RESEARCH ARTICLE

The effect of Advanced Higher Mathematics on success within STEM degree-programs

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Abstract

To gain access to higher education degree programmes, Scottish domiciled students must obtain the relevant grades in Scottish Higher qualifications typically achieved in either of the final two years of secondary school (S5 and S6). However, for admission to some of the most competitive degree programmes at higher education institutions in the UK, Advanced Highers are sometimes required or recommended. However, there exists little published literature on the effect of Advanced Higher on students' chances of success in higher education. This is relevant given that Advanced Highers are not compulsory and may not be available to every Scottish learner. This study fits Modified Poisson regression models to 10 years' worth of student registration records at a single Scottish higher education institution. Results indicated that students on Mathematics and Statistics programmes and had an Advanced Higher in Mathematics were 36.1% more likely to progress at the end of their first year and 57.3% to complete their degree within four years, compared to their peers with just Higher Mathematics. For other Science and Engineering programmes, there was a significant interaction between having a Higher/Advanced Higher Mathematics qualification and whether or not it was recommended. Given these results, if access to Advanced Highers is found to be associated with socio-economic background, then this could undermine Scotland's Widening Access agenda.

Keywords: Advanced Higher Mathematics, Student success, STEM degree programmes

1. Background

To gain access to higher education degree programmes, Scottish domiciled students must obtain the relevant grades in Scottish Higher qualifications typically achieved in the final two years of secondary school (S5 and S6). However, for S6 students who have already obtained a Higher in a given subject but wish to study further, the opportunity exists to sit a more advanced qualification, the Advanced Higher.

Advanced Highers were introduced in 1999 as a replacement for Certificate of Sixth Year Studies (Johnson and Hayward, 2008). Students may take Advanced Highers in a range of subjects, for example, English, Mathematics, Statistics, Physics, Chemistry, Biology, etc. (Scottish Qualifications Authority, n.d.). Typically, students are expected to have at least passed the relevant Higher as a pre-requisite to sitting an Advanced Higher, though ultimately presentation for the award is at the discretion of the school. Advanced Higher learners are encouraged to be more "pro-active" and "independent" in their studies to bridge the gap between secondary and higher education (Scottish Qualifications Authority, 2009). Advanced Highers rank as Level 7 on the Scottish Credit and Qualifications Framework (roughly equivalent to UK Level 4), the same level as a Higher National Certificate achieved at college (Scottish Credit and Qualifications Framework, 2023).

Unlike Highers, Advanced Highers are not compulsory subjects for university entry. Yet, for admission to some of the most competitive degree programmes at higher education institutions in the UK, Advanced Highers are sometimes required or recommended. For example, the University of Oxford expects pupils to achieve at least AAB at Advanced Higher unless there is sufficient evidence from the applicant that their school was unable to provide these qualifications (University of Oxford, n.d.). In contrast, the Universities of Glasgow and Edinburgh do not require Advanced Highers for most programmes except medicine (University of Edinburgh, 2023; University of Glasgow, 2023). The University of Strathclyde generally recommends, but does not require, Advanced Highers for entry to its Science, Engineering, Business and Law degrees (University of Strathclyde, 2024). In some Scottish institutions, students with Advanced Higher qualifications may be able to forgo certain examinations from the first year of their degree programme or skip the first year entirely and enter directly into second year. This is because the content from an Advanced Higher may overlap with the content taught at the first stage of the typical four-year Scottish degree programme.

A critical question arises from this context. If Advanced Highers are recommended, is this because they improve Scottish students' chances of success at university? In one of the few published literature that covers this topic, Croxford et al. (2014) found that students with "more Advanced Highers and/or A-levels achieve better degree outcomes on average". In 2018, students who had attended Glasgow Caledonian's "Advanced Higher Hub" associated their positive early-experience of university with attendance at the hub (MacFarlane, 2018). However, participants were self-selected, meaning that the results from MacFarlane (2018) are not generalisable.

If Advanced Highers do indeed improve Scottish students' chances of success at university, it then begs the question of whether or not Scottish students have equal access to Advanced Highers in secondary school. This question has been raised by various British media outlets (Borland, 2023; The Herald, 2018). Some have even referred to what they perceive as inequal access to Advanced Highers as a "postcode lottery" (Phipps, 2018). This coverage serves to highlight the public interest in access to Advanced Highers and their impact on educational outcomes.

