

CHILDREN'S READINESS FOR GRADE R BEFORE, DURING AND AFTER COVID-19



Analysis of differences in domain-specific Early Learning Outcomes Measures scores over the years 2016 to 2022

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ABSTRACT

This report aims to investigate the influence that the Covid-19 pandemic had on preschool outcomes, as measured by the Early Learning Measures (ELOM) Tool in South Africa. The report focuses on domain-specific ELOM scores as defined by the Early Learning Measure Tool. It is important to understand the influence of the pandemic on the ELOM scores, for the purposes of future initiatives and future-proofing of the early childhood development (ECD) sector.

The data used in this study comes from various sources. It was collated and sourced by the DataDrive2030 team. The years that the studies were conducted range from 2016 to 2022. The studies include a 2016 Validation study; a 2018 Early Learning Programme Outcomes (ELPO) study; a 2019 Grade R study; the 2021 Thrive by Five Index; a 2022 Roots and Shoots study; and 2019 to 2022 data from The Learning Initiative (TLI). All data aside from the TLI data were collated in one primary dataset that was used for modelling purposes.

Three comparisons between pre-Covid-19 (2016-2019) and later (2021-2022) periods were constructed from the studies in the primary dataset and multiple comparisons were drawn from the TLI data. Notably, data from the 2020 hard lockdown is excluded in the primary dataset, whereas it is included in the TLI dataset. The TLI comparisons were done separately from the master dataset, as it spanned the broadest year range of all the studies (2019-2022). All the comparisons were done for all five ELOM domain scores. The analysis used Generalised Additive Models (GAMs) to model the effects of variables on the domain ELOM scores. The variables included gender, quintile, province, whether a child was stunted or not, and age. The domain ELOM scores were modelled separately, and a best model chosen by minimised Root Mean Squared Error was selected for each domain.

T-tests were conducted on the mean excess ELOM scores (defined as the difference between the predicted model values and the children's ELOM scores) between each comparator in the three primary datasets and TLI comparisons. In this way, the differences in ELOM scores between the selected time periods were identified.

In the primary dataset comparisons, apart from the Validation vs Thrive by Five comparison, signals are mixed. Where there is the longest time lag between datasets (2016 Validation study vs 2021 Thrive by Five), the Thrive by Five excess scores exceed the (pre-Covid-19) Validation study significantly ($p < 0.001$). Although comparability of these samples is influenced by the degree of prior exposure to early learning programmes (all subjects in Thrive by Five, only partial in 2016), the strength of the results provides tentative evidence of ELOM scores having increased over time despite the effects of the pandemic. This would be consistent with a narrative of general improvements in the ECD sector over the intervening time period. Although hard evidence for these is sparse, this interpretation should be treated with a high degree of caution. For TLI, where there should in principle be the lowest degree of heterogeneity between time periods, there is clearer evidence of a Covid-19 effect on ELOM outcomes. The excess ELOM scores are significantly lower across all domains when comparing 2020, or 2020-2021, to both prior and subsequent years ($p < 0.001$ for all).

Although signals are mixed for the primary dataset comparisons, the TLI comparisons lend support to the widely-held belief that the Covid-19 pandemic had a significant negative influence on ELOM scores and school readiness. The caveats to the comparisons highlight the importance of ensuring consistency and comparability in future data collection to allow for stronger inferences about changes over time and eventual effects.

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Responsibility for the contents of this report however vests entirely with the authors.



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ACRONYMS AND ABBREVIATIONS

CEF	Cognition and Executive Functioning
ECD	Early Childhood Development
ELL	Emergent Literacy and Language
ELOM	Early Learning Measure
ELP	Early Learning Programme
ELPO	Early Learning Programme Outcomes
ENM	Emergent Numeracy and Mathematics
FMC-VMI	Fine Motor Coordination and Visual Motor Integration
GAM	Generalised Additive Model
GMD	Gross Motor Development
RMSE	Root Mean Squared Error
SES	Socio-Economic Status
TGMD-2	Test of Gross Motor Development-2
TLI	The Learning Initiative

1. INTRODUCTION

On 18 March 2020, early learning programmes (ELPs) across South Africa were instructed to close as part of national efforts to curb the spread of Covid-19. This period of closure is referred to as the 'Covid lockdown'. In July of that same year, ELPs were legally permitted to reopen provided they met Covid-19 specific health and safety standards. Sector recovery was slow and many ELPs were unable to resume their services for much of 2020. During this time, hundreds of thousands of young children lost out on months of access to structured early learning opportunities.

