Deaths in young people aged 0–24 years in the UK compared with the EU15+ countries, 1970–2008: analysis of the WHO Mortality Database

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Summary

Background **Concern is growing that mortality and health in children and young people in the UK lags behind that of similar countries.**

Methods **We analysed death registry data provided to the WHO Mortality Database to compare UK mortality for children and young people aged 0–24 years with that of European Union member states (before May, 2004, excluding the UK, plus Australia, Canada, and Norway [the EU15+ countries]) from 1970 to 2008 using the WHO World Mortality Database. We grouped causes of death by Global Burden of Disease classification: communicable, nutritional, or maternal causes; non-communicable disorders; and injury. UK mortality trends were compared with quartiles of mortality in EU15+ countries. We used quasi-likelihood Poisson models to explore differences between intercepts and slopes between the UK and the EU15+ countries.**

Findings **In 1970, UK total mortality was in the best EU15+ quartile (<25th centile) for children and young people aged 1–24 years, with UK infant mortality similar to the EU15+ median. Subsequent mortality reductions in the UK were smaller than were those in the EU15+ countries in all age groups. By 2008, total mortality for neonates, infants, and children aged 1–4 years in the UK was in the worst EU15+ quartile (>75th centile). In 2008, UK annual excess mortality compared with the EU15+ median was 1035 deaths for infants and 134 for children aged 1–9 years. Mortality from non-communicable diseases in the UK fell from being roughly equivalent to the EU15+ median in 1970 to the worst quartile in all age groups by 2008, with 446 annual excess deaths from non-communicable diseases in the UK (280 for young people aged 10–24 years) in 2008. UK mortality from injury remained in the best EU15+ quartile for the study period in all age groups.**

Interpretation **The UK has not matched the gains made in child, adolescent, and young adult mortality by other comparable countries in the 40 years since 1970, particularly for infant deaths and mortality from non-communicable diseases, including neuropsychiatric disorders. The UK needs to identify and address amenable social determinants and health system factors that lead to poor health outcomes for infants and for children and young people with chronic disorders.**

Funding **None.**

Introduction

Improvement in mortality and health in the UK seems to lag behind that of other wealthy countries. Adults in the UK have worse health and more premature mortality than do people in similar European and other countries;[1] the UK has dropped down comparative mortality rankings for children and young people since 1990,[1] and findings from a recent study[2] showed that the UK had worse all-cause mortality in children aged 0–14 years than did many European countries.[2]

This difference has serious implications for the provision of health services for children and young people in the UK, and has galvanised the attention of the UK Government and the health system.[3] However, data to guide action are lacking. Findings from a systematic review[4] showed no previous comparative studies of long-term trends in all-cause and cause-specific mortality for children and young people in the UK compared with other wealthy countries. Detailed data are needed to support action, particularly because the UK does well in some factors that contribute substantially to child and youth mortality (eg, mortality from injuries).

We used data from national death registries provided to the the WHO World Mortality Database to compare trends in all-cause and cause-specific mortality in children and young people aged 0–24 year in the UK during the past 40 years with trends in a group of similar wealthy countries.

Methods

Study design

For this analysis of registry data, we defined comparator countries as the EU15+ countries, recently suggested[1] to be the most rational comparator group for health issues in the UK because of similar or higher health expenditure in these countries and their previous inclusion in benchmarking exercises for health in the UK. These countries are the EU member states before May, 2004,

not including the UK (ie, Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, and Sweden) and Australia, Canada, and Norway. We did not include the USA because of its very high infant and child mortality compared with the EU15+ countries (including the UK).[5,6]

Procedures

We derived data for mortality from countries of interest from the WHO World Mortality database,[7] accessed May 6, 2013. The database contains country-level data for deaths by age, sex, and cause of death from 1955 onwards, as reported annually by WHO member states from their civil registration systems. We included data from 1970 (when all countries had very high completeness of death registration) until 2008, because deposition after this year was variable. Reliable later data were also not available for the UK because of late deposition of UK data about deaths from external injuries.[8]

We aggregated data within the age groups of younger than 1 year (ie, infants) and 1–4, 5–9, 10–14, 15–19, and 20–24 years, stratified by sex. Infant data were further subdivided into neonatal (day 0–27) or postneonatal (day 28–365) deaths. We used the Global Burden of Disease classification for causes of death, grouping deaths as group I (communicable, nutritional, or maternal causes), group II (non-communicable disease [NCD] causes), or group III (injury causes), with non-specific causes proportionally redistributed within the group I and II categories.[9] Because these classifications apply poorly to infants, we categorised infant causes by International Classification of Disease (ICD) chapter (ie, perinatal disorders, congenital malformations and chromosomal abnormalities, injuries, and other causes; appendix).

Statistical analysis

For each country and year, we calculated death rates per 100 000 population in the specific age group using population data from the WHO World Mortality Database or, when missing, from other UN sources. We expressed infant mortality per 100 000 population to allow convenient comparison with other age groups.

We analysed data using Stata (version 12.0). Current mortality was defined for countries as the mean of last available data between 2005 and 2008, and was reported as mortality per 100 000 person-years of observation across these years. We then calculated the 25th, 50th (median), and 75th centiles of mortality for the EU15+ countries (excluding the UK) in each age group for each year per 100 000 person-years of observation, and graphically compared these centiles with UK mortality. Data for children aged 0–9 years were not disaggregated by sex, because mortality was similar for boys and girls.

To test the significance of apparent differences between the UK and the EU15+ group, we constructed Poisson regression models for change in mortality between 1970 and 2008 in each age group. Each model included all available data-years for all countries, including a total of 666 country-years of mortality data across the 18 countries (the UK and the 17 EU15+ countries). Because data were over-dispersed, the models used quasi-likelihood generalised estimating equations; we calculated robust standard errors using the Huber-White-Sandwich linearised estimator of variance.[10] Predictor terms in each model included time, country group (UK or EU15+), and the interaction of country group with time. Quadratic terms for time and the time–country interaction were included when significant. Significance in the models was defined as $p<0\cdot01$, and in calculation of median differences was defined as $p<0\cdot05$. We then compared UK mortality for age in 2008 with each EU15+ country, calculating the median[11] difference between the UK and EU15+ to identify excess UK mortality. We estimated excess annual deaths in the UK by applying the excess mortality rate to the UK population for age group and sex in 2008.

More detailed analyses are presented for the two groups for which UK mortality was higher than in the EU15+ countries (ie, infant and NCD mortality). We restricted these analyses to data that were deposited using the ICD-10 classification system to ensure maximum comparability of disease coding. Thus, these analyses were restricted to 2001–08 and did not include Greece, because it had not adopted ICD-10. We grouped mortality by ICD-10 chapter for infants and NCD causes, collapsing causes with few deaths into an "other" group (ie, benign neoplasms, sense organ disorders, genitourinary disorders, skin disorders, and dental conditions; appendix). For NCD causes, trends are shown for children aged 1–9 years and adolescents and young adults aged 10–24 years.