The aim of this paper is to contribute to the literature on Advanced Highers and their effect on student's academic outcomes at higher education. Using university registration data for students from Science and Engineering programmes, the following research question will be answered:

> *Does Advanced Higher Mathematics improve students' chances of achieving a positive outcome in Mathematics, Science and Engineering degree programmes?*

It was decided to focus on Mathematics since this is one of the most commonly recommended Advanced Highers across a range of Science and Engineering programmes. If Advanced Higher Mathematics is found to have positive effect on student's academic outcomes at university and future analyses find that access to Advanced Highers is not equal, then this could be problematic.

2. Data

The data for this analysis came from the University of Strathclyde's school-leavers dataset (SLD). These were the same data analysed in Burns et al. (2025), hence many of the definitions in the SLD remain the same across both analyses. The SLD is a combination of student registration and attainment data, entry requirements data and the Scottish Index of Multiple Deprivation (SIMD) datasets (Scottish Government, 2016, n.d.). SIMD is a commonly-used measure of area-level deprivation across Scotland, where SIMD Quintile 1 represents the 20% most deprived areas and SIMD Quintile 5 represents the 20% least deprived areas. For more information on SIMD see (Scottish Government, 2020). The SLD only considers "Scottish school-leavers", defined to be full-

time, first-degree, Scottish domiciled undergraduates, who were aged 18 or under at the point of their first registration. For this analysis the SLD was subset to only include students from the Faculties of Science and Engineering. The resultant subset was denoted the "STEM-SLD" and contained 6,914 unique students who each began their registration at the University between academic sessions 2012/13 and 2018/19 (Table 1).

2.1. Defining the Progression and Completion Outcomes

There were two binary academic outcomes of interest: progression at the end of the first registration year (Progression) and completion of a Bachelor's with Honours degree within four years (Completion). These definitions are identical to those defined in Burns et al. (2025).

Students were considered to have successfully progressed if they advanced one academic stage after their first year of registration. Students who failed to progress may have been withdrawn, have been in suspension (for academic or personal reasons) or may have repeated a stage of their programme. Around 89.5% of students in the STEM-SLD successfully progressed at the end of first year (Table 1).

Bachelor's with Honours degrees are typically four years' duration in Scotland. Thus, students were considered to have successfully completed their degree if they had achieved a: first-class, second-class, or third-class honours degree, or had passed the fourth stage of their Integrated Master's programme, within four registration years (regardless of whether they changed degree programme). Integrated Master's students were included in the analysis because (i) they could not be distinguished from Bachelor's with Honours students, and (ii) various programmes which offered these pathways were identical up to the final Masters year. Failure to complete a degree included anyone who exited the university at any stage with none of the aforementioned classifications or took longer than four years to complete their degree. Roughly 71.1% of students from Academic Cohorts 2012/13 – 2018/19 successfully completed their degree within four years (Table 1).

Table 1: Summary of categorical and outcome variables within STEM-SLD dataset (began registration between 2012/13 – 2018/19).

		Count	Proportion
Categorical Variables			
Academic Cohort	2012/13	1013	0.147
	2013/14	1040	0.150
	2014/15	1044	0.151
	2015/16	1000	0.145
	2016/17	967	0.140
	2017/18	943	0.136
	2018/19	907	0.131
Best Mathematics Qualification	Adv. Higher	3397	0.491
	Higher	3474	0.502
	None	43	0.006
Department	Mathematics and Statistics	760	0.110
	Other	6154	0.890

Ethnicity	Ethnic-minority	560	0.081
	Refused/Not given	47	0.007
	White	6307	0.912
SIMD Quintile	1	682	0.099
	2	932	0.135
	3	1199	0.173
	4	1545	0.223
	5	2556	0.370
Sex	Female	2200	0.318
	Male	4714	0.682
Outcome Variables			
Progression	No	723	0.105
	Yes	6191	0.895
Completion	No	1996	0.289
	Yes	4918	0.711
Total	**-**	**6914**	**1.00**

2.2. Prior Attainment and Best Mathematics Qualification

Each student's "Prior Attainment Points" from secondary school was defined as the combined "score" they had achieved across their Higher and Advanced Higher qualifications. A simple scoring system was used such that for Higher the grades: A – 3 points, B – 2 points, C – 1 point, D – 0 points; while for Advanced Higher: A – 4 points, B – 3 points, C – 2 points and D – 1 point. A similar definition for prior attainment was also used in Burns et al. (2025). A single point increase corresponds to an increase in grade in Higher or Advanced Higher, for example a C to a B, or a B to an A. The Prior Attainment Points can therefore be interpreted as each of the Scottish students' academic potential at the moment they first registered at the university. UCAS tariff points were considered but ruled-out in favour of Prior Attainment Points since a single-point increase was easier to interpret. The median Prior Attainment Points total across the STEM-SLD was 19.00 points, which is roughly the equivalent of six Higher A grades.