For the purposes of this paper we refer to the period prior to March 2020 as 'pre Covid-19' and the period after March 2020 as 'post Covid-19'.

This analysis is an exploratory exercise investigating the differences in children's ELOM scores over time. It is the first time that this data has been analysed specifically with the effects of the Covid-19 era in mind. It is also the first time that this data has been collated in this way.

The ELOM 4&5 Years Assessment (ELOM 4&5) tool is an age-validated, standardised assessment of whether children are developmentally on track for their age. The measure focuses on school readiness and has been specifically validated on South African children between 50 and 69 months old. This tool was used in all the studies in the report as the standard measure of children's progress on major developmental milestones in five domains:

1. Gross Motor Development (GMD);
2. Fine Motor Coordination and Visual Motor Integration (FMC-VMI);

3. Emergent Numeracy and Mathematics (ENM);
4. Cognition and Executive Functioning (CEF); and
5. Emergent Literacy and Language (ELL).

We attempt to explore the effects of the Covid-19 pandemic in two ways, corresponding to two broad sections in this report. The first section attempts to draw inferences from (broadly) comparable subsets of the master dataset compiled by DataDrive2030, which included several studies and is described in section 2 on the next page; this dataset was also used for modelling the effects of significant control variables in order to facilitate comparability between ELOM results by controlling explanatory factors such as age, gender and location. In the master dataset, no individual study spanned the time period both before and after the Covid-19 pandemic (2019-2020). Furthermore, since none of the studies were exactly alike, this control can only go so far towards supporting comparability. The difficulties and challenges of this analysis are discussed in detail below.

Section 3 looks at The Learning Initiative (TLI) data. The great advantage of the TLI dataset is its longitudinal nature, spanning 2019 to 2022 (before, during and after the Covid-19 pandemic). It should be noted that the TLI data does not follow children longitudinally, but follows the programme. This means that it is likely to be more comparable and have less structural heterogeneity than the comparators in the master dataset. However it also has its challenges, outlined later in the report.

2. MASTER COLLATED DATASET ANALYSIS

The data used for this analysis was a combination of data collected from various sources, collated by DataDrive2030. The data comes from five different sources - the 2021 Thrive by Five Index; a 2016 Validation study; a 2018 comparative study of five early learning programmes (the Early Learning Programme Outcomes study); a 2019 Grade R study and the 2022 Roots and Shoots study.

2.1 Data sources

The following information boxes provide some detail on the different data sources and studies. It is worth stressing that comparisons require careful consideration of the differences in sampling frames and the timing of data collection.

INFO BOX 1: INFORMATION ON THE 2016 VALIDATION STUDY

**STUDY NAME:**

Early Learning Outcomes Measure (ELOM) Age Validation Study

**DATE OF STUDY:**

2016



Purpose: The goal of the ELOM age validation process was to construct a sample that was likely to be as representative as possible of children eligible to enter Grade R in January 2016, drawn from across South Africa's socio-economic distribution including five major language groups.



Sample size: 1,243



Provinces: KwaZulu-Natal, North West, Western Cape



Sampling approach: In the 2016 Validation study, ELOM tools were administered to children enrolled in public schools at the commencement of their Grade R year in 2016, including schools of all five quintiles in three provinces. A two-stage clustered sample design was employed. In the first stage, and in each district, probability proportional to Grade R population size sampling was used to randomly select schools within each of the five school quintile bands. Two schools in traditional, more rural areas in North West and KwaZulu-Natal were recruited independently of this exercise to explore the influence of more "traditional" approaches to child rearing. In the second stage, learners were selected within Grade R classes using simple random sampling. A minimum of nine children per school were selected per cluster (Innovation Edge, 2016).

INFO BOX 2: INFORMATION ON THE 2018 ELPO STUDY



STUDY NAME:

Early Learning Programme Outcomes (ELPO) study (Baseline data)



DATE OF STUDY:

2018



Purpose: To examine the relative effectiveness of different programmes that aim to improve the early learning outcomes of young children (three- to five-year-olds) from low-income backgrounds.



