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How many Children and Young People with Life Limiting Conditions are clinically unstable?; a National data linkage study

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ABSTRACT

Objective

To determine the clinical stage (stable, unstable, deteriorating or dying) for children and young people (CYP) aged 0-25 years in Scotland with a life limiting condition (LLC).

Design

National cohort of CYP with a LLC using linked routinely collected healthcare data.

Setting

Scotland.

Patients

20436 CYP identified as having a LLC and resident in Scotland between 1 April 2009 and 31 March 2014

Main Outcome

Clinical stage based on emergency inpatient and intensive care unit admissions and date of death.

Results

Over 2200 CYP with a LLC in Scotland were unstable, deteriorating or dying in each year. Compared to 1-5 year olds, under 1s had highest risk of instability (OR 6.4, 95% CI 5.7-7.1); all older age groups had lower risk. Girls were more likely to be unstable than boys (OR 1.15, 95% CI 1.06-1.24). CYP of South Asian (OR 1.61, 95% CI 1.28-2.01), Black (OR 1.58, 95% CI 1.04-2.41) and Other (OR 1.33, 95%

CI 1.02-1.74) ethnicity were more likely to experience instability than White CYP. Deprivation was not a significant predictor of instability. Compared to congenital abnormalities, CYP with most other primary diagnoses had a higher risk of instability, only CYP with a primary Perinatal diagnosis had significantly lower risk (OR 0.23, 95% CI 0.19-0.29).

Conclusions

The large number of CYP with a LLC who are unstable, deteriorating or dying may benefit from input from specialist pediatric palliative care. The under 1 age group and CYP of South Asian, Black and Other ethnicities should be priority groups.

WHAT IS ALREADY KNOWN?

National prevalence of children and young people with Life-Limiting Conditions is rising in England.

Children and young people with Life-Limiting Conditions have complex health care needs – often with repeated hospital admissions, particularly at end of life.

WHAT THIS STUDY ADDS?

In each year, over 2200 children and young people with Life-Limiting Conditions in Scotland are unstable, deteriorating or dying.

Children under 1 year of age are more likely than older children to be unstable, deteriorating or dying.

CYP from South Asian, Black or Other ethnic groups are more likely to be unstable, deteriorating or dying than White children.

INTRODUCTION

The prevalence of children and young people (CYP) with a life limiting condition[1] (LLC) is increasing, with numbers in England estimated to be over 40,000.[1 2] Although many of the individual diagnoses are rare, as a group, CYP with a LLC represent a larger patient population than many other long term conditions in children (e.g. diabetes mellitus).[3] CYP with a LLC have unpredictable disease trajectories, but typically have complex health care needs – often with repeated hospital admissions, particularly at end of life.[4 5] During childhood care is usually coordinated by tertiary paediatric specialists or community paediatricians. Although the WHO definition of children's palliative care states that 'It begins when illness is diagnosed, and continues regardless of whether or not a child receives treatment directed at the disease',[6] paediatric palliative care specialists are often not involved until later in the disease process. Identifying CYP who would benefit from specialist input earlier may be beneficial to them and health and social care services.

To date there has been no published research estimating the proportion of CYP with LLC who were not clinically stable and therefore in greater need of input from specialist paediatric palliative care services. This study used routinely collected national healthcare data to identify CYP with LLC in Scotland, their clinical stage and risk factors for instability.

PATIENTS AND METHODS

Definition of Life-Limiting Conditions

Individuals with LLC were identified using a previously developed ICD-10[7] coding framework,[2] further refined by removing ICD-10 codes where, in the current dataset, no individuals had died (information not available when the original framework was developed).

[1] Life Limiting Conditions (LLC) are those for which there is no reasonable hope of cure and from which children or young people (CYP) will ultimately die prematurely, e.g., Duchenne Muscular Dystrophy or neurodegenerative disease. Life-threatening conditions (LTC) are those for which curative treatment may be feasible but can fail, e.g. cancer. LLC will be used throughout this paper to include LLC and LTC.

Datasets used

Extracts from the following routinely collected datasets were used (Supplementary Figure S1 & Supplementary Table S1):

- Scottish Birth Record (SBR)
- Scottish Morbidity Record (SMR01) - General Acute Inpatient and Day Case
- Prescribing Information System data (available from 2009/10)
- Scottish Outpatient Dataset (SMR00)
- Scottish Cancer Registry (SMR06)
- GRO Death registration data
- Paediatric Intensive Care Audit Network (PICANet) (available from 2007/8)

Data access was approved by the Privacy Advisory Committee (ref: XRB14010). The Health Research Authority approved linkage of PICANet data with NHS National Services Scotland (NSS) data (PIAG 4-07(c)/2002 Amendment 16 February, 2015).

All data were analysed within the NSS Electronic Data Research and Innovation Service (eDRIS) safe haven.[8] The presented results underwent disclosure control.[9]

Data Management

Data linkage was undertaken by the eDRIS team. A probabilistic algorithm using surname; first initial (forename and second initial if available); sex; year, month and day of birth; and postcode was used to match individuals in each dataset to the population spine dataset (CHI index) which contains personal identifiable data for all individuals in Scotland who have used an NHS Scotland service (including GP registration).[10] False positive and false negative rates in the matching are kept close to 1%.[10] The datasets were then linked deterministically using the CHI number.

There were multiple sources of demographic information. Individuals were assigned the most commonly recorded gender. The various ethnic groups recorded were collapsed to four main groups: White; South Asian (Indian, Pakistani and Bangladeshi); Black; Other (including mixed

ethnicity) and then the most commonly recorded ethnic group (excluding "not known") was assigned to each individual. Date of birth was assigned as the most commonly recorded date. Individuals were assigned an age group (under 1; 1-5; 6-10; 11-15; 16-20; 21-25 years) in each financial year based on age at the start of the first record for that year.

Five population weighted deprivation categories, using the Scottish Index of Multiple Deprivation (SIMD) 2009, with 20% of the Scottish population in each category, were assigned by eDRIS using Data Zone (the Scottish Government's preferred small geography area)[11] of residence. SIMD is a national area based measure of relative deprivation which consists of 35 indicators in seven domains.[12] Individuals were assigned the first deprivation category recorded each year.

LLC diagnoses were categorized into 11 groups based on the main ICD-10 chapters: neurology, haematology, oncology, metabolic, respiratory, circulatory, gastrointestinal, genitourinary, perinatal, congenital, and 'other'. Individuals may have more than one LLC diagnosis. A primary diagnosis category was defined as the modal diagnosis category in the first diagnostic field in SMR01 and SBR records for that financial year. If there was no mode, the first record for the financial year was used. If there was no SMR01 or SBR record in a given year, the preceding year's primary diagnostic group was used.

Dates of death were based on the death registration data. Other sources (SMR01, SMR06 and PICANet) replaced only invalid (more than a day before the last inpatient admission) or missing dates.