The Best Mathematics Qualification is an identifier variable that indicates whether the student had ever received an A-D grade at Advanced Higher Mathematics. Those who failed Advanced Higher Mathematics but had the equivalent Higher were classified as "Higher". Those who had neither of these qualifications were classified as "None" (43 students). These students came predominantly from the departments of Pharmacy, Architecture and Computing Science. It is likely the case that these students either had an alternative Mathematics qualification that was recognised by the department (e.g. A-level), or that Mathematics was not a required subject when the student applied. It was assumed that any passing grade at Advanced Higher is equivalent to, or better than, any grade awarded at Higher. The Department of Mathematics and Statistics had the largest proportion of Advanced Higher Mathematics students at 76.8%. The remaining departments had a proportion which ranged from 14.8% (Strathclyde Institute of Pharmacy and Biomedical Sciences) to 75.9% (Mechanical and Aerospace Engineering). The median Prior Attainment Points total for Advanced Higher Mathematics students was 21.00 points and for Higher Mathematics students was 16.00 points.

2.3. Recommendation of Advanced Higher Mathematics

For this analysis, if a degree programme had ever explicitly encouraged the study Advanced Higher in the University's 2012/13 – 2021/22 hand-outs to prospective undergraduates, it was considered to have recommended it. Advanced Higher Mathematics is recommended to all students studying a degree programme offered by the Mathematics and Statistics department. Across the "other" Science and Engineering departments this recommendation varied from programme-to-programme. Within other Science and Engineering programmes which recommended Advanced Higher Mathematics, 58.7% of students held this qualification. In programmes which did not recommend Advanced Higher Mathematics, only 24.4% of students held this qualification.

Breaking this down further, there were higher progression and completion rates within Advanced Higher Mathematics students when compared to Higher Mathematics students (Figure 1); this was regardless of whether or not Advanced Higher was recommended. It is notable that progression/completion rates for Advanced Higher Mathematics students were relatively similar whether or not the qualification was recommended (Figure 1). For Higher Mathematics students on the other hand, completion rates on programmes which recommended Advanced Higher were 9.2 percentage-points lower than on programmes which did not recommend it (Figure 1). The number of students that had neither a Higher nor Advanced Higher Mathematics qualification was too small to interpret any valid conclusions on their progression and completion rates.