See Online for appendix

For UK mortality relative to EU15+ mortality at baseline, positive coefficients suggest that UK mortality was higher than EU15+ mortality in 1970, whereas negative coefficients suggest that UK mortality was lower than in the EU15+ countries. Coefficients for annual reduction in log mortality rate refer to the slope of change for either the UK or the EU15+ countries over time. For the EU15+ countries, negative coefficients suggest a falling annual mortality rate. For the UK rate of reduction compared with EU15+ countries, a positive coefficient suggests that the UK's rate of mortality decline was lower than the EU15+, whereas a negative coefficient suggests a greater rate of decline. Coefficients for quadratic terms for rate of change follow the same convention.

Role of the funding source

There was no funding source for this study. RMV confirms that he had full access to all the data in the study and had final responsibility for the decision to submit for publication.

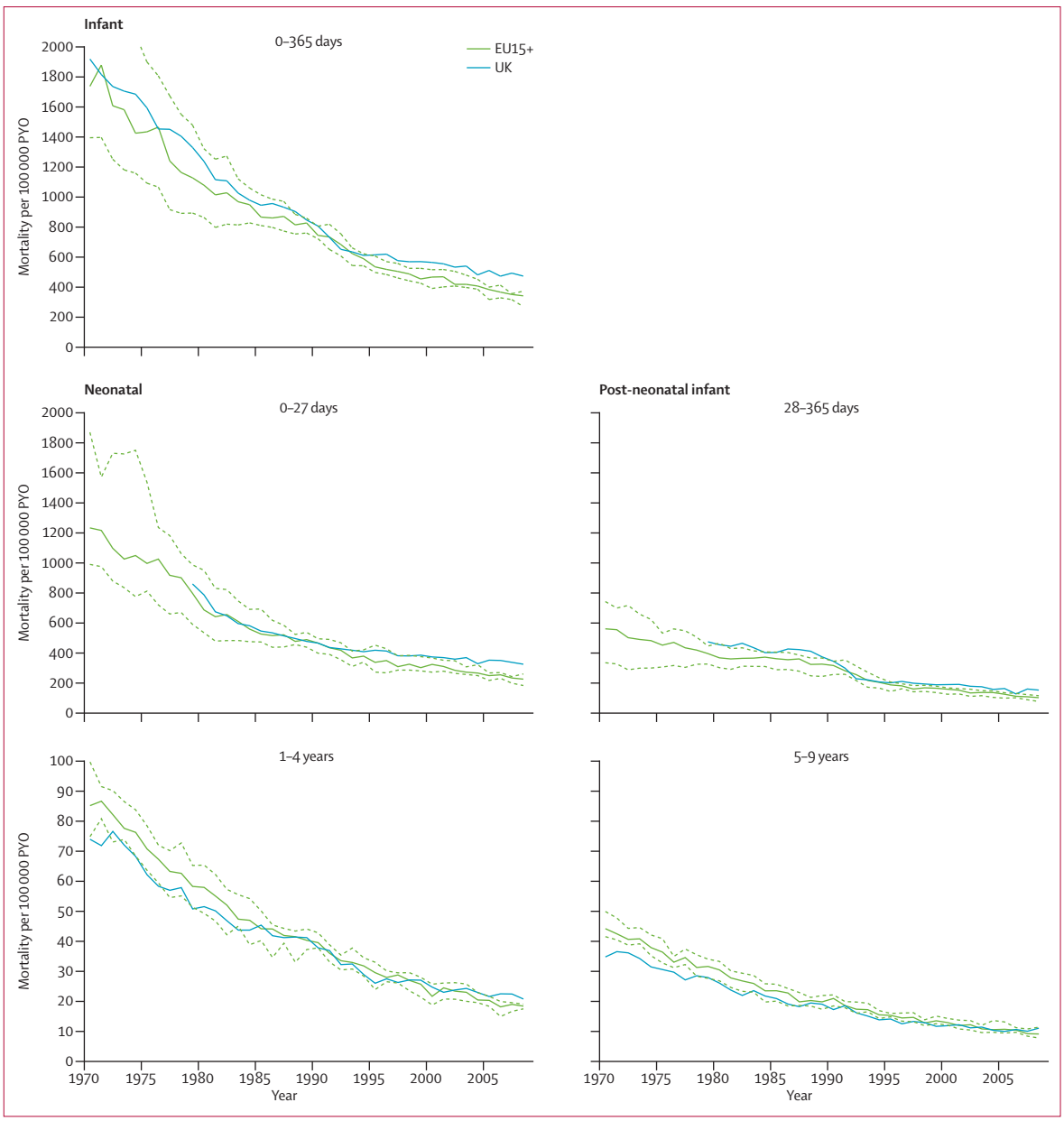

Figure 1: **Total mortality trends for children aged 0–9 years from 1970 to 2008**
Solid blue line shows UK mortality; solid green line shows median mortality for the EU15+ countries; dashed green lines show the 25th and 75th centiles for mortality in the EU15+ countries. Note change in Y-axis scale. PYO=person-years of observation.

Results

The UK had the second-highest current mortality (mean 2005–08) for infants (second to Canada) and children aged 1–4 years (second to Belgium) in both sexes (appendix). UK mortality for children and young people aged 5–24 years was similar to that of most EU15+ countries. Total mortality trends across 1970 to 2008 for the UK and the EU15+ countries are shown in figure 1 (0–9 year olds) and figure 2 (10–24 year olds). Table 1 shows longitudinal Poisson regression models for change in log total mortality across the study period.

In 1970, the UK had infant mortality similar to the EU15+ mean. Mortality fell across the study period in both the UK (–75·3%) and the EU15+ countries (–80·2%), but in the UK this reduction slowed substantially after the mid-1980s, consistent with the quadratic interaction term in the model. After the mid-1990s, UK infant mortality moved into the worst quartile (ie, >75th centile) of EU15+ mortality. A similar pattern was noted for neonatal mortality, which contributed to 70·0% of UK mortality and 66·4% of median EU15+ mortality for 2005–08. UK postneonatal mortality began the 1980s