Sample size: 427



Provinces: Free State, Western Cape, Mpumalanga



Sampling approach: The study included elements of randomisation on two levels: programme site- and child-level randomisation, as well as convenience sampling when random selection of sites was not feasible. The sample comprised 369 children (average age 54 months at baseline and 62 months at endline) attending five-day per week centre-based programmes (n = 195), or playgroups (n = 174) one to three mornings per week (Dawes et al., 2020).

Descriptive analysis was undertaken in five of the programmes. The study investigated their relative effectiveness, as well as the contribution of child, programme, and home factors to a change in the children's ELOM performance over the course of the interventions. Children were assessed using the Early Learning Outcomes Measure 4&5 (ELOM 4&5) in March and October 2018. Early childhood development practitioners were interviewed to gather data about the programmes that may affect children's early learning outcomes. The ELPO study purposefully sampled ELPs that were of good quality.

Significant improvements in total ELOM scores were observed for four programmes included in multi-level modelling, with the extent of change ranging from 13 to 20 ELOM standard score points. A summary report is provided with the dataset.¹

INFO BOX 3: INFORMATION ON THE 2019 GRADE R STUDY



STUDY NAME:

Grade R Early Learning Outcomes Measure (ELOM) study



DATE OF STUDY:

2019



Purpose: To explore variation of ELOM scores in Grade R children.



Sample size: 1,792



Provinces: Western Cape, Eastern Cape, KwaZulu-Natal and North West

¹The full report can be found here: <https://www.datafirst.uct.ac.za/dataportal/index.php/catalog/863/download/11890>



Sampling approach: The 2019 Grade R ELOM data used the ELOM 4&5 tool to collect data on children at the start of their Grade R year. This study included data on children in four provinces. In each of the provinces, two education districts were selected to form part of the sample. These districts consisted of schools from all 5 socio-economic quintiles. Larger samples were taken from the lower quintiles, namely quintiles 1-3. In the final sample, quintile 1 had roughly the same number of children as quintiles 2-3 combined and 4-5 combined.

The schools selected were stratified by district and quintile group, and children from each school were stratified by gender. The target figure was 25 children per school. Children were assessed using the ELOM 4&5 and the Social-Emotional Rating scales.

The data collection process was due to start in January/February 2019, however due to some project delays, the collection process began only after the first school term. This means that the children would have already been exposed to one term of Grade R, and this is likely to have influenced child outcomes (DataDrive2030, 2019).

INFO BOX 4: INFORMATION ON THE 2021 THRIVE BY FIVE INDEX



STUDY NAME: Thrive by Five Index



DATE OF STUDY: 2021



Purpose: The Index is the largest survey of preschool child outcomes undertaken in South Africa. The aim was a representative sample of children aged 50 to 59 months enrolled in ELPs, both at a national and provincial level with a confidence interval (CI, "margin of error") of 5% points at a confidence level of 95%.



Sample size: 5,139 (final weighted sample)



Provinces: National



Sampling approach: In the absence of a complete sampling frame for either children or ELPs, it was decided to cluster ELPs via primary schools for random sampling. In each province, 48 schools (432 nationwide) were randomly selected to be used as clusters. Clusters are defined as a 10km radius around a school, or, where this is impractical because there were not enough ELPs in the vicinity of the schools, as the ward in which the school is located. The school sample in each province is stratified by socio-economic quintiles (1 to 5).


Child assessments (ELOM) were conducted at 3 randomly selected ELPs per cluster, resulting in a sample of 144 ELPs per province (1,296 nationwide), of which 522 randomly selected ELPs were audited (an average of 1.2 audits per cluster).

Participating children (on average four per ELP) were randomly selected from the pool of children who were present on the day when consent forms were distributed and in attendance

on the day assessments were undertaken.

The result of this approach is a multistage cluster sampling design that considers what we know about variances and intra-cluster correlations in ELOM scoring from previous assessments while remaining practical and feasible in the absence of a complete sampling frame. The final weighted sample of 5,139 children allows us to reliably report on the percentage of children aged 50 to 59 months enrolled in ELPs in SA who are at the age-appropriate level in key areas of development. Information can be viewed nationally and disaggregated by sex, province and income levels (Giese et al., 2022).

