Supplementary Table 1: Phase 1 Estimated unadjusted and adjusted odds ratios (OR), lower and upper 95% Confidence Intervals for risk of living alone by main effects (deprivation, housing type, region, and rurality), adjusted for age and sex interaction term (age-gender specific odds shown separately)

Term (main effects)	Unadjusted results				Adjusted results			
	OR	Lower CI	Upper CI	P-value	OR	Lower CI	Upper CI	P-value
Deprivation - 2	1.03	1.03	1.03	<0.000	1.09	1.09	1.10	<0.000
Deprivation - 3	0.96	0.95	0.96	<0.000	1.09	1.08	1.09	<0.000
Deprivation - 4	0.89	0.88	0.89	<0.000	1.05	1.04	1.05	<0.000
Deprivation - Least deprived	0.76	0.76	0.77	<0.000	0.96	0.96	0.96	<0.000
Rurality: Rural town and fringe	1.22	1.22	1.23	<0.000	1.06	1.06	1.07	<0.000
Rurality: Rural town and fringe in a sparse setting	0.98	0.98	0.98	<0.000	1.19	1.18	1.20	<0.000
Rurality: Rural village and dispersed	1.33	1.32	1.34	<0.000	1.05	1.04	1.05	<0.000
Rurality: Rural village and dispersed in a sparse setting	0.84	0.83	0.84	<0.000	1.11	1.11	1.12	<0.000
Rurality: Urban city and town in a sparse setting	0.95	0.95	0.96	<0.000	1.07	1.06	1.08	<0.000
Housing type: semi-detached	1.20	1.20	1.20	<0.000	1.33	1.33	1.33	<0.000
Housing type: terraced	1.40	1.40	1.41	<0.000	1.68	1.68	1.69	<0.000
Housing type: flat	5.80	5.78	5.83	<0.000	7.35	7.32	7.38	<0.000
Housing type: other	2.59	2.57	2.61	<0.000	3.00	2.98	3.02	<0.000
Housing type: missing	1.46	1.44	1.47	<0.000	1.58	1.57	1.60	<0.000
Region: Mid-Wales	1.16	1.16	1.17	<0.000	1.17	1.16	1.17	<0.000
Region: North Wales	1.07	1.07	1.07	<0.000	1.15	1.14	1.15	<0.000
Region: South-West Wales	1.11	1.11	1.11	<0.000	1.17	1.16	1.17	<0.000
Year	1.01	1.01	1.01	<0.000	1.01	1.00	1.01	<0.000

Supplementary Table 2: Phase 1 Estimated adjusted odds ratios for risk of living alone by age-gender interaction, adjusted for all main effects in Phase 1 model (deprivation, housing type, region, and rurality), reference group = 16-30 year old males

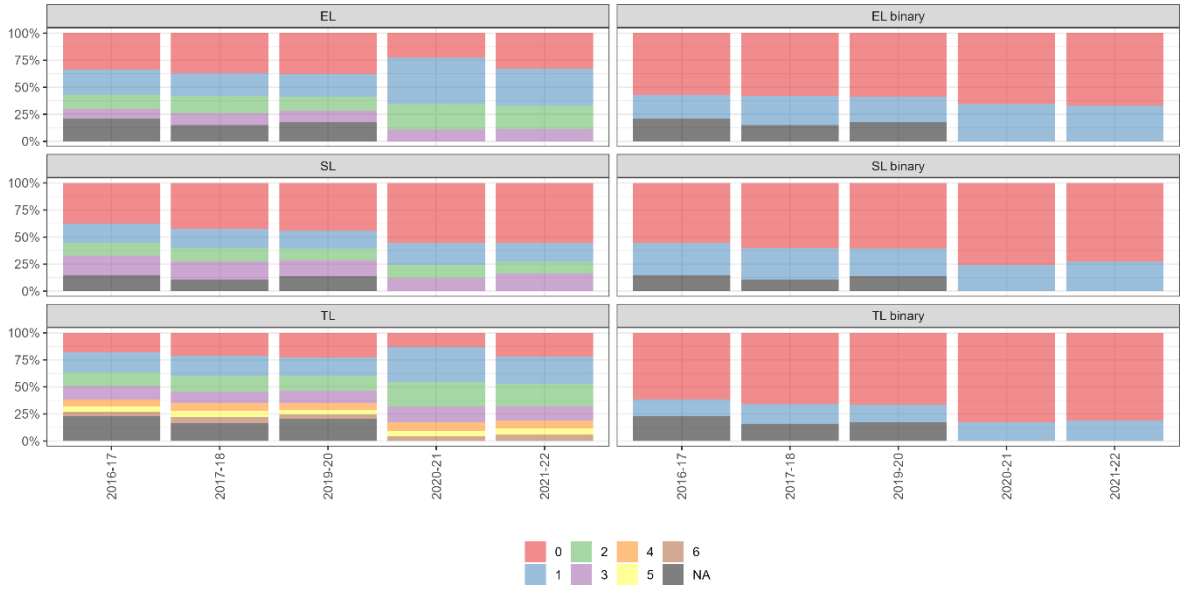
Gender	Reference group	16-30	31-45	46-60	61-75	76+
Male	Males aged	1.0	0.52	0.53	0.56	0.96
Female	16-30	0.8	0.40	0.63	1.72	4.19
Female to male odds ratio	Males within same age band	0.8	0.76	1.20	3.06	4.37