Analyses

All data analyses were performed using Stata version 12.[13]

Cohort Identification

The study cohort was defined as all individuals with a LLC resident in Scotland and aged 0-25 years between 1 April 2009 and 31 March 2014 (in this period, all datasets were available). To minimise

left edge effects (where some CYP diagnosed prior to 2009 but who were still alive and resident in Scotland with a LLC may be missed), LLC was assigned to an individual if any of their SBR or SMR01 records from 1 April 2003 to 31 March 2014 contained a framework ICD-10 code. Each year, individuals were deemed alive and resident in Scotland if they had a record in the SBR, SMR01 or community prescription records. LLC prevalence per 10000 population was calculated with population at risk determined from census-derived mid-year estimates.[14] 95% confidence intervals were calculated using a normality assumption.[15]

Clinical Stage

Four clinical stages (stable, unstable, deteriorating and dying) in palliative/end of life patients have been previously defined.[16,17] The palliative care funding review (PCFR) in England of adults and children aimed 'to develop a classification system which categorising palliative/end of life patients in according to level of need, which is capable of categorising palliative and end of life patients into meaningful groups based on comparable intensity of care needs and similarity in resource use'.[16] In the PCFR the phase of illness (clinical stage) was a subjective measure by the clinician in charge of care but for both adults and children this was the most important factor in determining the intensity of care need and resource use. In this current study we have reversed this process by defining clinical stage using an objective measure of healthcare use (Figure 1):

- Entering unstable stage: an unplanned admission to hospital lasting > 48 hours. >48 hours was chosen to avoid including children who had emergency admissions for service availability issues (e.g. 5pm on Friday) rather than level of illness
- Entering deteriorating stage: an emergency admission to an ICU or PICU
- Entering dying stage: the last 28 days before death (an arbitrary time prior to death was required and due to very small numbers of children and young people dying this was the only acceptable classification)

Individuals were stable when not in one of the other stages, e.g. only appearing in the prescribing data or only having planned inpatient hospital stays.

The most severe clinical stage was determined for each cohort member in each financial year. Sensitivity analyses were undertaken, classifying individuals at 1 month, 3 month and 6 month intervals, and varying the transition criteria, e.g. entering unstable: any unplanned admission; entering deteriorating: any PICU admission requiring ventilation; entering dying: 14 days prior to death. These results could not be released from the safe haven due to disclosure concerns.

The yearly percentage of cohort members in each clinical stage was calculated overall, by age group, deprivation category and diagnostic group. Analyses by ethnicity could not be disclosed due to small numbers. In each set of analyses, individuals with data missing for the variable under consideration were excluded.

Statistical Modelling

Due to small numbers, the non-stable categories were combined to create a single binary outcome variable (stable=0; not stable=1) for modelling. Age group, deprivation category, ethnicity, primary diagnostic category and gender were identified as predictors.

The data were clustered by individual with possible dependence in stability across multiple years, requiring a multi-level model. A random intercept logistic regression model was used, showing individual rather than population effects. Level 1 corresponded to financial years and level 2 to the individual. Further details are given in the supplement.

Univariable Analyses

Univariable random intercept logistic regression models were generated for each of the candidate predictors: age group, deprivation category, ethnicity, primary diagnostic category and gender.

Multivariable Analyses

For the multivariable model, candidate predictors were added in turn and retained if their odds-ratio for risk of instability was significantly ($p< 0.05$) different to 1 or their inclusion improved model fit (a decrease of >2 in Schwarz's Bayesian Information Criterion (BIC)[18,19]). Individuals were excluded from the model in a given year if, in that year, they had missing data for any of the predictors.

RESULTS

Refinement of diagnostic codes indicating LLC

Codes F80.3 (acquired aphasia with epilepsy (Landau-Kleffner)), Q74.8 (other specified congenital malformations of limbs) and Q44.5 (other congenital malformations of bile ducts) were removed from the coding framework.

Missing and conflicting data

Gender, date of birth and deprivation category were missing or conflicting for less than 1% of individuals. Ethnicity was missing for 4620 individuals (22.6%), with 173 conflicts.

Fewer than 10 individuals had inconsistent dates of death. 60 individuals had dates of death discarded due to at least one SBR or SMR01 episode beginning after the last recorded date of death.

Numbers of CYP with LLC in Scotland

20436 CYP with a LLC were alive and resident in Scotland between 1 April 2009 and 31 March 2014. Numbers increased from 12039 in 2009/2010 to 15404 in 2013/2014 (Table 1).

Table 1: Cohort demographics: for demographics that are constant across years, the number of individuals over the whole study period is provided; for demographics that do change across years, such numbers are not meaningful and these are marked 'N/A'.

Number of persons in the cohort	**Financial Year**					**Study period (1 April 2009 – 30 March 2014)**
	2009/10	**2010/11**	**2011/12**	**2012/13**	**2013/14**	
Overall cohort	12039	12930	13756	14573	15404	20436
Age group						
< 1	1163	1085	1087	1055	1096	N/A
1-5	3470	3552	3637	3683	3687	N/A
6-10	1887	2330	2729	3146	3452	N/A
11-15	1664	1748	1844	1992	2086	N/A
16-20	1818	1960	2068	2212	2388	N/A
21-25	2037	2255	2391	2485	2695	N/A
Sex						
Male	6547	6964	7414	7916	8333	11217
Female	5490	5964	6340	6654	7068	9215
Deprivation category						
1 (most deprived)	3041	3275	3478	3655	3897	N/A
2	2588	2780	2961	3199	3370	N/A
3	2340	2462	2624	2772	2915	N/A
4	2043	2262	2445	2561	2723	N/A
5 (least deprived)	2008	2128	2227	2358	2452	N/A
Ethnic group						
White	8558	9381	10261	11020	11851	14878
South Asian	257	287	323	350	380	455
Black	63	65	75	92	107	139
Mixed/Other	133	172	213	234	280	344
Unknown	3028	3025	2884	2877	2786	4620
Primary diagnostic category						
Neurology	1547	1626	1678	1765	1884	N/A
Haematology	655	723	782	854	905	N/A
Oncology	1798	1903	1997	2075	2169	N/A
Metabolic	317	356	395	444	491	N/A
Respiratory	1219	1292	1347	1405	1441	N/A
Circulatory	682	750	782	819	855	N/A
Gastrointestinal	202	210	215	220	220	N/A
Genitourinary	763	847	900	953	1004	N/A
Perinatal	1096	1148	1201	1267	1308	N/A
Congenital	3689	4007	4391	4701	5047	N/A
Other	71	68	68	70	80	N/A

Prevalence increased from 75.0 (95% CI 74.3-75.7) per 10,000 population in 2009/2010 to 95.7 (95% CI 94.9-96.5) per 10,000 population in 2013/2014 (Supplementary Table S2). Prevalence increased for all age groups except under 1 year olds (195.0 per 10,000 population, 95% CI 189.3-200.6 in 2009/10; 192.1 per 10,000 population, 95% CI 186.3-197.8 in 2013/14)(Table S2).

Clinical Stage

Each year, between 2201 and 2310 cohort members (14-19%) had at least one period of instability (Table S3). The number of individuals stable for the whole year increased from 9729 in 2009/2010 (80.8%; 95% CI 80.5-81.2%) to 13203 in 2013/2014 (85.7%; 95% CI 85.4-86.0%) (Figure 2, Table S3). Numbers of individuals in all other stages decreased: 1857 individuals were unstable in 2009/10 compared to 1783 in 2013/2014; 262 were deteriorating in 2009/2010 and 254 in 2013/14; 191 were dying in 2009/10 and 164 in 2013/14. There were variations by age, deprivation category and diagnostic group (Supplemental Figures S2-S4) with under 1 year olds and those in the most deprived categories most likely to experience instability, while those with perinatal conditions were most likely to be stable.