INFO BOX 5: INFORMATION ON THE 2022 ROOTS AND SHOOTS STUDY

 **STUDY NAME:**
Roots and Shoots study

 **DATE OF STUDY:**
2022



Purpose: To provide reliable evidence on the learning outcomes of children when they first enter school and through the first years of primary school ("Roots and Shoots Research from Early Learning to School Outcomes", 2022).



Sample size: 586



Provinces: Western Cape



Sampling approach: Selection of Afrikaans sample: The data is part of an existing Funda Wande/Western Cape Education Department (WCED) Randomised Control Trial (targeted at Foundation phase learners in the Western Cape). The intervention has 50 Afrikaans schools in the treatment group, compared to 50 matched, comparison schools. Within each educational district, statistical techniques were used to select the comparison schools such that they matched the treatment schools as closely as possible on performance on Grade 3 systemic assessments from 2017 to 2019.

Grade R learners were assessed in Term 1 of 2022 across 50 Afrikaans schools (half of the schools in the evaluation study). These schools are all located in the four Metro and Cape Winelands educational districts.

Selection of isiXhosa sample: In addition, children from 25 isiXhosa schools were sampled in the Western Cape. Only schools in the Cape Town Metro districts were considered since most isiXhosa schools are located in Cape Town. Schools were stratified in quintiles of their average Grade 3 Systemic Evaluation performance between 2017 to 2019 and then within each stratum, five schools were randomly selected (Hofmeyr, Ardington, and Spaul, 2022).

Below is a summary of the data in the above sources.

TABLE 1: DATA SUMMARY

	Comparison 1		Comparison 2		Comparison 3	
Study names	2016 Validation study	2021 Thrive by Five Index	2018 ELPO study	2021 Thrive by Five Index	2019 Grade R study	2022 Roots and Shoots
Sample size	1,243	5,222	427	5,222	1,792	586
Grade R / pre-Grade R	Grade R	Pre-Grade-R	Pre-Grade-R	Pre-Grade-R	Grade R	Grade R
Provinces	KwaZulu-Natal, North West, Western Cape	National	Free State, Western Cape, Mpumalanga	National	Western Cape, Eastern Cape, KwaZulu-Natal and North West	Western Cape
Quintile coverage	1-5	1-5	1-5 (Primarily quintiles 1-3)	1-5	1-5	1-5
Language of assessment	Afrikaans, English, isiXhosa, isiZulu, Setswana	All 11 official languages	Afrikaans, English, isiZulu, Sepedi, Sesotho	All 11 official languages	Afrikaans, English, isiXhosa, isiZulu, Setswana	Afrikaans, isiXhosa