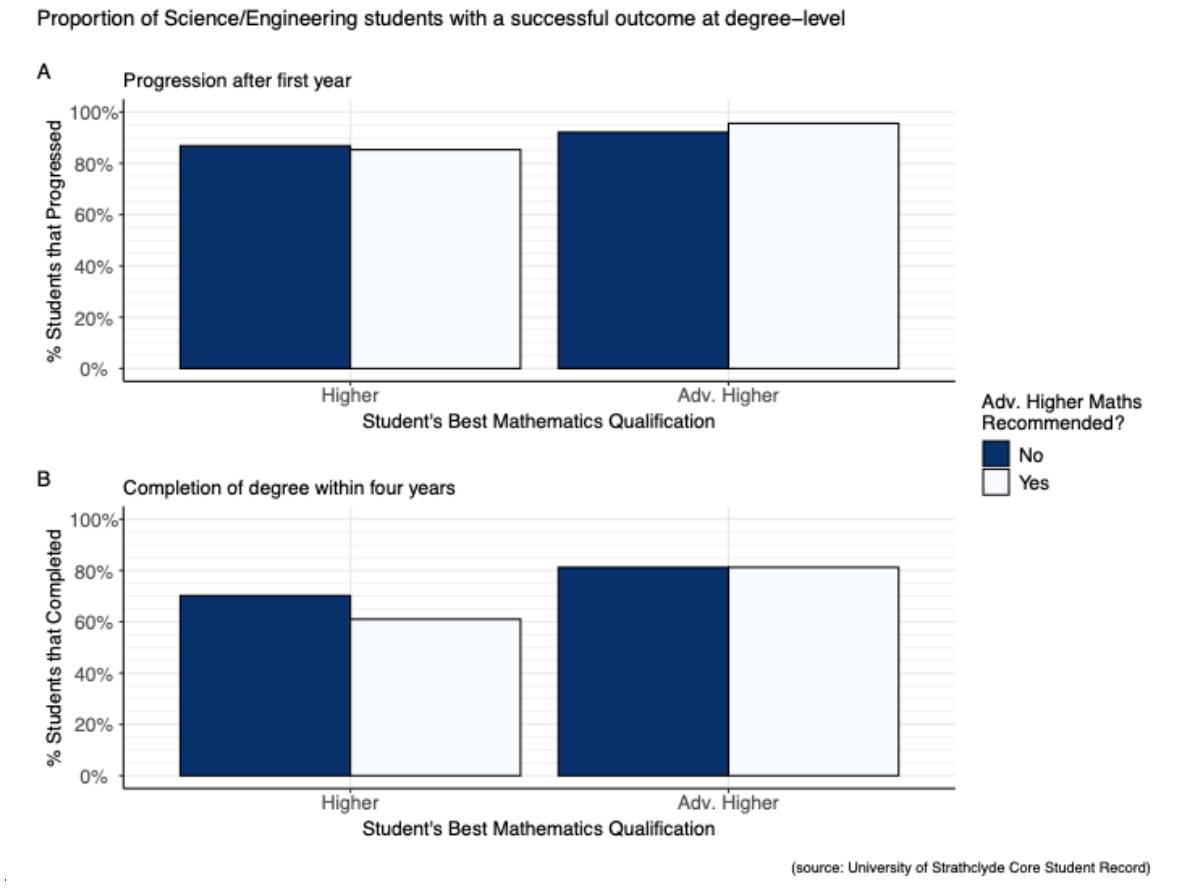

Figure 1: The proportion of successful progressions/completions amongst students in other Science and Engineering programmes (not including Mathematics), grouped by their Best Mathematics Qualification and whether or not their programme recommended Advanced Higher Mathematics.

3. Methods

Just as in Burns et al. (2025), Poisson regression models were fit to the data given that they can appropriately model the binary outcomes of progression and completion (random variable *Y*) when the error terms are calculated using "sandwich estimation" (Zeileis, 2006). Such models are known as modified Poisson regression models. Once exponentiated, the coefficients of these models approximate estimates of risk-ratios (RRs)

$$RR = \frac{P(Y = 1|X = 1)}{P(Y = 1|X = 0)} = \frac{\pi_1}{\pi_0}$$

where π_1 is the probability of experiencing the outcome for those who are exposed to the outcome, $X = 1$, over the probability π_0 of experiencing the outcome for those who were not exposed to the outcome, $X = 0$.

Two pairs of modified Poisson regression models were fit to subsets of the STEM-SLD dataset. The first pair of models looked at the progression and completion rates of students who were registered with the Department of Mathematics and Statistics only (n = 760), while controlling for the effects of Academic Cohort, Sex, Ethnicity and SIMD Quintile. The second pair of models used the same outcomes and control variables but for students registered with the rest of the Science and Engineering programmes offered by the University of Strathclyde (n = 6,154). The second pair of models also considered an interaction term between students' Best Mathematics Qualification, and whether or not their programme recommended Advanced Higher Mathematics, since not all programmes did so. Students who had neither a Higher nor Advanced Higher Mathematics qualification had to be removed to allow for this interaction term in model fitting (due to small sample sizes within groups).

4. Results

4.1. Department of Mathematics and Statistics

Students from the Department of Mathematics and Statistics who held an Advanced Higher Mathematics qualification were 37.4% [95% CI: 22.2%, 54.4%] more likely to progress and 57.9% [95% CI: 25.2%, 99.0%] more likely to complete their degree compared to their peers with only Higher Mathematics (Table 3). For each additional point (or grade) increase over the mean Prior Attainment Points, a student was 1.6% [95% CI: 0.9%, 2.3%] more likely to progress at the end of first year, and 5.9% [95% CI: 4.4%, 7.4%] more likely complete their degree within four years. There appears to be some association between the progression and completion rates of Mathematics and Statistics students and which Academic Cohort they belonged to. However, given that the sizes of these cohorts are relatively small (around 100 students each year) some volatility between cohorts is expected. Ethnic-minority students were 11.1% [95% CI: 1.8%, 21.3%] more likely to progress than White students, however both groups were just as likely to complete their degree. There does not appear to be an association between the academic outcomes and Sex and SIMD Quintile, in contrast to the findings from Burns et al. (2025).