Within age female to male odds ratios included to show gender based risk for age band.

Supplementary Table 3: Phase 2 cohort construction

Stage	Description	Observations	Reduction
1	Initial data: National Survey for Wales	57,909	–
2	Excluded non-/low-confidence linkage matches (<90%)	52,836	5,073
3	Linked NSW to Annual Population Snapshot (APS, WDS living alone)	49,487	3,349
4	Excluded records with missing NSW covariates (education, health, long-term illness, housing tenure)	49,167	320
	Final analytical cohort (records (r) / individuals (n))	r=49,167 n=43,196	

Supplementary Figure 1: Dichotomised and full scores for each loneliness scale (EL – Emotional, SL – Social, and OL – Overall) for each wave of National Survey for Wales included in the study



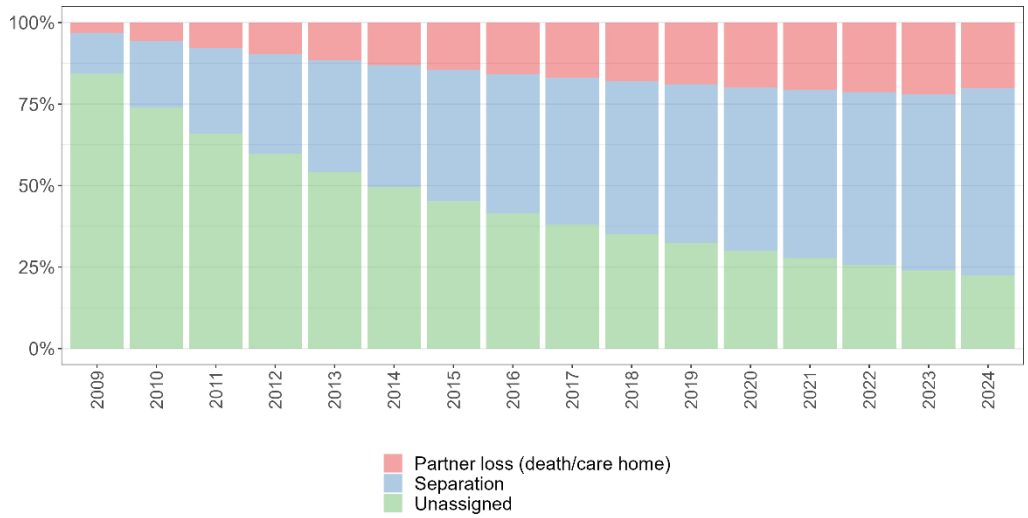
Notable change to missingness from 2020-21 wave onwards due to survey methodological changes.

