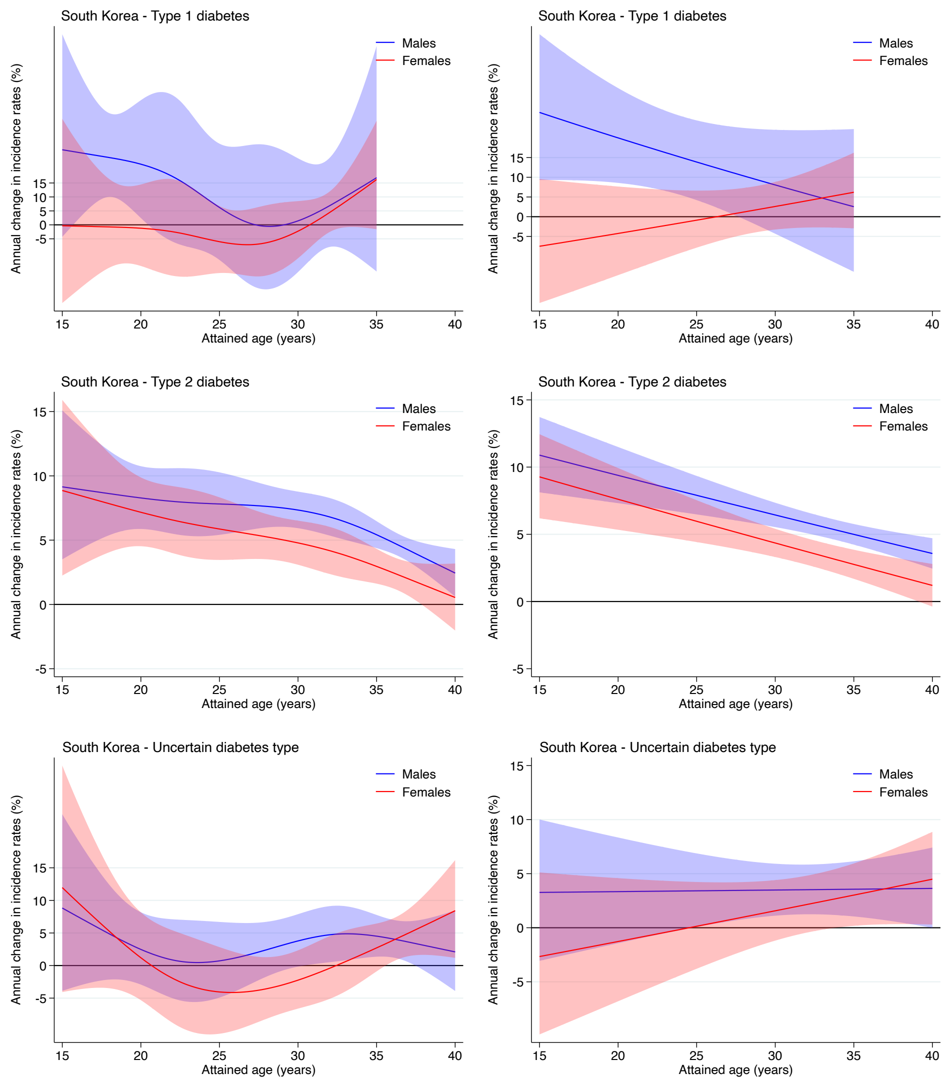

Figure 5.8: Annual percent change in the incidence of diabetes in South Korea by age, by diabetes type and sex. Values are predicted from a Poisson model with a spline effect of attained age, a log-linear effect of calendar time, and an interaction between age and calendar time. The left panels use a spline term for age in the interaction, the right panels use the product of age and calendar time in the interaction.

```
local c = "Finland"
}
if `i´ == 5 {
local c = "Hungary"
}
if `i´ == 6 {
local c = "Japan"
}
if `i´ == 7 {
local c = "Scotland"
}
if `i´ == 8 {
local c = "South Korea"
}
if "`iii´" == "inc_t1d" {
local oc = "Type 1 diabetes"
}
else if "`iii´" == "inc_t2d" {
local oc = "Type 2 diabetes"
}
else {
local oc = "Uncertain diabetes type"
}
forval a = 1/2 {
clear
append using APC_age_`i´_M_`iii´_`a´
append using APC_age_`i´_F_`iii´_`a´
if "`iii´" == "inc_t1d" {
drop if age > 35
}
twoway ///
(rarea ub lb age if sex == "M", color("blue%30") fintensity(inten80) lwidth(none)) ///
(line apc age if sex == "M", color("blue") lpattern(solid)) ///
(rarea ub lb age if sex == "F", color("red%30") fintensity(inten80) lwidth(none)) ///
(line apc age if sex == "F", color("red") lpattern(solid)) ///
,legend(ring(0) symxsize(0.13cm) position(2) region(lcolor(white) color(none)) ///
order(2 "Males" ///
4 "Females")  ///
cols(1)) ///
bgcolor(white) graphregion(color(white)) ///
ytitle("Annual change in incidence rates (%)", xoffset(-1)) ///
yline(0, lcolor(gs0)) ///
ylabel(-5(5)15, angle(0)) ///
xtitle("Attained age (years)") ///
xlabel(15(5)40) ///
title("`c´ - `oc´", placement(west) size(medium) color(gs0))
graph save "Graph" Apage_`i´_`iii´_`a´, replace
}
}
graph combine ///
Apage_`i´_inc_t1d_1.gph ///
Apage_`i´_inc_t1d_2.gph ///
Apage_`i´_inc_t2d_1.gph ///
Apage_`i´_inc_t2d_2.gph ///
Apage_`i´_inc_uncertaint_1.gph ///
Apage_`i´_inc_uncertaint_2.gph ///
, altshrink rows(3) xsize(3.5) graphregion(color(white))
> y age, by diabetes type and sex. ///
Values are predicted from a Poisson model with a spline effect of attained age, a log-linear effect
> of calendar time, and an interaction ///
between age and calendar time. The left panels use a spline term for age in the interaction, the rig
> ht panels use the product of ///
age and calendar time in the interaction.)
}
```

References

[1] Dianna J Magliano, Lei Chen, Rakibul M Islam, Bendix Carstensen, Edward W Gregg, Meda E Pavkov, Linda J Andes, Ran Balicer, Marta Baviera, Elise Boersma-van Dam, et al. Trends in the incidence of diagnosed diabetes: a multicountry analysis of aggregate data from 22 million diagnoses in high-income and middle-income settings. *The Lancet Diabetes & Endocrinology*, 9(4):203–211, 2021.

[2] Bendix Carstensen. Age–period–cohort models for the lexis diagram. *Statistics in medicine*, 26(15):3018–3045, 2007.

[3] Ben Jann. Creating latex documents from within stata using texdoc. *The Stata Journal*, 16(2):245–263, 2016.

[4] Garnier, Simon, Ross, Noam, Rudis, Robert, Camargo, Antônio Pedro, Sciaini, Marco, Scherer, and Cédric. *viridis - Colorblind-Friendly Color Maps for R*, 2021. R package version 0.6.2.

[5] Frank E Harrell. *Regression modeling strategies: with applications to linear models, logistic regression, and survival analysis*, volume 608. Springer, 2001.