4.2. Other Science and Engineering Departments

For each additional point (or grade) increase over the mean Prior Attainment Points, students from other Science and Engineering departments were 1.0% [95% CI: 0.8%, 1.2%] more likely to progress at the end of first year. There is no association between progression and any of the other explanatory variables in the model, except perhaps a small difference in the progression rates of those from Academic Cohorts 2012/13 and 2013/14.

Similarly, for each additional point (or grade) increase over the mean Prior Attainment Points, students from other Science and Engineering departments were and 3.0% [95% CI: 2.6%, 3.4%] more likely complete their degree within four years. Students on programmes which recommended Advanced Higher Mathematics were 13.9% [95% CI: 9.6%, 18.1%] less likely to complete their degree compared to students on programmes which did not recommend it. There was a significant interaction between Best Mathematics Qualification and whether or not Advanced Higher Mathematics was recommended. This means that the association between completion and holding an Advanced Higher Mathematics qualification was greater on programmes where it was recommended than courses where it was not. Students from SIMD Quintile 5 were 14.4% [95% CI: 7.1%, 22.1%] more likely to complete their degree than students from SIMD Quintile 1. Females were also 4.0% [95% CI: 0.7%, 7.4%] more likely to complete their degree than males.

Table 2: Risk-Ratio Estimates from the modified Poisson Regression model fit to student data from the Department of Mathematics and Statistics (n = 760).

Variables	**Risk-Ratios**	
	Progression Year 1 to Year 2	**Completion of a Degree Prog.**
(Intercept)	0.688 (0.588,0.806) [***]	0.413 (0.310,0.552) [***]
Best Maths Qual. – Adv. Higher (vs Higher)	1.374 (1.222,1.544) [***]	1.579 (1.252,1.990) [***]
Prior Attainment Points	1.016 (1.009,1.023) [***]	1.059 (1.044,1.074) [***]
2013/14 Cohort (vs 2012/13)	0.990 (0.916,1.070)	0.870 (0.717,1.056)
2014/15 Cohort (vs 2012/13)	0.941 (0.859,1.030)	0.748 (0.604,0.927) [**]
2015/16 Cohort (vs 2012/13)	0.886 (0.795,0.987) [*]	0.615 (0.466,0.813) [***]
2016/17 Cohort (vs 2012/13)	0.879 (0.792,0.975) [*]	0.816 (0.671,0.993) [*]
2017/18 (Cohort vs 2012/13)	0.871 (0.797,0.953) [**]	0.880 (0.739,1.048)
2018/19 Cohort (vs 2012/13)	0.878 (0.799,0.965) [**]	0.889 (0.741,1.067)
Female (vs Male)	0.984 (0.930,1.041)	1.053 (0.940,1.180)
SIMD Quintile 2 (vs 1)	1.027 (0.909,1.161)	1.029 (0.821,1.291)
SIMD Quintile 3 (vs 1)	1.043 (0.929,1.171)	1.101 (0.886,1.367)
SIMD Quintile 4 (vs 1)	1.019 (0.909,1.143)	1.065 (0.864,1.312)
SIMD Quintile 5 (vs 1)	1.087 (0.971,1.216)	1.088 (0.887,1.333)
Ethnic-minority (vs White)	1.111 (1.018,1.213) [*]	1.032 (0.846,1.258)
Refused/Not given (vs White)	0.810 (0.496,1.322)	0.613.213,1.759)

Table 3: Risk-Ratio Estimates from the modified Poisson Regression model fit to student data from the rest of the Science and Engineering programmes (n = 6,154).