Univariable Analyses

Individuals under 1 year of age were most likely to experience instability, 5.84 (95% CI 5.26-6.48) times more likely to experience instability than the 1-5 year old reference group. 6-10 year olds were less likely to experience instability (OR 0.60; 95% CI 0.54-0.67) while 11-25 year olds were more likely to experience instability (Table 2).

Table 2: Unadjusted odds ratios for risk of instability from univariable random intercept logistic regression models of instability in each year. Each variable has a separate model.

	Odds ratio	95% CI		P-value	Model characteristics
Univariable model: Age group					Log-likelihood: -27410.1 Degrees of freedom: 7 BIC: 54898.1 Data used: 68702 observations from 20436 persons
< 1	5.84	5.26	6.48	<0.01	
1-5	Ref				
6-10	0.60	0.54	0.67	<0.01	
11-15	1.14	1.02	1.28	0.02	
16-20	1.40	1.25	1.56	<0.01	
21-25	1.24	1.11	1.38	<0.01	
Univariable model: Gender					Log-likelihood: -28178.7 Degrees of freedom: 3 BIC: 56390.86 Data used: 68690 observations from 20432 persons
Male	Ref				
Female	1.12	1.03	1.21	<0.01	
Univariable model: Ethnicity					Log-likelihood: -24482.0 Degrees of freedom: 5 BIC: 49018.47 Data used: 54102 observations from 15816 persons
White	Ref				
South Asian	1.69	1.34	2.12	<0.01	
Black	2.01	1.31	3.07	<0.01	
Other	1.57	1.19	2.06	<0.01	
Univariable model: Deprivation category					Log-likelihood: -28097.2 Degrees of freedom: 6 BIC: 56261.25 Data used: 68566 observations from 20355 persons
1 – most deprived	Ref				
2	1.02	0.92	1.14	0.65	
3	0.92	0.82	1.03	0.13	
4	0.86	0.76	0.96	<0.01	
5 – least deprived	0.81	0.72	0.91	<0.01	
Univariable model: Primary diagnostic category					Log-likelihood: -27649.8 Degrees of freedom: 12 BIC: 55433.32 Data used: 68702 observations from 20436 persons
Neurological	1.68	1.48	1.90	<0.01	
Haematology	1.86	1.58	2.18	<0.01	
Oncology	2.27	2.03	2.55	<0.01	
Metabolic	2.00	1.61	2.47	<0.01	
Respiratory	3.03	2.65	3.45	<0.01	
Circulatory	0.64	0.53	0.78	<0.01	
Gastrointestinal	3.33	2.55	4.34	<0.01	
Genitourinary	2.72	2.35	3.15	<0.01	
Perinatal	0.27	0.23	0.32	<0.01	
Congenital	Ref				
Other	1.74	1.08	2.82	0.02	

Females were 1.12 (95% CI 1.03-1.21) times more likely to experience instability than males. Individuals of South Asian (1.69, 95%CI 1.34-2.12 times), Black (2.01, 95% CI 1.31-3.07) or Other ethnicity (1.57, 95% CI 1.19-2.06 times) were more likely to experience instability than those of White ethnicity.

There were differences in risk of instability by deprivation category, with the least deprived group less likely (0.81, 95% CI 0.72-0.91 times) to experience instability than the most deprived group.

There were also differences by primary diagnostic category. With congenital conditions as the reference category, all other primary diagnostic groups were associated with a higher risk of instability except perinatal conditions (OR 0.27, 95% CI 0.23-0.32) and circulatory conditions (OR 0.64, 95% CI 0.53-0.78).

Multivariable analyses

Age category, gender, ethnicity, deprivation category and primary diagnostic category were included in the final model (Table 3).

Table 3: Odds-ratios for risk of instability from multivariable random intercept logistic regression models of instability in each year.

	Odds ratio	**95% CI**		**P-value**
Age group				
<1	6.40	5.74	7.15	< 0.01
1-5	Ref			
6-10	0.54	0.49	0.60	< 0.01
11-15	0.73	0.65	0.82	< 0.01
16-20	0.80	0.71	0.90	< 0.01
21-25	0.66	0.59	0.75	< 0.01
Gender				
Male	Ref			
Female	1.15	1.06	1.24	< 0.01
Ethnicity				
White	Ref			
South Asian	1.61	1.28	2.01	< 0.01
Black	1.58	1.04	2.41	0.03
Other	1.33	1.02	1.74	0.04
Deprivation category				
1 – most deprived	Ref			

2	1.09	0.98	1.21	0.13
3	1.04	0.93	1.16	0.47
4	0.96	0.86	1.08	0.50
5 - least deprived	0.93	0.82	1.05	0.22
Primary diagnostic category				
Neurological	2.53	2.23	2.88	< 0.01
Haematology	2.41	2.03	2.87	< 0.01
Oncology	3.75	3.31	4.25	< 0.01
Metabolic	2.34	1.88	2.91	< 0.01
Respiratory	3.50	3.06	4.00	< 0.01
Circulatory	0.89	0.72	1.09	0.25
Gastrointestinal	5.22	3.91	6.96	< 0.01
Genitourinary	4.32	3.68	5.07	< 0.01
Perinatal	0.23	0.19	0.29	< 0.01
Congenital	Ref			
Other	3.11	1.88	5.12	< 0.01
Model characteristics				
Log likelihood	-23173.3			
Degrees of freedom	25			
BIC	46618.92			
Data used	53992 observations for 15756 persons			

Age was a significant predictor of instability. With 1-5 years as the reference category, under 1 year olds had highest risk of instability (OR 6.4, 95% CI 5.7-7.1). Older age groups had lower risk: 6-10 years OR 0.54 (95% CI 0.49-0.60); 11-15 years OR 0.73 (95% CI 0.65-8-0.82); 16-20 years OR 0.80 (95% CI 0.71-0.90); 21-25 years OR 0.66 (95% CI 0.59-0.75).

Instability was significantly more likely for girls than for boys (OR 1.15, 95% CI 1.06-1.24). Instability was more likely for CYP of South Asian (OR 1.61, 95% CI 1.28-2.01), Black (OR 1.58, 95% CI 1.04-2.41) and Other (OR 1.33, 95% CI 1.02-1.74) than White CYP.

Deprivation category was not a significant predictor of instability, but inclusion improved model fit (as indicated by BIC).

Primary diagnostic category was a significant predictor of instability. With congenital abnormalities as the reference category, most other primary diagnoses indicated a higher risk of instability. Only CYP with a Perinatal primary diagnosis had significantly lower risk (OR 0.23, 95% CI 0.19-0.29).

Primary Circulatory diagnoses did not indicate significantly different risk to the reference group (OR 0.89, 95% CI 0.72-1.09).

As many ethnicity data were missing, a sensitivity analysis was carried out excluding ethnicity from the model (Supplemental Table S4). Only circulatory primary diagnoses had an odds ratio for instability under this model that was significantly ($p<0.05$) different to the odds ratio under the model including ethnicity. Odds-ratios for other predictors did not differ significantly between the two models, although individuals in the most deprived category were significantly more likely than those in the least deprived category to experience instability according to the model excluding ethnicity – the two categories were not significantly different in the model including ethnicity.

DISCUSSION

This study identified increasing numbers of CYP with LLC living in Scotland, with over 2200 experiencing at least one episode of instability each year. These individuals may benefit from input from specialist paediatric palliative care services. Children's Hospice Association Scotland, the largest provider of children's palliative care in Scotland, received approximately 115 new referrals each year and currently looks after 380 children and families (personal communication). Therefore the potential demand for palliative care in the 0-25 year age group in Scotland outstrips the current provision.