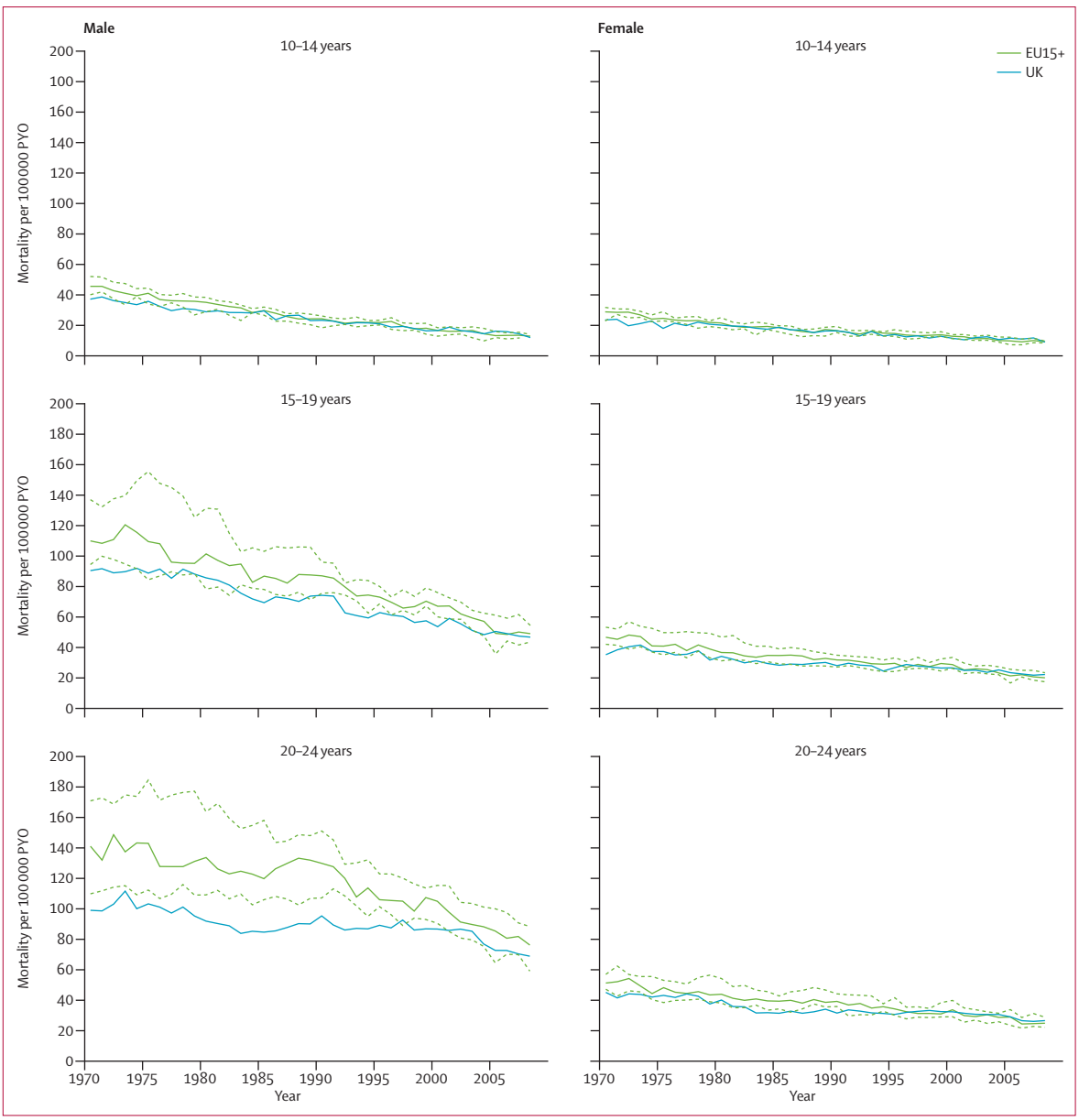

Figure 2: **Total mortality trends for children and young people aged 10–24 years from 1970 to 2008, by sex**
Solid blue line shows UK mortality; solid green line shows median mortality for the EU15+ countries; dashed green lines show the 25th and 75th centiles for mortality in the EU15+ countries. PYO=person-years of observation.

in the worst quartile and fell briefly to approximate the EU15+ median in the early 1990s, but thereafter the decrease slowed and UK postneonatal mortality ended the study period in the worst quartile. In 2008, the UK had significantly higher infant mortality compared with the EU15+ median in 2008, equivalent to about 1035 excess annual infant deaths (table 1).

For children aged 1–4 years, the UK began the study period with mortality in the best EU15+ quartile (ie, <25th centile), but did not significantly differ from the EU15+ mean. Thereafter, the reduction in UK mortality was similar to that of the EU15+ countries until the mid-1980s, when the UK decrease slowed, again consistent with the quadratic term in the model. UK mortality for children aged 1–4 years finished the study period in the worst quartile, with significantly higher mortality than the EU15+ median (equivalent to about 68 annual excess deaths in 2008; table 1). Reductions from 1970 to 2008 were –77·7% in the EU15+ countries and –71·1% in the UK.

For children aged 5–9 years, the UK began the 1970s with significantly better mortality than the EU15+ mean

	Infant (total; n=666)	Neonatal (n=462)	Postneonatal (n=462)	1–4 years (n=666)	5–9 years (n=666)	Male			Female		
						10–14 years (n=666)	15–19 years (n=666)	20–24 years (n=666)	10–14 years (n=666)	15–19 years (n=666)	20–24 years (n=666)
Total mortality at baseline in 1970											
Mean EU15+ mortality (log, deaths per 100 000 PYO)	7·55	6·6	6·1	4·61	3·84	3·88	4·88	4·95	3·36	3·89	3·97
UK mortality relative to EU15+ mortality (log, deaths per 100 000 PYO)	0·057	0·020	0·12	–0·25	–0·21†	–0·26‡	–0·33‡	–0·33‡	–0·22‡	–0·21‡	–0·16‡
Annual reduction in total mortality rate											
EU15+											
Linear term (log, deaths per 100 000 PYO per year)	–0·048‡	–0·043‡	–0·051‡	–0·055‡	–0·044‡	–0·034‡	–0·023‡	0·003	–0·029‡	–0·021‡	–0·017‡
Quadratic term (log, deaths per 100 000 PYO per year)²	..	..	..	0·0003*	..	..	..	–0·0005†	..	..	..
UK rate of reduction compared with EU15+ countries											
Linear term (log, deaths per 100 000 PYO per year)	–0·007*	–0·011	–0·016	0·0099†	0·0012	0·013‡	0·011‡	–0·008	0·012‡	0·002	–0·004‡
Quadratic term (log, deaths per 100 000 PYO per year)²	0·0004‡	0·001‡	0·0001‡	..	0·0002‡	–0·002‡	–0·0002‡	0·0004‡	–0·0001‡	0·0001‡	0·0002*
Difference in total mortality between the UK and EU15+ countries in 2008											
Excess UK mortality rate per 100 000 PYO (95% CI)	131·48 (94·88 to 167·89)	..	..	2·32 (1·78 to 2·87)	1·94 (1·23 to 2·66)	–0·95 (–2·06 to 0·09)	–2·27 (–6·32 to 1·78)	–7·31 (–14·89 to 0·27)	–0·21 (–0·64 to 0·22)	2·14 (–0·08 to 4·37)	1·68 (–0·60 to 3·95)
Estimated excess UK deaths per year (95% CI)	1035 (748 to 1323)	..	..	68 (52 to 84)	66 (42 to 90)	–18 (–39 to 2)	–47 (–129 to 37)	–158 (–322 to 6)	–4 (–11 to 4)	42 (–2 to 85)	35 (–12 to 81)

Table shows Poisson regression models for log of total mortality in the UK and the EU15+ countries from 1970 to 2008 and differences between the UK and the median EU15+ total mortality rate and estimated annual deaths in 2008. N refers to unique country-years. Quadratic terms for time (EU15+ reduction) and the interaction of time and country status (UK *vs* EU15+ reduction) were included in models only when significant. Excess deaths are shown as positive when UK mortality was higher than the EU15+ median. Neonatal and postneonatal models began from 1980, therefore the baseline in these models refers to 1980 and not 1970 as for other models. PYO=person-years of observation. *p<0·01. †p<0·001. ‡p<0·0001.