Supplementary Table 4: Table of results of unadjusted and adjusted odds ratios (and lower and upper 95% Confidence Intervals) for final model main effects for emotional, social, and overall loneliness scores

Term	Emotional loneliness (Adjusted)	Social loneliness (Adjusted)	Overall loneliness (Adjusted)	Emotional loneliness (Unadjusted)	Social loneliness (Unadjusted)	Overall loneliness (Unadjusted)
Live alone reason: Partner loss ≤2y	5.1 (4.3-6.0)	1.2 (1.0-1.4)	2.0 (1.7-2.5)	4.1 (3.5-4.8)	0.9 (0.7-1.1)	1.5 (1.3-1.9)
Live alone reason: Partner loss ≤5y	3.2 (2.8-3.8)	1.2 (1.0-1.4)	1.8 (1.5-2.2)	2.7 (2.3-3.1)	0.8 (0.7-1.0)	1.2 (1.0-1.5)
Live alone reason: Partner loss >5y	2.1 (1.8-2.4)	1.3 (1.1-1.5)	1.7 (1.4-2.1)	1.8 (1.6-2.1)	0.9 (0.7-1.0)	1.2 (1.0-1.4)
Live alone reason: Separation	1.7 (1.6-1.8)	1.3 (1.2-1.4)	1.5 (1.4-1.7)	2.0 (1.9-2.1)	1.4 (1.3-1.5)	1.8 (1.7-1.9)
Live alone reason: Unassigned	1.5 (1.4-1.6)	1.4 (1.3-1.5)	1.5 (1.4-1.7)	1.5 (1.4-1.6)	1.2 (1.1-1.3)	1.4 (1.2-1.5)
Ethnicity: Minority ethnic background	1.5 (1.3-1.8)	1.5 (1.3-1.8)	1.7 (1.4-2.0)	1.5 (1.3-1.7)	1.7 (1.5-1.9)	1.9 (1.6-2.2)
Ethnicity: Not linked to census	1.1 (1.0-1.1)	1.0 (1.0-1.1)	1.0 (1.0-1.1)	1.3 (1.2-1.4)	1.1 (1.1-1.2)	1.3 (1.2-1.4)
Education: A-Levels or Apprenticeships	1.1 (1.0-1.3)	0.9 (0.8-1.0)	1.0 (0.9-1.1)	1.3 (1.2-1.4)	1.0 (0.9-1.0)	1.2 (1.1-1.3)
Education: GCSE	1.2 (1.1-1.2)	0.8 (0.8-0.9)	0.9 (0.8-1.0)	1.5 (1.4-1.6)	0.9 (0.9-1.0)	1.2 (1.1-1.3)
Education: Other qualifications	1.1 (1.0-1.2)	0.8 (0.7-0.9)	0.9 (0.8-1.1)	1.5 (1.4-1.7)	0.9 (0.8-0.9)	1.2 (1.1-1.3)
Education: No qualifications	1.3 (1.2-1.4)	0.6 (0.6-0.6)	0.8 (0.8-0.9)	2.1 (1.9-2.2)	0.7 (0.7-0.8)	1.3 (1.2-1.4)
Education: Not collected	1.6 (1.5-1.8)	0.9 (0.8-1.0)	1.1 (1.0-1.3)	1.6 (1.5-1.7)	0.6 (0.6-0.7)	0.9 (0.9-1.0)
Housing tenure: Private rental	1.4 (1.3-1.5)	1.3 (1.2-1.4)	1.5 (1.3-1.6)	1.8 (1.7-2.0)	1.6 (1.5-1.7)	2.1 (1.9-2.3)
Housing tenure: Social housing	1.7 (1.6-1.8)	1.5 (1.4-1.6)	1.7 (1.6-1.9)	2.9 (2.7-3.1)	1.8 (1.7-1.9)	2.9 (2.7-3.1)