Prevalence of CYP with LLC was higher in this study than previous estimates in Scotland and England,[1 2] due to rising prevalence over time and the ability to include individuals alive in Scotland with a LLC who did not have a hospital admission in a single year. Prevalence increased in all age groups except under 1 year olds suggesting, in common with earlier studies,[1 2 20] that increased prevalence is due to improved survival times rather than increased incidence.

This is the first study to assign clinical stage based on routinely collected clinical data. Previous approaches have used subjective clinical assessments of care needs, often linked to resource usage.[17, 21-25] This limits assessments to individuals that come into contact with clinicians and may

underestimate the stable fraction. Such estimates can vary widely by location, possibly due to differences between individual clinicians' assessments.[21] While the transition criteria used in this study were arbitrary, their application to the data was objective and consistent. All CYP identified with a LLC were included, whether or not they had any known contact with clinicians in a given year. The results from the multivariate analyses highlighted groups with higher risk of instability who may therefore benefit from targeted input from paediatric palliative care specialists (e.g., the under 1 age group , more than 6 times more likely than any other to experience instability). This input should be a combination of direct provisioning of palliative care and training and education of healthcare professionals.

CYP in minority ethnic groups are more likely to experience instability than the White population. This may be due to different diagnoses within the same broad diagnostic categories used in the model or differences in health-seeking behaviours. There are known differences between ethnic groups in prevalence of LLC and critical illness,[1, 2, 26] diagnoses,[27, 28] general access to medical healthcare and likelihood of hospital admission[29-31] and access to specialist palliative care services.[32,33]

Deprivation category was not a significant predictor of risk of instability. It has been previously found that socioeconomic status did not significantly influence access to healthcare within Britain.[30,34]

Other than age, the strongest predictors of instability were the diagnostic groups. The low risk of instability associated with perinatal diagnoses may reflect inclusion of individuals who had life-threatening diagnoses/events around the time of birth or in the neonatal period but survived those and are no longer life-limited.

Given that the clinical stage categories are based on clearly defined patterns of healthcare usage (e.g. emergency hospital admission or PICU admission) they are useful in identifying clinical areas where integration of children's palliative care would be beneficial.

Strengths and Limitations

This study utilised high quality, linked, national healthcare data. The clinical stage definitions were arbitrary but based on clinical knowledge and their application is reproducible and objective. The definitions share some similarity with those previously defined,[17] particularly in emergency treatment defining the transition from stable to unstable phases, but differ in defining the deteriorating phase using PICU admission and the dying phase using a fixed period before death.

Cohort identification only required a life-limiting or life-threatening diagnosis to be recorded once within the hospital datasets. This may result in including individuals who have had a life-threatening event but would no longer be considered life-limited.

Cohort effects are evident and the lack of availability of the community prescribing data prior to 2009 may have accounted for some the rise in prevalence and the rise in the number of stable CYP with LLC (CYP only present in the prescribing data are, by the definitions used, stable).

Although this is a national study, small numbers in some of the categories restricted the analyses (e.g. clinical stage by ethnic group or on a quarterly rather than yearly basis). It is possible that the high number of missing ethnicity data influences the presented association between ethnic group and instability, but the sensitivity analysis suggests there is no significant effect on other predictors. As ethnicity recording is improving over time, future studies should be undertaken to validate the present findings.

CONCLUSION

Each year, over 2200 CYP with a LLC in Scotland are unstable, deteriorating or dying and therefore would benefit from input from specialist paediatric palliative care services.

The under 1 age group and CYP of South Asian, Black or Other ethnicities are most likely to be unstable, deteriorating or dying and would benefit from targeted input from pediatric palliative care specialists.

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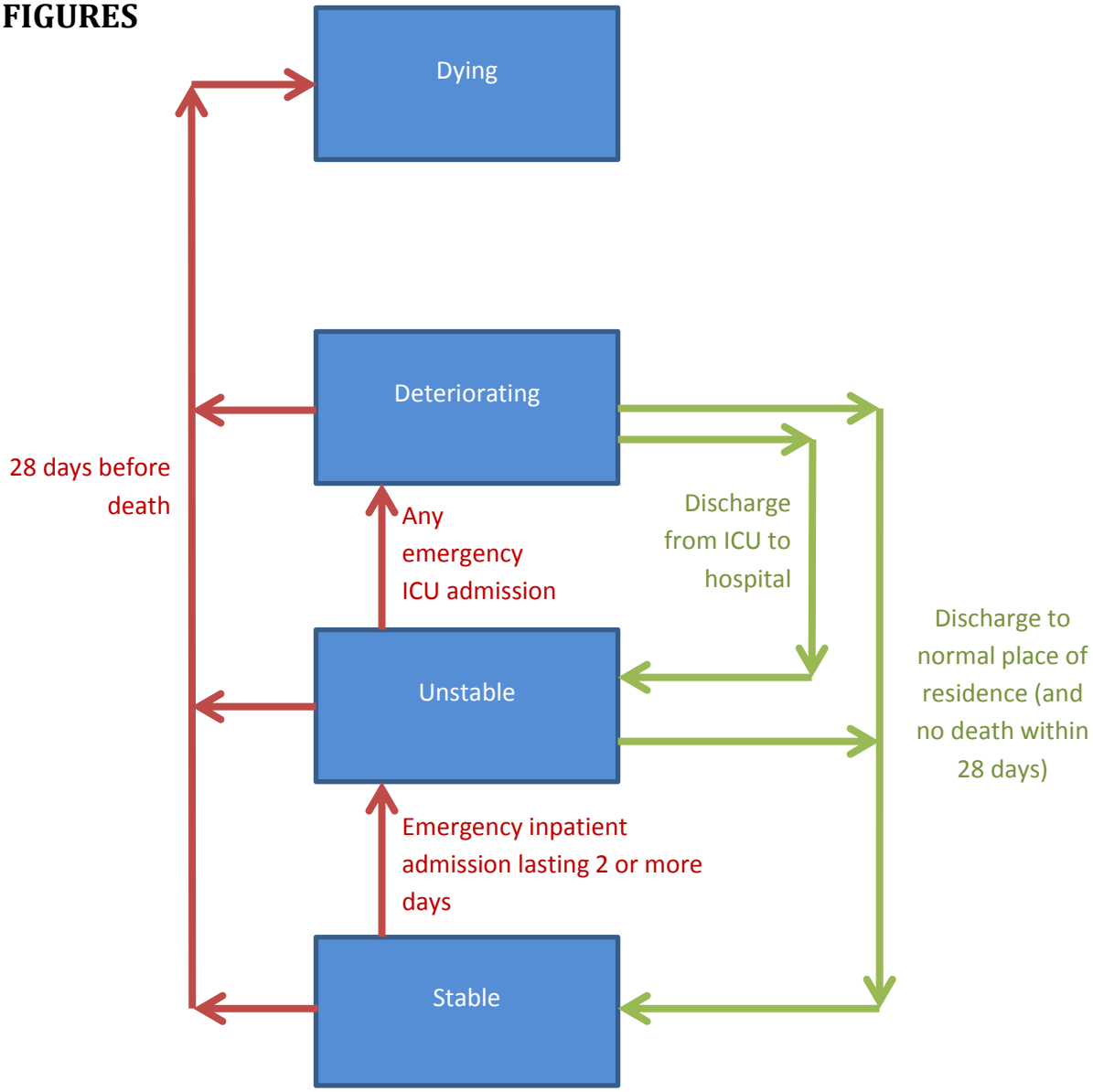
FIGURES