***Table 1*: Mortality models and excess mortality for total mortality**

and in the best EU15+ quartile (table 1, figure 2), but the slower reduction (–79·7% in the EU15+ countries *vs* –68·6% in the UK) left UK mortality significantly higher than the EU15+ median by 2008 (66 annual excess deaths; table 1).

The UK began the 1970s in the best mortality quartile in all groups of young people aged 10–24 years of both sexes, significantly below the EU15+ mean in each. For children aged 10–14 years this advantageous position was maintained until the 1980s, after which UK mortality fell significantly more slowly than in comparator countries, with UK mortality ending the study period similar to the EU15+ median (table 1, figure 2). Reductions from 1970 to 2008 were –72·2% in the EU15+ countries and –68·5% in the UK for boys and –68·0% and –61·6%, respectively, for girls.

For young people aged 15–24 years of both sexes, UK mortality was maintained in the best quartile until the late 1990s, after which the UK had a smaller reduction than did other EU15+ countries, ending the study period with similar mortality to the EU15+ median (table 1). For boys and young men, mortality reductions between

1970 and 2008 were –55·5% in the EU15+ countries and –48·4% in the UK for those aged 15–19 years, and –46·1% and 30·5% for those aged 20–24 years, respectively. For girls and young women, reductions were –57·1% and –37·0% for those aged 15–19 years, and –51·6% and –41·2% for those aged 20–24 years, respectively.

NCD causes accounted for 57% of UK mortality in children and young people aged 1–24 years in 2008 (figure 3, table 2). The UK began the 1970s with NCD

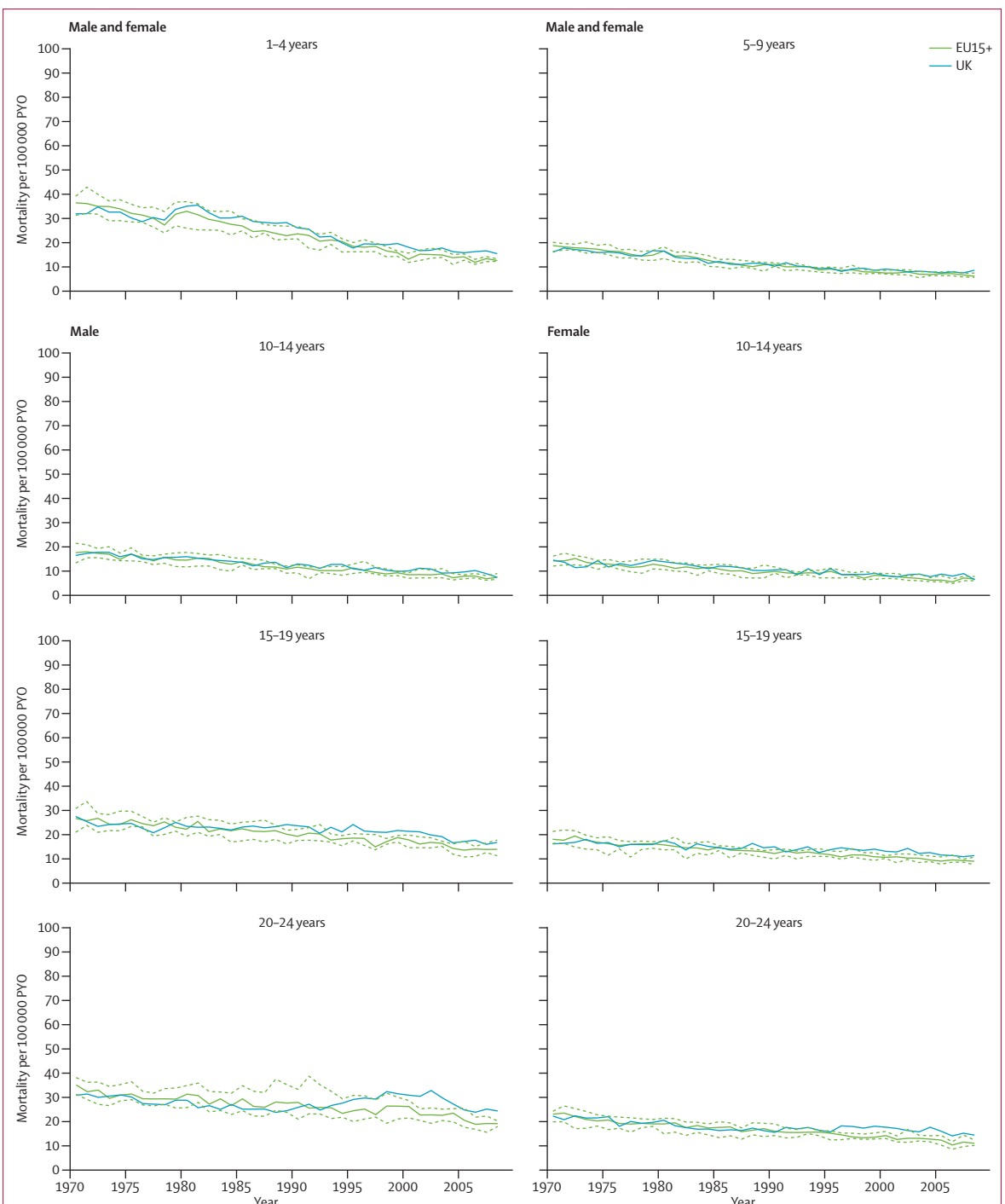

Figure 3: **NCD mortality trends for children and young people aged 1–24 years from 1970 to 2008**
Solid blue line shows UK mortality; solid green line shows median mortality for the EU15+ countries; dashed green lines show the 25th and 75th centiles for mortality in the EU15+ countries. NCD=non-communicable disease. PYO=person-years of observation.