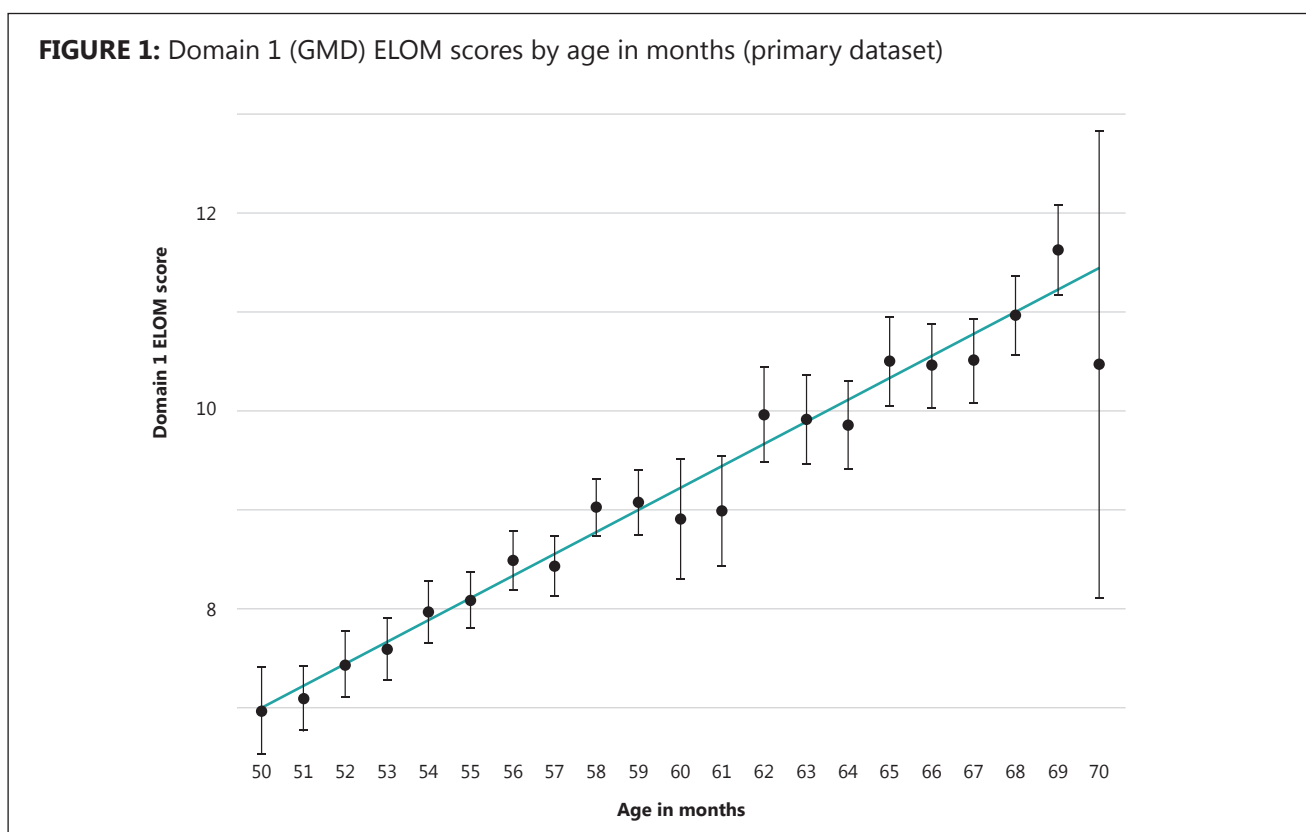
2.2 Initial exploratory data analysis

The master dataset was provided in one data frame, as collated by the DataDrive2030 team.

The primary collated data frame provided 12,753 observations in total. Excluding the programmatic data collected by organisations, and restricted only to the five sources discussed above, left the number of observations at 9,270.

This exploratory data analysis informed the variables that were controlled for in the data comparisons.

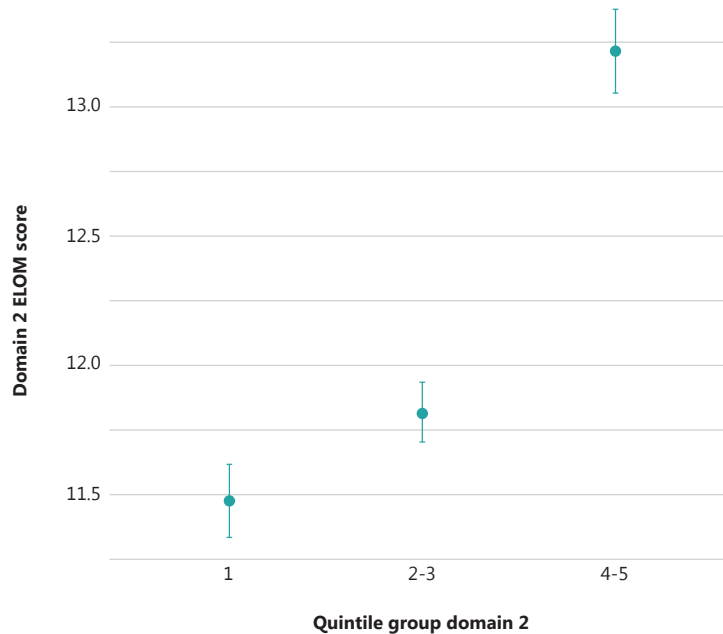
The ELOM domain scores were seen to be strongly linear on age. Figure 1 shows the relationship between child age and the domain 1 (GMD) ELOM scores, however, all ELOM domains showed similar linear relationships with age.