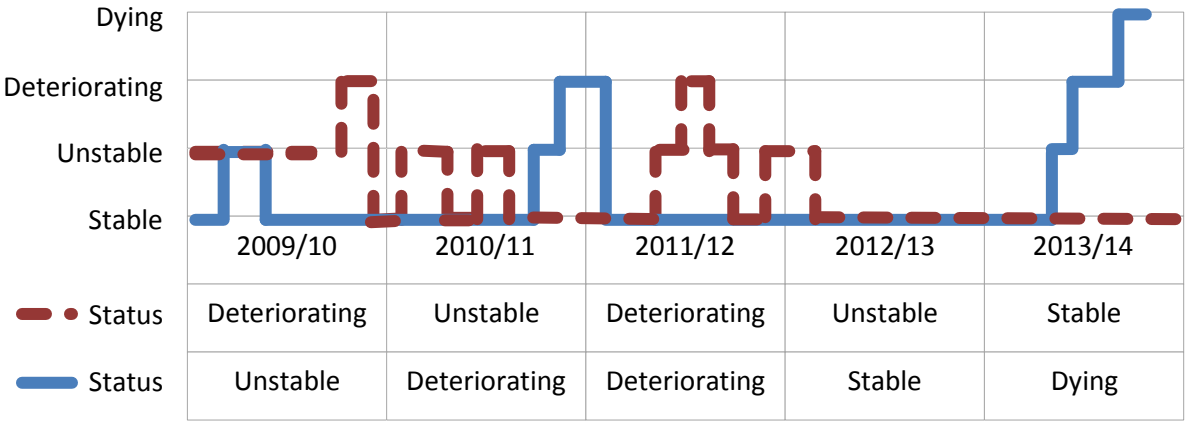


Figure 1: Criteria for transition between stages of condition for children and young people with a life limiting condition in Scotland. The charts at the bottom show two example patient trajectories, with multiple changes in clinical stage, and the most severe clinical stage recorded in each year.

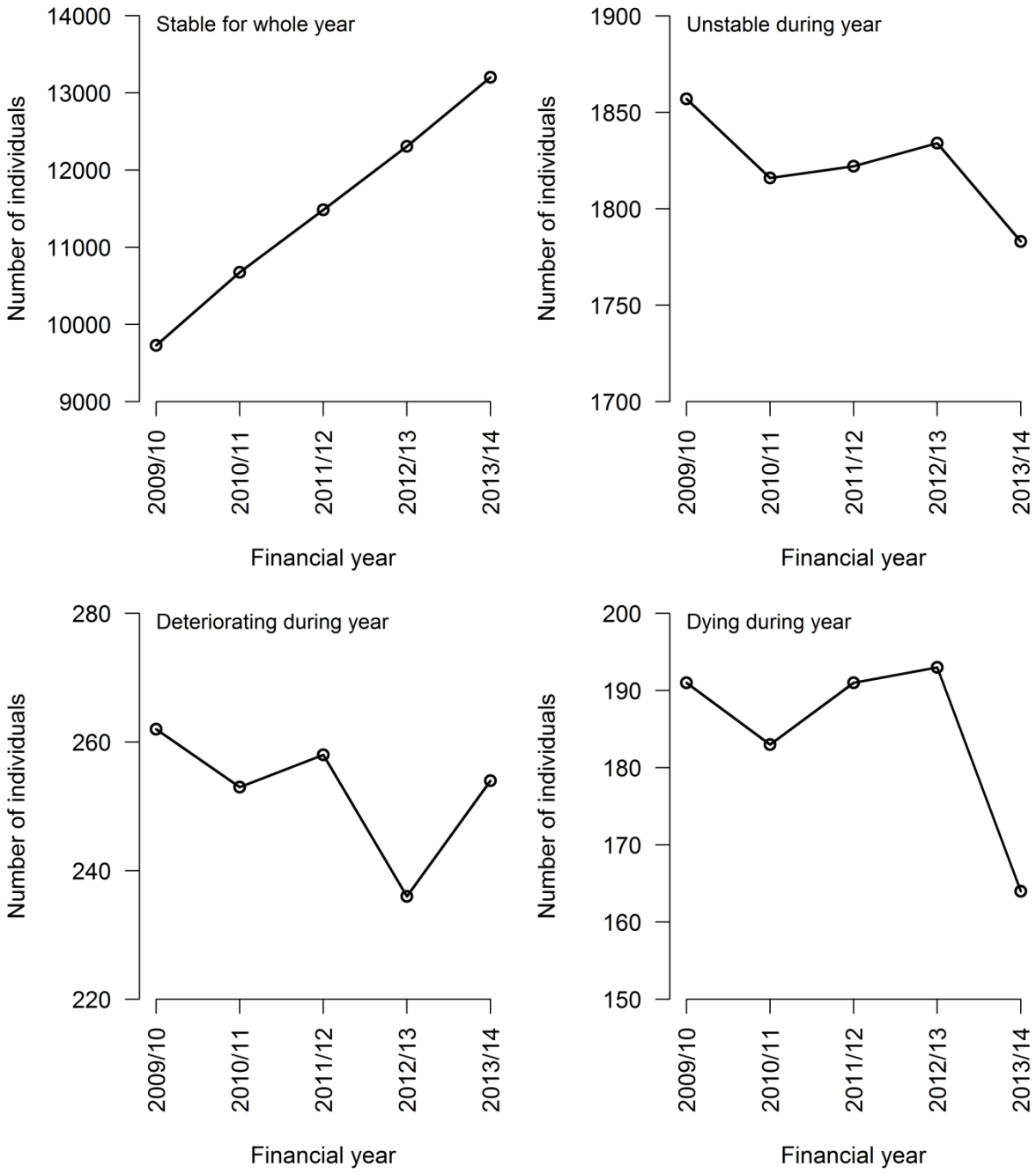


Figure 2: Clinical stage among children and young people in Scotland with a life limiting condition. Recorded status is the most severe clinical stage in the year.

Supplement

MODEL

The model used was a random intercept logistic regression model with, in each year, stability (0) or instability (1) of an individual as the outcome of predictor variables for that year. Dependence in stability/instability outcomes across years for an individual, not explained by the predictors, is represented by a random intercept (model constant) for that individual across all years.

If p_{ij} is the probability of an individual *i* (level 2) experiencing instability in year *j* (level 1) then:

$$\log_e(p_{ij}/(1-p_{ij})) = \beta_1 x_{1ij} + \beta_2 x_{2ij} + ... + \beta_n x_{nij} + C_i + \varepsilon_{ij}$$

where x_{nij} are predictors (values specific to individual and year), β the corresponding model coefficients (not specific to year nor individual), C_i the individual-specific random intercept and ε_{ij} the error term specific to individual and year, representing variance not explained by the model. For univariable models, there is only one predictor and so only one x_{ij}.