	1–4 years (n=664)	5–9 years (n=664)	Male			Female		
			10–14 years (n=664)	15–19 years (n=664)	20–24 years (n=664)	10–14 years (n=664)	15–19 years (n=664)	20–24 years (n=664)
NCD mortality at baseline in 1970								
Mean EU15+ mortality (log, deaths per 100 000 PYO)	3·62	2·98	2·92	3·34	3·56	2·68	2·92	3·12
UK mortality relative to EU15+ mortality (log, deaths per 100 000 PYO)	−0·13	−0·084	−0·057	−0·18*	−0·15*	0·074	−0·11	−0·019
Annual reduction in NCD mortality rate								
EU15+								
Linear term (log, deaths per 100 000 PYO per year)	−0·015†	−0·030†	−0·023†	−0·016†	−0·011†	−0·021†	−0·018†	−0·016†
Quadratic term (log, deaths per 100 000 PYO per year)^2	−0·0004†	..	..	..	..	..	..	..
UK rate of reduction compared with EU15+ countries								
Linear term (log, deaths per 100 000 PYO per year)	0·014†	0·0029	0·0082†	0·021†	0·007	0·013†	0·015†	0·0018
Quadratic term (log, deaths per 100 000 PYO per year)^2	..	0·0001†	−0·0001†	−0·0004†	0·002†	−0·0002†	−0·0002†	0·0003†
Difference in NCD mortality between the UK and EU15+ countries in 2008								
Excess UK mortality rate per 100 000 PYO (95% CI)	2·82 (2·46 to 3·18)	2·48 (2·12 to 2·85)	0·03 (−0·99 to 1·06)	2·51 (0·53 to 4·49)	5·21 (4·38 to 6·05)	−0·30 (−1·01 to 0·40)	2·35 (1·26 to 3·44)	3·38 (2·46 to 4·29)
Estimated excess UK annual deaths per year (95% CI)	82 (72 to 93)	84 (72 to 97)	1 (−19 to 20)	51 (11 to 92)	113 (95 to 131)	−5 (−18 to 7)	46 (24 to 67)	70 (51 to 88)

Table shows Poisson regression models for log of mortality from NCDs in the UK and the EU15+ countries from 1970 to 2008 and differences between the UK and the median EU15+ NCD mortality rate and annual deaths in 2008. N refers to unique country-years. Quadratic terms for time (EU15+ reduction) and the interaction of time and country status (UK *vs* EU15+ reduction) were included in models only when significant. Excess deaths are shown as positive when UK mortality was higher than the EU15+ median. NCD=non-communicable disease. PYO=person-years of observation. *p<0·01. †p<0·0001.

Table 2: **Mortality models and excess mortality for NCD mortality**

mortality similar to the EU15+ mean in all age groups. Thereafter, NCD mortality reductions in the UK were significantly smaller than were those in comparator countries for all age groups (table 2). By 2000, the UK's NCD mortality was in the worst EU15+ quartile for all age groups (figure 3), and was significantly higher than the EU15+ median for all age groups (other than for children aged 10–14 years). By 2008, there were roughly 446 annual excess deaths from NCD causes in the UK (166 for children aged 1–9 years, 164 for boys and young men aged 10–24 years, and 116 for girls and young women aged 10–24 years).

For both age groups of 1–9 years and 10–24 years, there seemed to be broadly consistent and stable trends in deaths from cardiovascular disorders, congenital abnormalities, and other NCD causes between 2001 and 2008 in the UK and the EU15+ countries, with cancer deaths being slightly higher in the UK (figure 4). The UK had higher mortality from neuropsychiatric, endocrine, respiratory, and digestive disorders. Excess neuropsychiatric deaths in the UK were mainly due to cerebral palsy, epilepsy, and substance misuse disorder.

Mortality from communicable, nutritional, or maternal causes for the UK and the EU15+ countries was very low (<112 deaths per 100 000 person-years of observation per year) in all age groups in both the UK and the EU15+ countries for most of the study period; therefore, we did not analyse it further. Mortality from communicable, nutritional, and maternal causes in the UK tracked above the EU15+ median after 1990 in all age groups (appendix).

The UK began the 1970s with mortality due to injuries significantly lower than the EU15+ mortality in all age groups and both sexes, in the best quartile for most age groups (table 3, appendix). The UK maintained injury mortality in the best quartile for much of the study period in all age groups, but had lower reductions in injury mortality than did the EU15+ countries for children aged 5–14 years and girls aged 15–19 years. In 2008, the UK had significantly lower mortality from injuries in children aged 1–9 years and boys and young men aged 10–24 years than the EU15+ median.

The UK excess in neonatal mortality was almost entirely due to perinatal causes (figure 5). Perinatal and other causes accounted for increased UK postneonatal mortality, with mortality from congenital malformations and injuries being similar between the UK and the EU15+ countries.

Discussion

The UK has not matched the gains made in infant, child, adolescent, and young adult mortality by similar European and other countries in the 40 years since 1970.

The UK had a significant mortality advantage in 1970 compared with most other EU15+ countries, with all-cause mortality in the best EU15+ quartile for all age groups aside from infants, for whom UK mortality was average. Subsequently, all countries achieved major reductions in mortality across the age groups studied,