The quintile variable was grouped as follows: 1, 2-3, and 4-5. This is because the domains showed similar patterns in the ELOM scores for these three groups of quintiles. Generally, as seen in Figure 2 below, the ELOM scores for quintile 1 were the

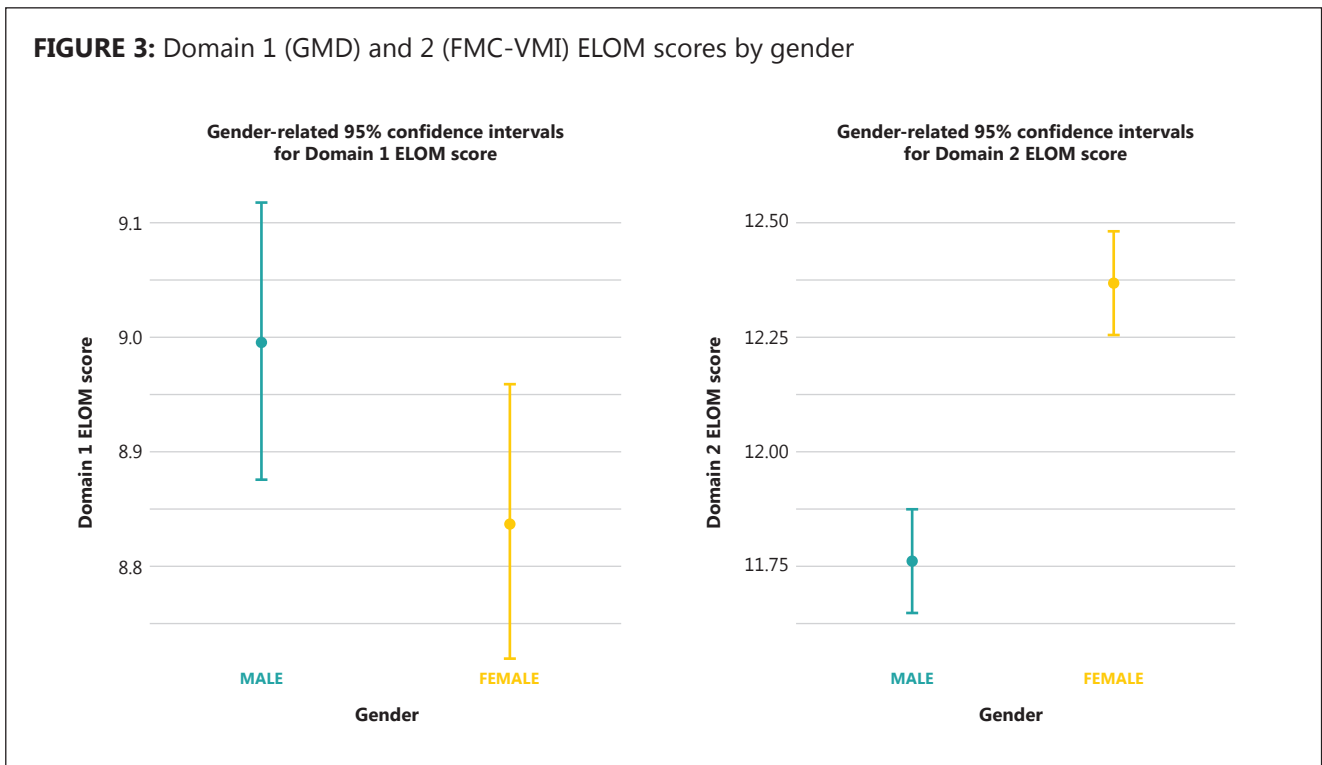
lowest, followed by scores for quintiles 2 and 3, with a large increase in scores for quintiles 4 and 5. Although the grouping was not quite significant for domain 1 (GMD), it was kept consistent for modelling and interpretation purposes.