The variables had the following levels:

- Level 1 (possible variation each year for an individual):
    - Age group
    - Deprivation category
    - Primary diagnostic category
- Level 2 (constant for an individual across years):
    - Sex
    - Ethnic group

TABLES

Table S1: Datasets used in the study

Name	Purpose	Type	Coding system	Population coverage	Data collection methods
CHI Community Health Index	The CHI number has been mandated as the primary patient identifier across Scotland.	Administrative	N/A	All persons who have been registered with a Scottish GP	Most health board patient administration and clinical systems have been seeded with CHI numbers for their patients.
Scottish Birth Record	Records all of a baby's neonatal care in Scotland, from antenatal through to post delivery, including readmissions and transfers in one electronic record.	Administrative	ICD10	All new births in Scotland	Continuous data collection
Scottish Morbidity Record (SMR01) - General Acute Inpatient and Day Case	Collects episode level data on hospital inpatient and day case discharges from acute specialities from hospitals in Scotland.	Administrative	ICD10	Covers all residents in Scotland that receive care in hospital and general acute specialities.	Continuous data collection
Prescribing Information System	The definitive data source for all prescribing relating to all medicines and their costs that are prescribed and dispensed in the community in Scotland.	Administrative	ICD10	Every prescription dispensed in the community in Scotland	Updated monthly

Scottish Outpatient Dataset	Collects episode level data from patients on new and follow up appointments at outpatient clinics in all specialities (except A&E and Genito-Urinary Medicine). Some variation over time and between providers on recording of follow-up appointments.	Administrative	ICD10	The Outpatient Attendance dataset covers all people offered a new or follow up outpatient appointment at a Scottish NHS hospital.	Continuous data collection
Scottish Cancer Registry	Responsible for the collection of information on Scottish residents when they are diagnosed with malignant (and some benign) tumours	Clinical register	ICD10	Covers all residents in Scotland that have had a diagnosis of cancer	Annual returns from clinicians
GRO Death registration data	Death records	Administrative	ICD10	All Deaths occurring in Scotland	Continuous data collection
UK Paediatric Intensive Care Audit Network	International audit of paediatric intensive care which collects data on all children admitted to paediatric intensive care units (PICUs) in the UK and Ireland.	National Clinical Audit	Read Codes	All admissions to PICU in the UK and Ireland	Continuous data collection

Table S2: Prevalence of life limiting conditions in children and young people in Scotland throughout the study

	Financial Year				
	2009/10	**2010/11**	**2011/12**	**2012/13**	**2013/14**
Prevalence per 10000 population (95% CI)					
Age 0-25	75.0 (74.3-75.7)	80.2 (79.5-81.0)	85.0 (84.3-85.7)	90.3 (89.5-91.0)	95.7 (94.9-96.5)
Age < 1	195.0 (189.3-200.6)	182.9 (177.4-188.4)	180.1 (174.7-185.5)	179.8 (174.3-185.2)	192.1 (186.3-197.8)
Age 1-5	122.9 (120.9-125.0)	123.8 (121.7-125.8)	125.9 (123.8-127.9)	125.2 (123.1-127.2)	124.3 (122.2-126.3)
Age 6-10	69.1 (67.5-70.7)	86.3 (84.5-88.1)	101.1 (99.2-103.1)	116.0 (114.0-118.1)	125.1 (122.9-127.2)
Age 11-15	54.5 (53.2-55.8)	58.0 (56.6-59.4)	62.1 (60.7-63.5)	68.5 (67.0-70.1)	74.0 (72.4-75.6)
Age 16-20	53.8 (52.6-55.1)	57.5 (56.3-58.8)	60.7 (59.4-62.0)	66.5 (65.1-67.9)	73.3 (71.8-74.8)
Age 21-25	58.7 (57.4-60.0)	63.9 (62.6-65.2)	66.2 (64.9-67.6)	67.7 (66.4-69.1)	72.5 (71.1-73.9)

Table S3: Clinical stage of children and young people in Scotland throughout the study

Clinical stage	**Financial Year**				
	2009/10	**2010/11**	**2011/12**	**2012/13**	**2013/14**
Number of persons					
Stable	9729	10678	11485	12310	13203
Not stable	2310	2252	2271	2263	2201
Unstable	1857	1816	1822	1834	1783
Deteriorating	262	253	258	236	254
Dying	191	183	191	193	164
% of persons present in year					
Stable	80.8	82.6	83.5	84.5	85.7
Not stable	19.2	17.4	16.5	15.5	14.3
Unstable	15.4	14.0	13.2	12.6	11.6
Deteriorating	2.2	2.0	1.9	1.6	1.6
Dying	1.6	1.4	1.4	1.3	1.1

Table S4: Odds-ratios for risk of instability in each year for children and young people with a life limiting condition in Scotland. Odds-ratios obtained from a random intercept logistic regression model on a binary outcome variable for the most severe clinical stage in each year: stable (0) or not stable (1). Sensitivity analysis excluding ethnic group from the model.

	Odds ratio	**95% CI**		**P-value**
Age group				
<1	7.20	6.47	8.01	< 0.01
1-5	Ref			
6-10	0.50	0.45	0.55	< 0.01
11-15	0.70	0.62	0.78	< 0.01
16-20	0.73	0.65	0.81	< 0.01
21-25	0.58	0.52	0.65	< 0.01
Gender				
Male	Ref			
Female	1.12	1.04	1.21	< 0.01
Deprivation category				
1 – most deprived	Ref			
2	1.05	0.95	1.17	0.31
3	0.97	0.87	1.09	0.64
4	0.90	0.81	1.01	0.08
5 - least deprived	0.88	0.79	0.99	0.04
Primary diagnostic category				
Neurological	2.61	2.29	2.96	< 0.01
Haematology	2.38	2.02	2.81	< 0.01
Oncology	3.77	3.34	4.25	< 0.01
Metabolic	2.15	1.73	2.66	< 0.01
Respiratory	3.86	3.38	4.41	< 0.01
Circulatory	0.57	0.48	0.69	< 0.01
Gastrointestinal	5.15	3.93	6.75	< 0.01
Genitourinary	4.40	3.77	5.14	< 0.01
Perinatal	0.19	0.15	0.22	< 0.01
Congenital	Ref			
Other	2.89	1.78	4.67	< 0.01
Model characteristics				
Log likelihood	-26486.66			
Degrees of freedom	22			
BIC	53218.29			
Data used	68554 observations from 20351 persons			