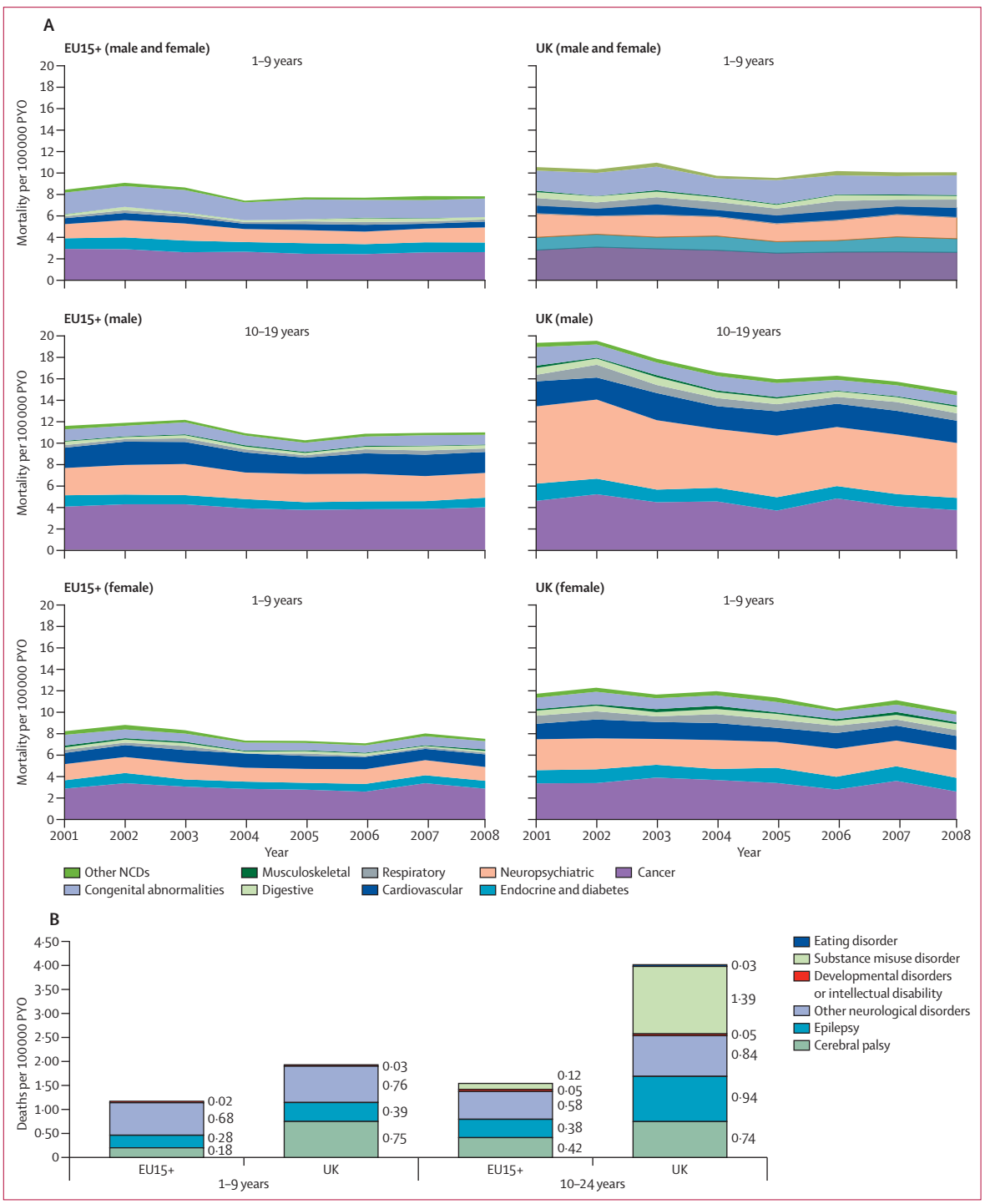

Figure 4: **NCD mortality trends**

(A) Trends in NCD mortality by ICD-10 chapter from 2001 to 2008, for children aged 1–9 years and children and young people aged 10–24 years, for the UK and the EU15+ countries. (B) Neuropsychiatric causes of death in the UK and the EU15+ countries (average for 2001–08). Mortality from psychotic disorders, mood disorders, and other psychiatric disorders were <0·01 per 100 000 PYO in the UK and the EU15+ countries, and are not shown. NCD=non-communicable disease. PYO=person-years of observation. ICD-10=International Classification of Disease 10.

	1–4 years (n=664)	5–9 years (n=664)	Male			Female		
			10–14 years (n=664)	15–19 years (n=664)	20–24 years (n=664)	10–14 years (n=664)	15–19 years (n=664)	20–24 years (n=664)
Injury mortality at baseline in 1970								
Mean EU15+ mortality (log, deaths per 100 000 PYO)	3·48	3·15	3·20	4·49	4·64	2·42	3·29	3·15
UK mortality relative to EU15+ mortality (log, deaths per 100 000 PYO)	−0·39‡	−0·50‡	−0·41‡	−0·39‡	−0·46‡	−0·58‡	−0·35‡	−0·28†
Annual reduction in injury mortality rate								
EU15+								
Linear term (log, deaths per 100 000 PYO per year)	−0·045‡	−0·051‡	−0·025‡	−0·008	0·0056	−0·031‡	−0·018	0·0057
Quadratic term (log, deaths per 100 000 PYO per year)^2	..	..	−0·0005*	−0·0005‡	−0·0006‡	..	..	−0·0005
UK rate of reduction compared with EU15+ countries								
Linear term (log, deaths per 100 000 PYO per year)	0·006	0·021‡	0·014*	0·0021	−0·0025	0·032‡	−0·0017	−0·013
Quadratic term (log, deaths per 100 000 PYO per year)^2	−0·0001‡	−0·0008‡	..	..	..	−0·0007‡	0·00007‡	..
Difference in injury mortality between the UK and EU15+ countries in 2008								
Excess UK mortality rate per 100 000 PYO (95% CI)	−0·75 (−2·55 to 0·04)	−0·73 (−1·13 to −0·33)	−0·73 (−1·28 to −0·18)	−2·10 (−6·85 to 2·66)	−10·0 (−18·21 to −1·78)	0·01 (−0·21 to 0·22)	0·68 (−1·67 to 3·03)	−1·82 (−3·80 to 0·17)
Estimated excess UK annual deaths per year (95% CI)	−22 (−74 to 1)	−25 (−38 to −11)	−14 (−24 to −4)	−43 (−140 to 54)	−217 (−394 to −39)	0 (−4 to 4)	13 (−32 to 59)	−38 (−78 to 4)

Table shows Poisson regression models for log of mortality from injuries in the UK and the EU15+ countries from 1970 to 2008 and differences between the UK and the median EU15+ injury mortality rate and annual deaths in 2008. N refers to unique country-years. Quadratic terms for time (EU15+ reduction) and the interaction of time and country status (UK *vs* EU15+ reduction) were included in models only when significant. Excess deaths are shown as positive when UK mortality was higher than the EU15+ median. PYO=person-years of observation. *p<0·01. †p<0·001. ‡p<0·0001.