Housing tenure: Other	1.1 (0.9-1.4)	0.9 (0.7-1.1)	1.1 (0.8-1.4)	1.4 (1.1-1.7)	0.9 (0.8-1.2)	1.3 (1.0-1.6)
Housing type: Semi-detached	1.0 (0.9-1.1)	0.9 (0.9-1.0)	0.9 (0.9-1.0)	1.4 (1.3-1.5)	1.1 (1.0-1.1)	1.3 (1.2-1.4)
Housing type: Terraced	1.1 (1.0-1.2)	1.0 (0.9-1.0)	1.0 (1.0-1.1)	1.7 (1.6-1.8)	1.2 (1.1-1.3)	1.7 (1.5-1.8)
Housing type: Flat	1.1 (0.9-1.2)	1.0 (0.9-1.1)	1.1 (0.9-1.2)	2.8 (2.6-3.1)	1.7 (1.6-1.9)	2.8 (2.5-3.1)
Housing type: Other/missing	1.0 (0.8-1.4)	1.1 (0.9-1.5)	1.3 (0.9-1.8)	1.7 (1.4-1.9)	1.3 (1.2-1.5)	1.9 (1.6-2.2)
Deprivation: Q2	1.0 (0.9-1.0)	1.0 (0.9-1.1)	1.0 (0.9-1.1)	0.8 (0.7-0.8)	0.9 (0.8-1.0)	0.8 (0.8-0.9)
Deprivation: Q3	0.9 (0.8-1.0)	1.0 (0.9-1.1)	0.9 (0.9-1.0)	0.7 (0.6-0.7)	0.8 (0.8-0.9)	0.7 (0.6-0.7)
Deprivation: Q4	0.9 (0.8-1.0)	1.0 (0.9-1.1)	0.9 (0.8-1.0)	0.5 (0.5-0.6)	0.8 (0.7-0.8)	0.6 (0.5-0.6)
Deprivation: Q5 - least deprived	0.8 (0.8-0.9)	0.9 (0.9-1.0)	0.8 (0.8-0.9)	0.4 (0.4-0.5)	0.7 (0.7-0.8)	0.5 (0.4-0.5)
Rurality: Town	0.9 (0.9-1.0)	1.0 (0.9-1.1)	0.9 (0.9-1.0)	0.9 (0.9-1.0)	1.0 (0.9-1.0)	0.9 (0.8-1.0)
Rurality: Village	0.9 (0.8-1.0)	1.0 (0.9-1.1)	1.0 (0.9-1.1)	0.7 (0.7-0.8)	0.9 (0.9-1.0)	0.8 (0.7-0.8)
General health: Fair	2.0 (1.9-2.1)	1.7 (1.6-1.8)	2.1 (2.0-2.2)	2.4 (2.3-2.5)	1.6 (1.6-1.7)	2.3 (2.1-2.4)
General health: Bad, very bad	3.9 (3.6-4.3)	2.3 (2.2-2.5)	3.9 (3.6-4.2)	5.4 (5.0-5.8)	2.4 (2.3-2.6)	4.9 (4.5-5.2)
Long-term illness: Yes	1.5 (1.4-1.6)	1.2 (1.1-1.2)	1.4 (1.3-1.5)	2.4 (2.3-2.5)	1.4 (1.3-1.4)	2.0 (1.9-2.2)
Long-term illness: Not collected	1.1 (1.0-1.2)	1.0 (0.9-1.1)	1.0 (0.9-1.1)	1.7 (1.6-1.8)	0.8 (0.8-0.9)	1.2 (1.1-1.3)
Greenness category: Q2	1.0 (0.9-1.0)	1.0 (0.9-1.1)	1.0 (0.9-1.1)	0.9 (0.9-1.0)	1.0 (0.9-1.0)	0.9 (0.8-1.0)
Greenness category: Q3	1.0 (0.9-1.0)	1.0 (0.9-1.1)	1.0 (0.9-1.0)	0.9 (0.8-1.0)	1.0 (0.9-1.0)	0.9 (0.8-1.0)
Greenness category: Q4 - most dense	1.0 (0.9-1.0)	1.1 (1.0-1.1)	1.0 (0.9-1.1)	0.8 (0.7-0.8)	1.0 (0.9-1.0)	0.8 (0.7-0.8)
Greenness category: Other/missing	1.2 (0.9-1.6)	1.0 (0.8-1.4)	1.0 (0.7-1.5)	1.0 (0.9-1.2)	1.1 (1.0-1.3)	1.1 (0.9-1.4)