FIGURE 2: Domain 2 (FMC-VMI) quintile variable mean-se graph



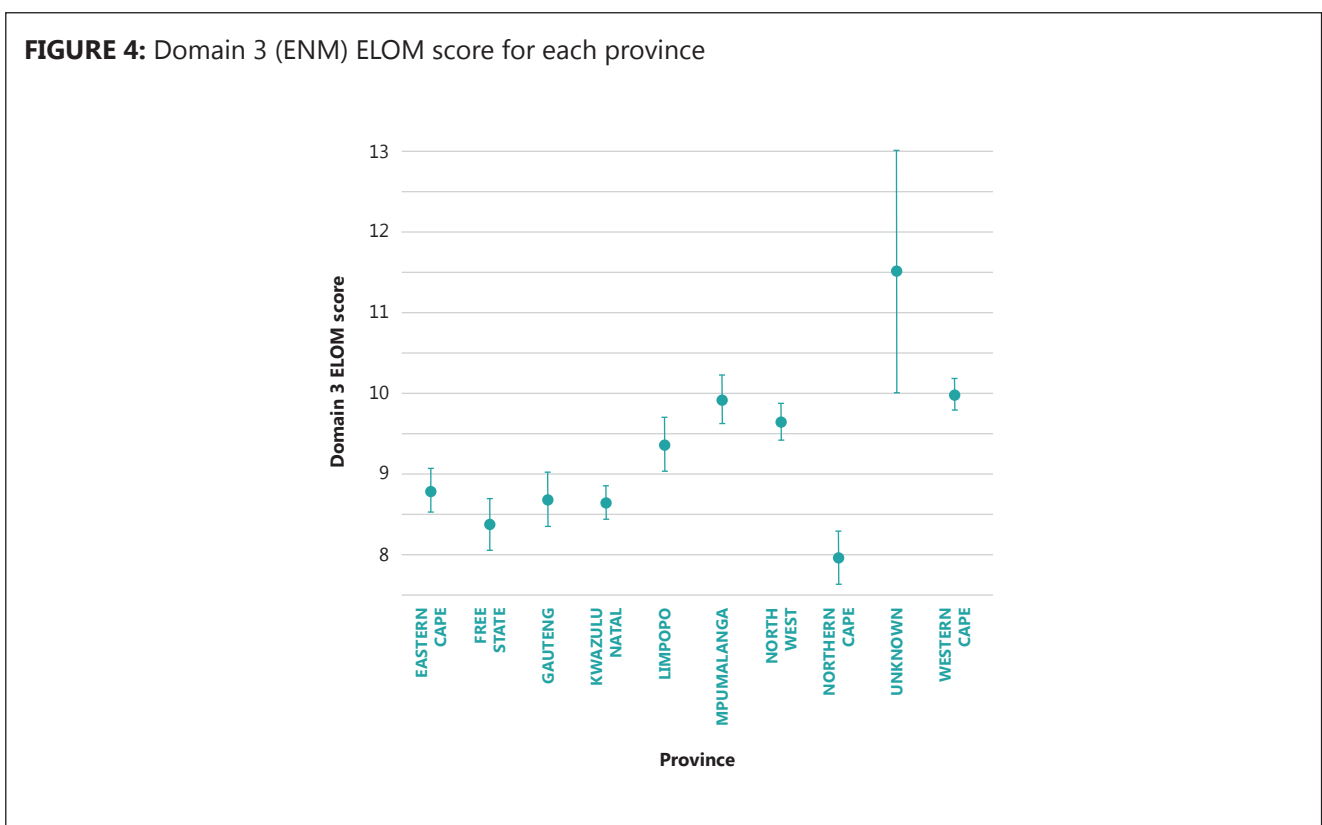
When plotting age against the ELOM scores for each domain, it was seen that females generally

had significantly better ELOM scores for all domains, except domain 1 (GMD).