FIGURES

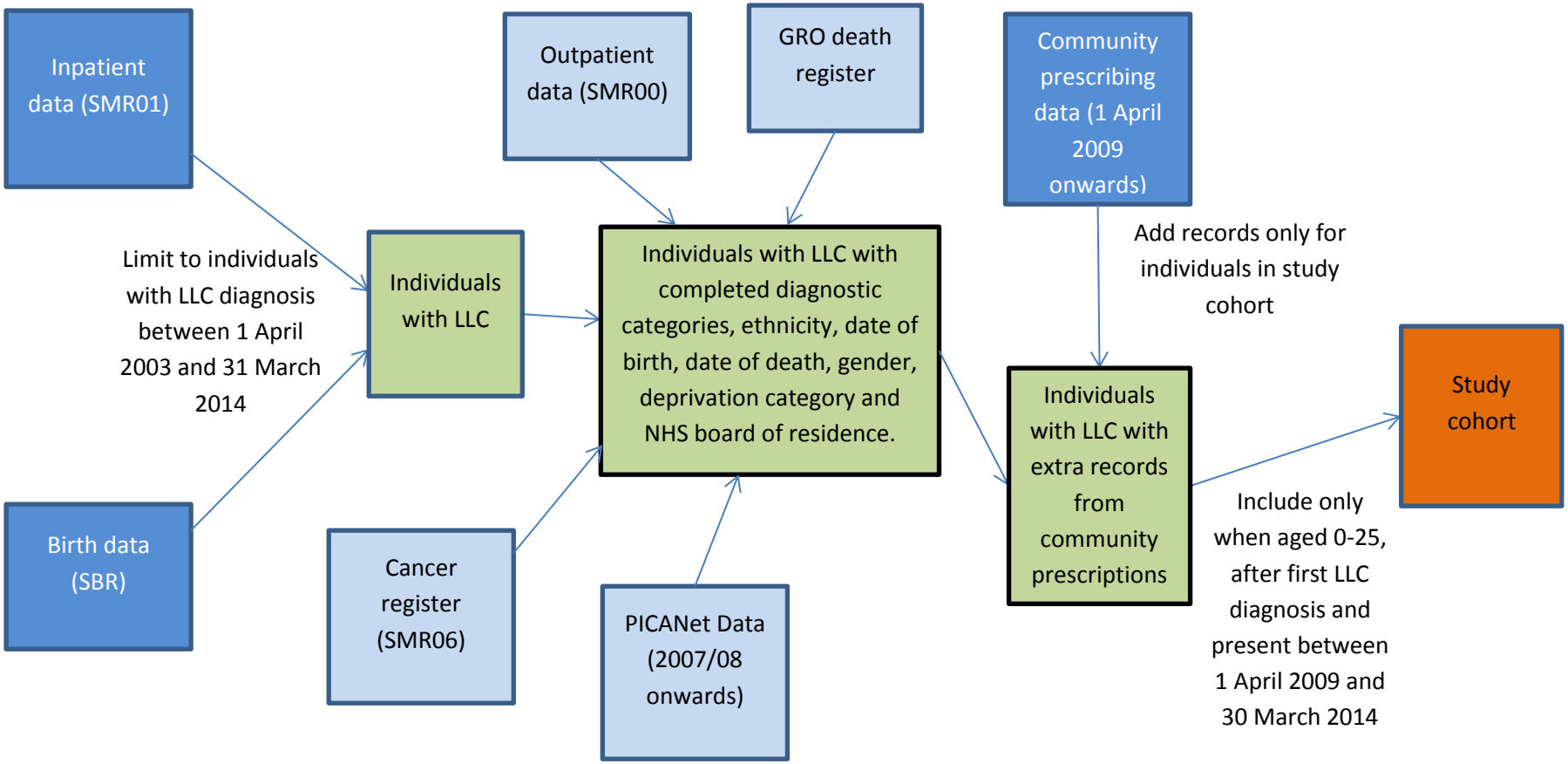


Figure S1: Datasets used to form the study cohort and complete patient demographics for prevalence analyses and the process of identifying children and young people in Scotland with a life limiting condition.

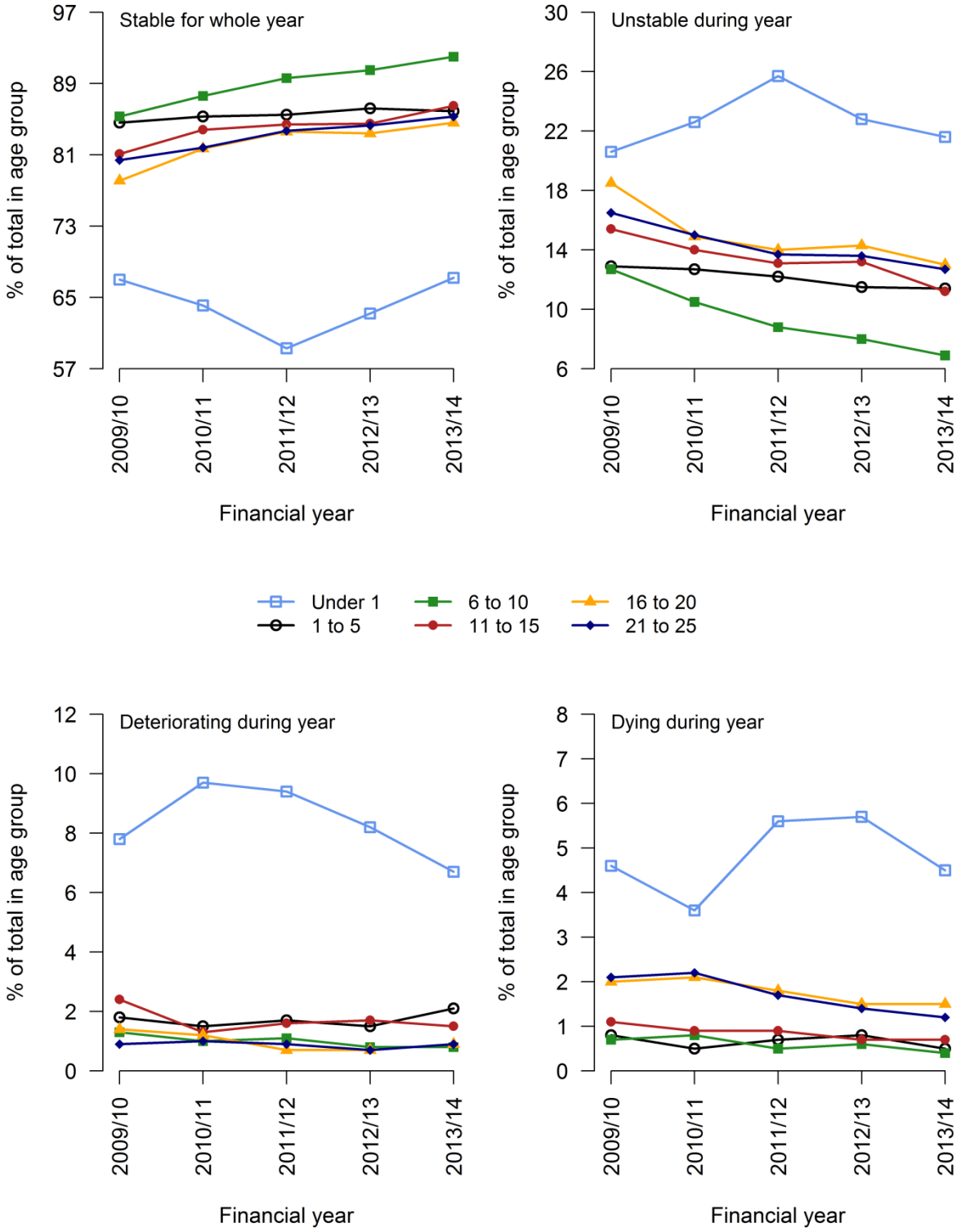


Figure S2: Clinical stage by age group among children and young people in Scotland with a life limiting condition. Recorded status is the most severe clinical stage in the year.