Active living environment: Low	1.0 (0.9-1.1)	1.0 (0.9-1.0)	1.0 (0.9-1.1)	1.1 (1.0-1.1)	1.0 (1.0-1.1)	1.1 (1.0-1.1)
Active living environment: Moderate	1.1 (1.0-1.1)	1.0 (0.9-1.1)	1.1 (1.0-1.2)	0.8 (0.8-0.9)	1.0 (0.9-1.0)	0.9 (0.8-0.9)
Active living environment: High	1.0 (0.9-1.1)	1.0 (0.9-1.1)	1.0 (0.9-1.1)	1.1 (1.0-1.2)	1.1 (1.0-1.2)	1.2 (1.1-1.3)
Active living environment: Missing	1.0 (0.8-1.2)	0.9 (0.8-1.1)	0.8 (0.6-1.0)	1.1 (0.9-1.3)	0.9 (0.8-1.1)	0.9 (0.7-1.1)
Survey period: pre-Covid-19	0.9 (0.9-1.0)	1.6 (1.5-1.7)	1.2 (1.1-1.3)	0.9 (0.8-0.9)	1.6 (1.6-1.7)	1.2 (1.2-1.3)
Gender: Female	1.1 (0.9-1.2)	1.0 (0.9-1.1)	1.0 (0.9-1.2)	1.4 (1.3-1.4)	0.8 (0.8-0.9)	1.1 (1.1-1.2)
Gender: Female	1.1 (0.9-1.2)	1.0 (0.9-1.1)	1.0 (0.9-1.2)	1.2 (1.1-1.4)	1.1 (0.9-1.2)	1.2 (1.0-1.4)
Age group: 31-45	0.7 (0.6-0.8)	1.0 (0.9-1.2)	0.8 (0.7-0.9)	0.7 (0.7-0.8)	1.0 (0.9-1.0)	0.8 (0.7-0.9)
Age group: 31-45	0.7 (0.6-0.8)	1.0 (0.9-1.2)	0.8 (0.7-0.9)	0.8 (0.7-0.9)	1.1 (0.9-1.2)	0.8 (0.7-1.0)
Age group: 46-60	0.6 (0.5-0.7)	1.1 (1.0-1.3)	0.7 (0.6-0.8)	0.8 (0.7-0.9)	1.0 (0.9-1.1)	0.8 (0.8-0.9)
Age group: 46-60	0.6 (0.5-0.7)	1.1 (1.0-1.3)	0.7 (0.6-0.8)	0.8 (0.7-0.9)	1.2 (1.1-1.4)	0.9 (0.8-1.1)
Age group: 61-75	0.4 (0.3-0.4)	0.8 (0.7-0.9)	0.4 (0.4-0.5)	0.7 (0.6-0.7)	0.7 (0.7-0.8)	0.6 (0.5-0.6)
Age group: 61-75	0.4 (0.3-0.4)	0.8 (0.7-0.9)	0.4 (0.4-0.5)	0.6 (0.5-0.7)	0.9 (0.8-1.0)	0.6 (0.5-0.7)
Age group: 75+	0.4 (0.3-0.4)	0.5 (0.5-0.6)	0.3 (0.3-0.4)	0.8 (0.7-0.9)	0.5 (0.5-0.6)	0.5 (0.4-0.6)
Age group: 75+	0.4 (0.3-0.4)	0.5 (0.5-0.6)	0.3 (0.3-0.4)	0.7 (0.6-0.8)	0.6 (0.5-0.7)	0.5 (0.4-0.6)
Interaction: female, 31-45	1.0 (0.9-1.3)	0.9 (0.8-1.1)	1.1 (0.9-1.3)	0.9 (0.8-1.1)	0.8 (0.7-1.0)	1.0 (0.8-1.2)
Interaction: female, 46-60	1.2 (1.0-1.4)	0.8 (0.7-0.9)	1.0 (0.8-1.2)	1.0 (0.9-1.2)	0.7 (0.6-0.8)	0.9 (0.7-1.0)
Interaction: female, 61-75	1.5 (1.2-1.7)	0.8 (0.6-0.9)	1.1 (0.9-1.3)	1.3 (1.1-1.5)	0.7 (0.6-0.8)	1.0 (0.8-1.2)
Interaction: female, 75+	1.3 (1.1-1.5)	0.8 (0.6-0.9)	1.0 (0.8-1.3)	1.3 (1.1-1.5)	0.7 (0.6-0.9)	1.0 (0.8-1.2)