Variables	Risk-Ratios	
	Progression Year 1 to Year 2	**Completion of a Degree Prog.**
(Intercept)	0.874 (0.837,0.913) [***]	0.663 (0.612,0.718) [***]
Best Maths Qual. – Adv. Higher (vs Higher)	1.024 (0.993,1.056)	1.040 (0.988,1.094)
Prog. Recommended Adv. Higher Maths (vs not)	0.978 (0.952,1.005)	0.861 (0.819,0.904) [***]
Prior Attainment Points	1.010 (1.008,1.012) [***]	1.030 (1.026,1.034) [***]
2013/14 Cohort (vs 2012/13)	1.032 (1.003,1.062) [*]	0.996 (0.938,1.057)
2014/15 Cohort (vs 2012/13)	1.003 (0.973,1.033)	1.029 (0.972,1.089)
2015/16 Cohort (vs 2012/13)	0.985 (0.955,1.017)	0.994 (0.938,1.053)
2016/17 Cohort (vs 2012/13)	0.976 (0.944,1.008)	1.012 (0.955,1.072)
2017/18 (Cohort vs 2012/13)	0.997 (0.965,1.029)	1.057 (0.999,1.119)
2018/19 Cohort (vs 2012/13)	0.970 (0.938,1.003)	1.038 (0.980,1.099)
Female (vs Male)	1.008 (0.990,1.026)	1.040 (1.007,1.074) [*]
SIMD Quintile 2 (vs 1)	1.001 (0.960,1.043)	1.082 (1.003,1.167) [*]
SIMD Quintile 3 (vs 1)	1.014 (0.976,1.053)	1.083 (1.008,1.164) [*]
SIMD Quintile 4 (vs 1)	1.034 (0.998,1.072)	1.100 (1.026,1.178) [**]
SIMD Quintile 5 (vs 1)	1.026 (0.991,1.062)	1.144 (1.071,1.221) [***]
Ethnic-minority (vs White)	1.020 (0.991,1.049)	1.021 (0.967,1.077)
Refused/Not given (vs White)	0.922 (0.809,1.052)	0.841 (0.672,1.052)
Interaction: Best Maths Qual. & Recommended	1.035 (0.997,1.075)	1.083 (1.014,1.157) [*]

5. Discussion

The results indicate that Advanced Higher Mathematics had a strong and positive association with the successful progression and completion rates of students enrolled on Mathematics and Statistics degrees at the University of Strathclyde. The association between success and Advanced Higher Mathematics across other Science and Engineering programmes was more complicated to interpret. Programmes which recommended Advanced Higher Mathematics had lower completion rates than programmes which did not. However, this association was weaker if the student held an Advanced Higher Mathematics qualification. This could be seen as either a justification or, more cynically, a rationalisation for recommending Advanced Higher Mathematics in such programmes. Attainment in other subjects may be affecting the interpretation of the effect of Advanced Higher Mathematics. For example, this analysis did not account for the effects of other Advanced Highers in relevant science subjects, Physics, Chemistry, Biology, etc.

As acknowledged in Burns et al. (2025), Prior Attainment Points are also an imperfect measure of the academic potential to succeed though are simple to implement and interpret. Models were also fit using UCAS tariff points where the relationships between the covariates and the outcomes remained the same, including significance tests. Further investigation is required into how best to measure and compare similar attainment profiles across Highers and Advanced Highers.

Progression and degree completion are popular in the literature but are not ideal for fitting regression models given that they are not rare (<10%). A more effective approach may be the application of survival models such as those which measure the rate of student drop-out over time (Arulampalam et al., 2004). The models for the completion outcome do not include any information on students' attainment at university-level, which is assumed to be a critical explanatory variable. Future research should investigate whether this link is present across other Advanced Higher subjects and degree programmes and other higher education institutions.

The positive effect of Advanced Higher Mathematics on degree-level outcomes leads to the inevitable question of who has access to these qualifications. If access is not equal for all learners across Scotland, then this could be evidence of an unfair system. If students from more socio-economically deprived areas are disproportionately affected, then this could jeopardise Scotland's Widening Access ambitions. Further research should therefore establish whether there is a link between a student's socio-economic status and access to Advanced Higher.

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7. Appendix

Prior Attainment Points was mean-centred in the model fits. The p-values from Wald’s tests on each coefficient were derived using $\alpha = 0.05$ as the critical value. All analyses were conducted using the statistical software R (version 4.3.1) (R Core Team, 2023). Poisson regression models were fit using the glm() function from the stats package (R Core Team, 2023). Robust variances for the modified Poisson Regression model were derived using the sandwich (3.1-0) package (Zeileis, 2006). Additional packages for general data cleaning and visualisations were used from the tidyverse (2.0.0) (Wickham H, Averick M, Bryan J, Chang W, McGowan LD, François R, Grolemund G, et al., 2019).