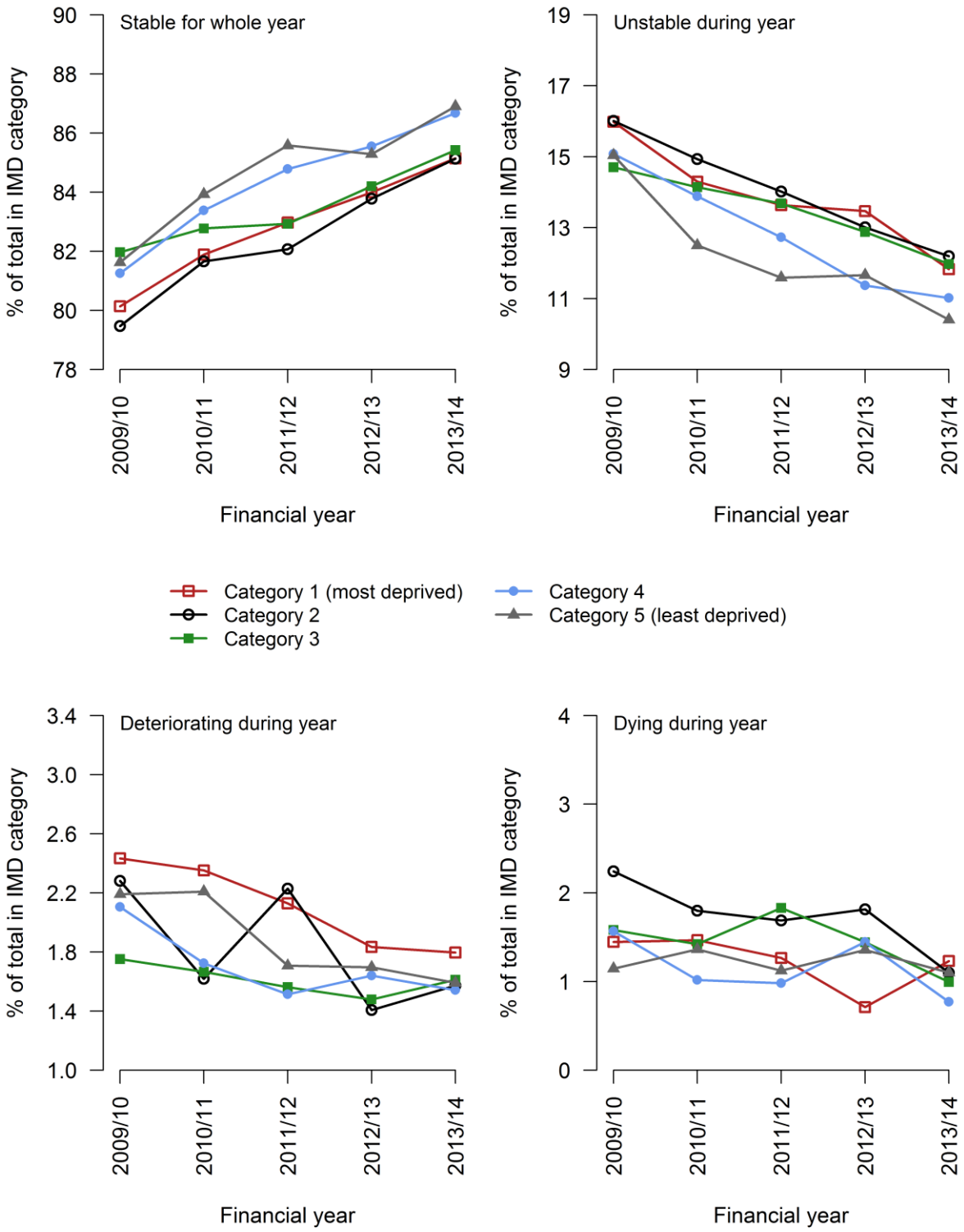


Figure S3: Clinical stage by deprivation (SIMD 2009) category among children and young people in Scotland with a life limiting condition. Recorded status is the most severe clinical stage in the year.

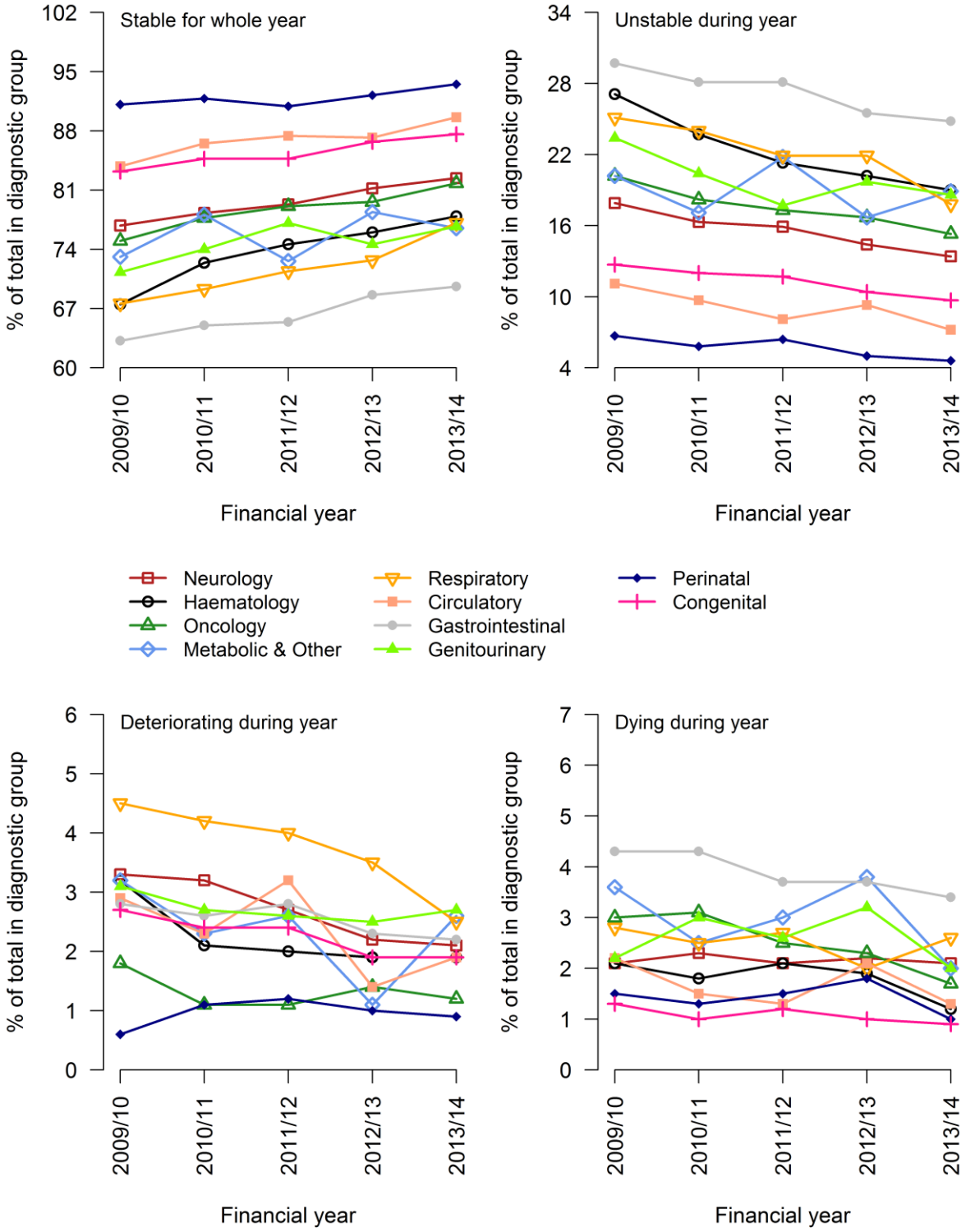


Figure S4: Clinical stage by diagnostic category among children and young people in Scotland with a life limiting condition. Recorded status is the most severe clinical stage in the year.