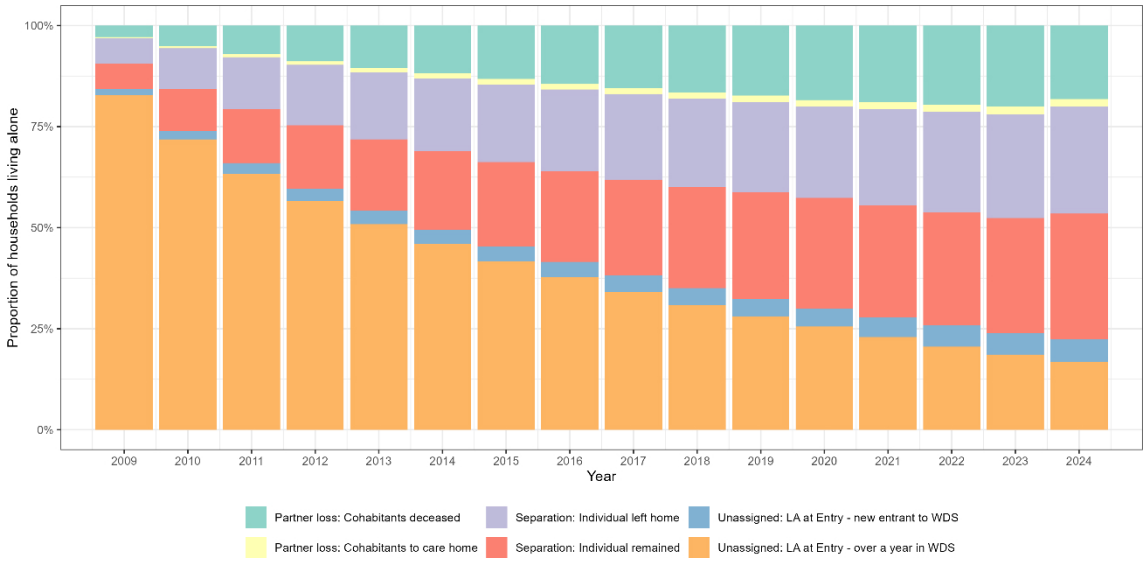
(Also adjusted for age-gender interaction terms).