Table 3: **Mortality models and excess mortality for injury mortality**

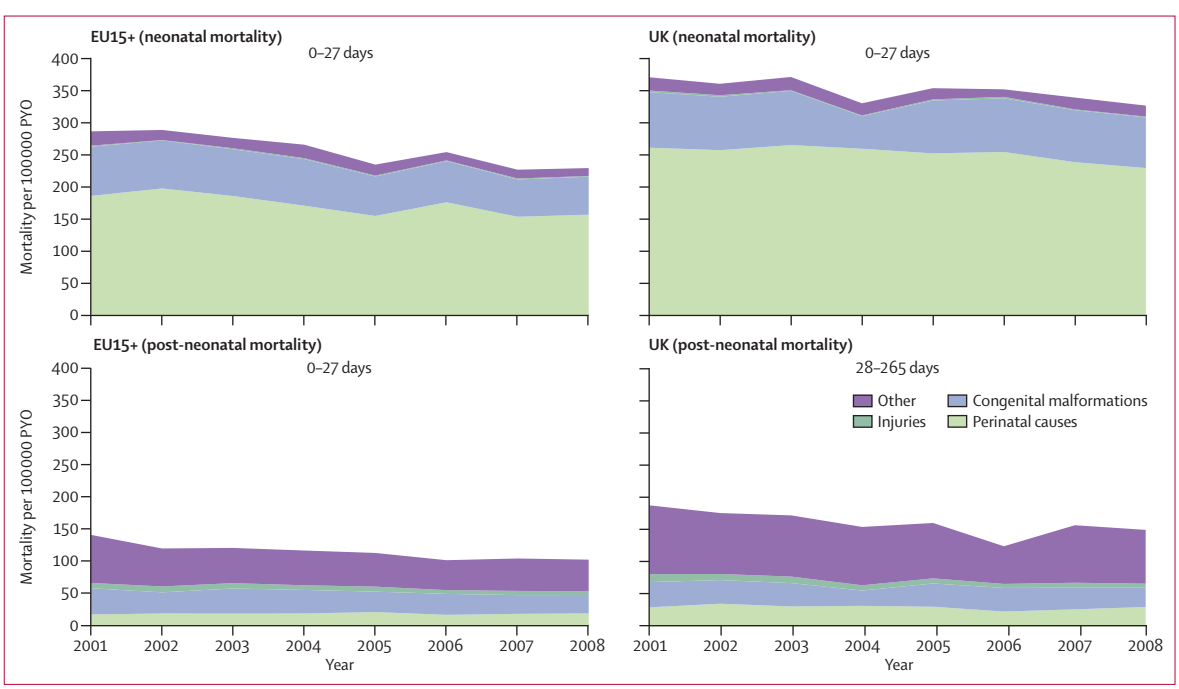

Figure 5: **Causes of neonatal and postneonatal mortality from 2001 to 2008 by ICD-10 chapter**
ICD=International Classification of Disease. PYO=person-years of observation.

but mortality reductions in the UK were smaller than the EU15+ mean in every age group and across total, NCD, and injury mortality. All-cause mortality in the UK dropped into the worst EU15+ quartile for infants and children aged 1–4 years, and close to median mortality for older age groups by 2008. In view of these adverse long-term trends, the differential between the UK and EU15+ median might have widened since 2008.

Poor performance by the UK was most notable for total mortality in infants and children aged 1–9 years, and for NCD mortality in children and young people aged 1–24 years. For both neonatal and postneonatal mortality, reductions in the UK tracked falls in mean EU15+ mortality until the early 1990s, after which the UK did not match continuing reductions in the EU15+ countries. By 2008, we estimate that the UK had an excess of about 1000 annual infant deaths compared with the EU15+ median.

The UK's poor recent record on infant mortality is well described (panel),[12] and evidence suggests that it relates mostly to high rates of preterm birth. About 70% of UK infant deaths were in neonates, which is strongly related to the largely preventable factors of prematurity and low birthweight.[13] Although data for gestational age and birthweight were not available from the WHO World Mortality database, findings from previous studies[14] have shown that about two-thirds of UK infant mortality occurs in preterm births, and that high neonatal mortality in the UK largely results from high rates of preterm delivery by comparison with other European countries[15,16] and Australia.[17]

After infancy, differences in total mortality rates between the UK and EU15+ median in 2008 were small, and significant only in children aged 1–9 years. However, in view of the UK's large population, this discrepancy results in about 130 excess annual deaths in children aged 1–9 years compared with the EU15+ countries.

Importantly, small (for children aged 1–9 years) or non-significant (for children and young people aged 10–24 years) differences in total mortality concealed poor UK performance for NCD mortality, because NCD deaths were offset by good performance in injury mortality compared with the EU15+ countries. NCD mortality in all age groups in the UK fell from average in 1970 to the worst quartile by 2008, with significant excess deaths compared with the EU15+ countries in all age groups aside from children aged 10–14 years. We estimated that there were about 446 additional annual deaths from NCD causes in the UK in 2008, most (280) in young people aged 15–24 years.

NCD causes with a substantial UK excess included neuropsychiatric causes, endocrine disorders and diabetes, and respiratory and digestive disorders, with cerebral palsy, epilepsy, and substance misuse disorder being the largest contributors to the UK excess of neuropsychiatric mortality. These findings are consistent with reports of poor UK performance for adult NCD mortality by comparison with the EU15+ countries.[1] They are also consistent with published evidence of higher mortality in the UK than in European countries for some childhood disorders such as asthma,[18] and poorer UK survival for some cancers.[19]

Poor UK performance in NCD mortality probably has several contributing factors, including accessibility and quality of health service provision for chronic disorders and disability in children and young people,[2] and high levels of relative deprivation and inequality,[20] which have been linked with a range of NCDs and their risk factors.[21] High NCD mortality in the UK probably cannot be accounted for simply by increased prevalence of particular disorders. Although the UK has comparatively high prevalence of asthma[18] and type 1 diabetes,[22] the prevalence of other chronic disorders or disability in the UK seems to be similar to that of other wealthy countries.[23–25]

The extent to which health system factors cause increased mortality is unclear and needs further study. Poor UK performance on disease control measures in childhood NCDs (eg, diabetes),[26,27] and evidence of substantial variation in outcomes and quality-of-care markers for diabetes and epilepsy across the UK,[26,27] suggest that health system factors probably have some role. Some of the UK excess in NCD mortality might result from persistent effects of high rates of preterm births,[13] particularly because evidence suggests that low birthweight increases risk of mortality to a small but statistically significant extent in later childhood.[28] However, other investigators[13] have reported that the prevalence of common neurological sequelae of prematurity (eg, epilepsy[29] and cerebral palsy[25]) is similar in the UK and other European countries.

Communicable and nutritional diseases contributed little to differences between the UK and other European countries. The UK performed well on injury mortality, with most age groups maintaining best quartile mortality across the study period, consistent with previous reports that the UK has some of the lowest mortality from injury among EU15+ countries for children and young people.[1,4] This low rate particularly results from low mortality from road-traffic injuries in the UK,[30] which is the largest component of injury mortality in high-income countries. However, the UK's advantage in injury mortality is under threat, because more rapid reductions were achieved by other EU15+ countries in most age groups in the early 21st century.

Comparisons of UK mortality with other similar countries can identify key factors for which concerted action is needed, and also provides information about what can be aimed for. However, how these goals might be achieved is less clear. There are no simple explanations for the disparity in performance between the UK and the EU15+ countries, and equally no simple solutions. Policy research for children's health systems is at an early stage, and understanding of the causes and deep explanations for why children die is highly complex and involves structural

Panel: **Research in context**

Systematic review

We searched PubMed with the terms ((((“Mortality”[Majr]) AND (“Child”[Majr]) OR “Adolescent”[Majr])) AND “Longitudinal Studies”[Majr] AND (“Europe”[Majr]) OR “Great Britain”[Majr]) on Jan 17, 2014. Our systematic review showed no previous studies of long-term trends in all-cause and cause–specific mortality for children and young people aged 0–24 years in the UK compared with other wealthy countries.

Findings from previous studies have suggested that the UK has dropped down comparative European rankings for mortality in children and young people since 1990, and that the UK has worse all-cause mortality in children aged 0–14 years than do some European countries. By contrast, some evidence suggests that the UK does well in some factors that contribute substantially to child and youth mortality (eg, mortality from injuries).

Interpretation

We analysed trends in all-cause, communicable disease, non-communicable disease, and injury mortality in the UK and 17 similar wealthy countries (European Union member states before May, 2004, plus Australia, Canada, and Norway; termed the EU15+ countries) in children and young people aged 0–24 years from 1970 to 2008.