Supplementary Figure 2: Phase 1 population level living alone reason for those living alone by year



Derived living alone reason annual trends; classified as partner loss (death or care home), separation, or unassigned. Distribution across the Phase 1 study period reflects increased ability to infer living alone reason in more recent years. In 2024, of 363,133 households classified as living alone, 20% (n=72,938) were due to partner loss, 58% (n=208,917) to separation, and 22% (n=81,278) unassigned.

Supplementary Figure 3: Phase 1 population level living alone reason for those living alone by year



Derived living alone reason annual trends with additional granularity; defined as: partner loss: care home entry and death; separation: leaving a previous residence, remaining.

Supplementary Table 5: Results of sensitivity analyses for emotional loneliness model using cluster-robust standard errors clustered at the individual level to assess the impact of repeated observations on statistical inference

Model term (Emotional loneliness model)	Original model estimate (adjusted OR)	Clustered model estimate (adjusted OR)	Original model standard error	Clustered model standard error	Ratio of standard errors	Original model p-value	Clustered model p-value
(Intercept)	0.17	0.17	0.08	0.09	0.97	0.00	0.00
Live alone reason: loss of partner (under 2 years)	5.09	5.09	0.08	0.09	0.95	0.00	0.00
Live alone reason: loss of partner (2-5 years)	3.24	3.24	0.08	0.08	0.94	0.00	0.00
Live alone reason: loss of partner (5+ years)	2.05	2.05	0.08	0.08	0.93	0.00	0.00
Live alone reason: separation	1.68	1.68	0.04	0.04	0.97	0.00	0.00
Live alone reason: Unknown	1.49	1.49	0.04	0.05	0.95	0.00	0.00
Gender: Female	1.08	1.08	0.07	0.08	0.98	0.30	0.31
Age group: 31-45	0.69	0.69	0.07	0.08	0.97	0.00	0.00
Age group: 46-60	0.58	0.58	0.07	0.07	0.97	0.00	0.00
Age group: 61-75	0.37	0.37	0.07	0.07	0.97	0.00	0.00
Age group: 75+	0.37	0.37	0.08	0.08	0.97	0.00	0.00
Ethnicity: Minority ethnic background	1.50	1.50	0.08	0.09	0.95	0.00	0.00
Ethnicity: Not linked to census	1.08	1.08	0.03	0.03	0.96	0.03	0.04
Education: A-Levels or Apprenticeships	1.15	1.15	0.05	0.05	1.01	0.00	0.00
Education: GCSE	1.15	1.15	0.04	0.04	1.02	0.00	0.00
Education: No qualifications	1.25	1.25	0.04	0.04	1.01	0.00	0.00
Education: Not collected in survey	1.61	1.61	0.05	0.05	1.01	0.00	0.00
Education: Other qualifications	1.08	1.08	0.05	0.06	0.99	0.15	0.15
Tenure: Other	1.11	1.11	0.11	0.11	0.98	0.35	0.36
Tenure: private rental	1.41	1.41	0.04	0.04	0.98	0.00	0.00
Tenure: social housing	1.71	1.71	0.04	0.04	0.97	0.00	0.00
General health: bad, very bad	3.93	3.93	0.04	0.04	0.98	0.00	0.00
General health: fair	2.01	2.01	0.03	0.03	0.98	0.00	0.00
Long-term illness: Yes	1.53	1.53	0.03	0.03	1.00	0.00	0.00
Long-term illness: Not collected in survey	1.06	1.06	0.05	0.05	0.99	0.22	0.22
Deprivation: 2	0.96	0.96	0.04	0.04	0.98	0.25	0.26
Deprivation: 3	0.92	0.92	0.04	0.04	0.96	0.03	0.04
Deprivation: 4	0.88	0.88	0.04	0.05	0.96	0.00	0.01
Deprivation: 5 - least deprived	0.82	0.82	0.05	0.05	0.98	0.00	0.00
Rurality: town	0.95	0.95	0.04	0.04	0.97	0.15	0.17
Rurality: village	0.92	0.92	0.05	0.05	0.97	0.12	0.13
House type: flat	1.06	1.06	0.06	0.06	0.95	0.31	0.33
House type: other or missing	1.02	1.02	0.15	0.15	0.97	0.88	0.88
House type: semi-detached	1.02	1.02	0.04	0.04	0.98	0.67	0.68
House type: terraced	1.09	1.09	0.04	0.04	0.96	0.02	0.02
Greenness category: 2	0.97	0.97	0.04	0.04	0.96	0.39	0.40
Greenness category: 3	0.97	0.97	0.04	0.04	0.97	0.37	0.38
Greenness category: most dense	0.96	0.96	0.04	0.04	0.96	0.31	0.33
Greenness category: other or missing	1.19	1.19	0.16	0.16	0.99	0.27	0.27
Active living environment: low	1.01	1.01	0.03	0.03	0.98	0.79	0.80
Active living environment: moderate	1.06	1.06	0.04	0.04	0.96	0.16	0.18
Active living environment: high	1.04	1.04	0.05	0.05	0.97	0.49	0.50
Active living environment: missing	0.97	0.97	0.09	0.10	0.97	0.73	0.74
Survey period: pre-April 2020	0.94	0.94	0.03	0.03	1.00	0.04	0.04
Interaction: female, 31-45	1.05	1.05	0.09	0.10	0.98	0.62	0.62
Interaction: female, 46-60	1.15	1.15	0.09	0.09	0.98	0.11	0.11
Interaction: female, 61-75	1.47	1.47	0.09	0.09	0.97	0.00	0.00
Interaction: female, 75+	1.28	1.28	0.10	0.10	0.97	0.01	0.01

Absolute differences are presented between models for key model metrics, i.e. adjusted odds ratios (estimates), standard errors (including ratios), and p-values.

Supplementary Table 6: Comparison of age and sex distributions between linked and non-linked participants at key stages of cohort construction

Stage comparison description	Group comparison rule	Percentage female	Mean age (standard deviation)
Stage 1: Initial data: National Survey for Walesversus Stage 2: Excluded non & low-confidence (<90%) linkage matches	Stage 1 and not Stage 2 Stage 2 only	48.0% 56.3%	54.2 (20.7) 56.0 (18.3)
Stage 1: Initial data: National Survey for Walesversus Stage 3: Linked NSW to Annual Population Snapshot (APS, WDS living alone)	Stage 1 and not Stage 3 Stage 3 only	49.8% 56.5%	53.5 (20.2) 56.2 (18.2)
Stage 1: Initial data: National Survey for Walesversus Stage 4: Excluded records with missing NSW covariates (education, health, long-term illness, housing tenure)	Stage 1 and not Stage 4 Stage 4 only	50.0% 56.6%	53.5 (20.3) 56.2 (18.2)