Our findings show that the UK had smaller mortality reductions for total, non-communicable disease, and injury mortality than did similar EU15+ countries, with the UK position falling from the best EU15+ quartile in 1970 to the worst or median quartile by 2008. UK performance was particularly poor for neonatal, postneonatal, and non-communicable disease mortality. By 2008, the UK had roughly 1–69 excess deaths annually compared with the EU15+ countries, with about 446 excess annual deaths from non-communicable diseases.

Investigation and remedying of the causes of poor performance relative to other wealthy countries presents a major opportunity for health gain in the UK. A renewed focus is needed for the prevention of premature delivery and improvements to care of long-term disorders in children and young people.

and demographic factors, environmental conditions, social care and education, and aspects of health systems and services ranging from organisation to clinical practice.[2]

We identified neonatal, postneonatal, and NCD mortality as the key topics for action. Improvements in neonatal mortality will need a continued concerted focus on reduction of preventable preterm births in high-risk groups. Although UK governments have identified reductions in inequalities as a key lever to reduce infant deaths since 2000, present efforts have had very little success[16] and need extension and reformulation, alongside further development of neonatal care networks.[31–33] Interventions to prevent preterm births supported by strong evidence should be deployed widely, including smoking cessation, progesterone, cervical cerclage, reductions in elective caesarean delivery or induction of labour, and restricted embryo transfer in assisted reproduction, although even full implementation of these strategies would have a small effect on incidence of preterm births.[34] Interventions to reduce inequalities relating to the perinatal period will also probably be effective to reduce postneonatal mortality, for which social gradients seem to be at least as high as in neonatal mortality.[28,35]

A new focus is needed to improve outcomes for chronic disorders in children and young people in the UK, in view of the high contribution of NCDs to mortality (75% of UK death in children aged 1–9 years and 50% of deaths in children and young people aged 10–24 years in our study), the increasing prevalence of many chronic disorders in UK children,[26,27] and evidence that many children and young people who die from injuries in the UK also had a chronic condition.[28] These efforts need to include research to understand the contribution of health system factors to poor UK performance, but also examination of whether other European models of child and adolescent health care are better adapted to the epidemiological transition away from communicable disease and towards NCDs. Such models include earlier access to more specialist paediatric care and better integration of care.[2] Irrespective of whether the UK’s poor record for NCDs relates to demographic, structural, or health system factors, further development of present policy initiatives towards integrated disease networks across primary, secondary, and tertiary care will probably improve outcomes.[3,36] Because the greatest burden of NCDs and the greatest disparity between the UK and the EU15+ countries in children and young people is in those aged 15–24 years, such networks should encompass them and ensure seamless integration with adult care for chronic disorders. These efforts need to include mental health services, ranging from promotion of mental wellbeing to care for young people with established mental illness. Multisectorial review of child deaths should be strengthened and extended into young adulthood.

A strength of our study is that we used highly complete data about national death registration from the WHO Mortality Database for a group of wealthy countries previously used as a comparator group for the UK. We examined mortality in broad causal groups to allow examination across a wide timeframe in which several versions of the ICD were in use, and to minimise bias from differences in coding between countries.

To avoid misinterpretation of chance variability around the mean as excess mortality, we graphically compared longitudinal trends in UK mortality to quartiles of EU15+ mortality. We then fitted longitudinal Poisson regression models accounting for data overdispersion. We noted similar trends between UK performance and EU15+ quartiles across all age groups, and models consistently showed poorer reductions in UK total and NCD mortality at high levels of significance.

Our findings are subject to several limitations. The comparator group consisted of 17 countries and there was moderately high variance in mortality at the beginning of the study period. However, the IQR narrowed substantially in most age groups by the mid-1990s. Although three EU15+ countries had not deposited data after 2006, the absence of this data did not widen the IQR. Some of the international variation in neonatal mortality rates could be due to variations among countries in the registration of

premature deaths of infants,[12] although definitions of infant mortality were similar across included countries. However, it could not account for the divergence of UK neonatal mortality from the EU15+ median after the mid-1990s, and would not account for the very similar findings for UK postneonatal mortality. Although such registration issues do not apply to postneonatal or later total mortality, our estimates of cause mortality might be affected by differences in coding practice between countries. However, mortality coding practice has been consistent in the UK since the 1970s,[37] and our use of quartiles for the EU15+ countries minimises bias due to intercountry variations. We further minimised coding bias by examining causes of mortality in high-level groups (ie, communicable, nutritional, or maternal causes; NCD causes; and injury causes as defined by the Global Burden of Disease studies). Use of the Global Burden of Disease groupings allowed comparability across the study period, although the transition from ICD-8 to ICD-9 in the late 1980s resulted in a small shift of mortality previously attributed to group I (CD) to group II (NCD) reported in both the UK and the EU15+ countries. To account for this shift, we reran all NCD models beginning only in 1980, and noted that models were not materially different from those reported that relate to the whole study period.

Although differences in coding practices might have affected the balance between NCD and injury mortality across countries, we noted smaller reductions in UK mortality for both NCDs and injuries than for the EU15+ countries.

Differences in population dynamics are unlikely to account for the trends we describe, because the UK ranked midrange among included countries in terms of population growth across the study period and in population diversity in country of origin at the end of the study period.[38] Population age structures and profiles of mortality across age groups by sex were also similar across countries.

More detailed examination of causes was done only for NCD and infant mortality. Again, we subdivided mortality into ICD chapters to minimise bias from intercountry differences in coding, and restricted analyses only to ICD-10 data because coding substantially shifted between ICD-9 and ICD-10. Systematic differences between coding practice in the UK and in other countries might have affected findings. Higher neuropsychiatric mortality in the UK might result from miscoding of deaths by suicide as deaths from neuropsychiatric disorders, although most deaths in this category were due to neurological causes, and miscoding would not account for the UK excess of deaths from neuropsychiatric disorders in children aged 1–14 years for whom suicide rates were very low in all countries.

The UK is not keeping pace with other wealthy countries to meet the health needs of children and young people, particularly for infant mortality and care of chronic disorders and disability. Worsening trends in NCD mortality have cancelled out the benefits of the UK's traditionally low injury mortality. Demographic change, including increasing birth rates in the UK compared with other EU15+ countries and increasing prevalence of common chronic disorders in children, could magnify these disparities during the next 20 years.

Mortality, although rare, is a proxy for the wider health of the UK's children and young people compared with other wealthy nations. Beyond concern about the cost in terms of health in later life, maintaining good health for children and adolescents is a cornerstone of later economic productivity.[39] Investigation and remedying of the causes of poor performance relative to other wealthy countries presents a major opportunity for health gain in the UK.

Contributors

RMV and IW conceived the study and led the writing of the Article. CC and RMV obtained the data and RMV analysed the data. DSH, CC, and GCP contributed to revisions of the Article. RMV guarantees the study.

Declaration of interests

We declare that we have no competing interests. IW is married to Richard Horton, Editor of *The Lancet*.

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