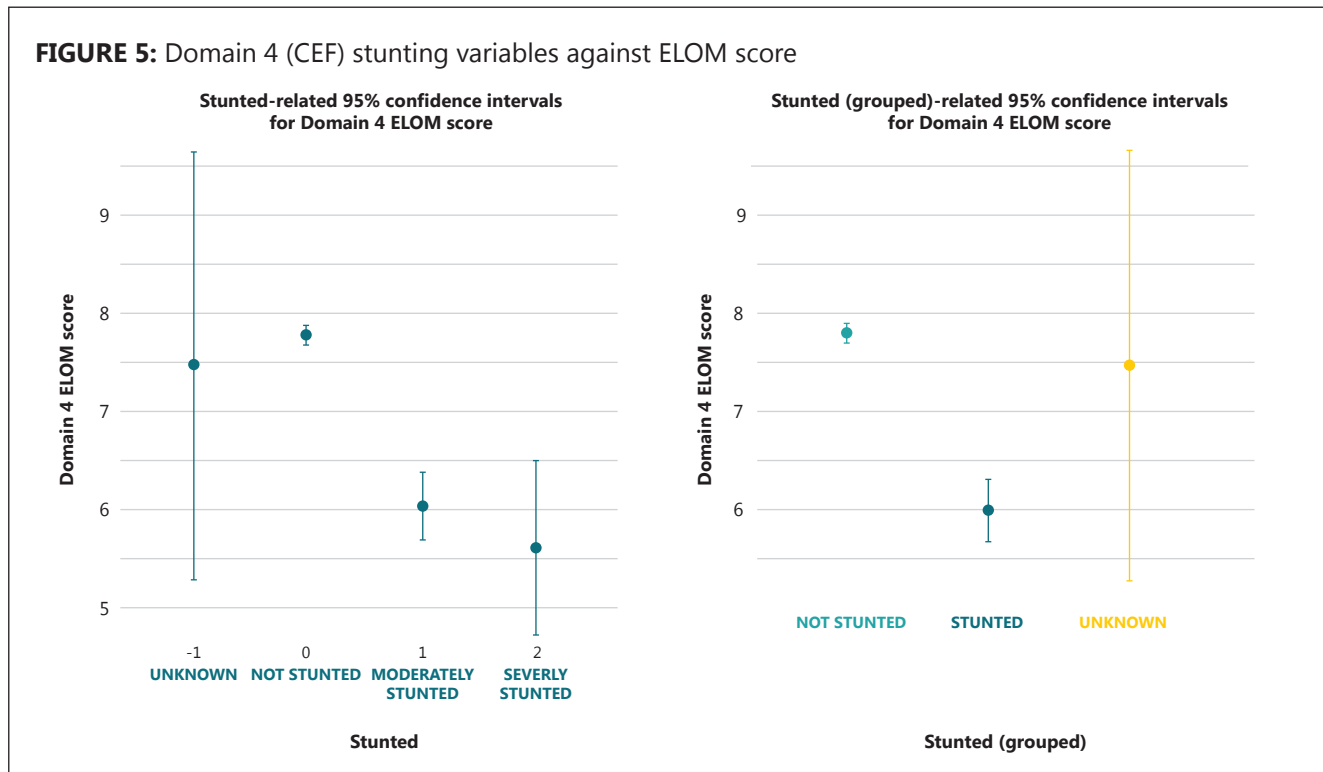
The province variable showed slightly different results for each domain, so it was left as the raw province and not grouped in any way. An example of each of the province's ELOM scores is below,

for domain 3 (ENM). The "Unknown" category is not available and missing data (either intentionally missing – did not intend on collecting the information or missing at random).



The stunting factor was grouped in terms of whether a child was stunted or not stunted. This is because the ELOM domain scores were similar between children who were categorised as either stunted or severely stunted. However, the differences between

not being stunted and being stunted / severely stunted were significant. Below is an example of the raw vs the grouped stunted variable for domain 4 (CEF).



2.3 Description of the data comparisons

The available data sources in the collated dataset facilitate three separate comparisons between the pre-Covid-19 and “post-Covid-19” time periods. These comparisons are as follows:

- 2016 Validation study vs 2021 Thrive by Five Index
- 2018 ELPO study vs 2021 Thrive by Five Index
- 2019 Grade R study vs 2022 Roots and Shoots study

Unless otherwise qualified, we use the term “post-Covid-19” in this report to cover any results from the 18th of March 2020 onwards, i.e. including the hard lockdown of 2020, the slight easing of 2021 and the removal of restrictions in 2022. This acknowledges the fact that the “post-Covid-19” terminology refers to a time period which may not in fact be “post” the pandemic; however, for consistency and in the absence of a more accurate but succinct description, this terminology is used throughout the report.

2.3.1 2016 Validation study vs 2021 Thrive by Five study

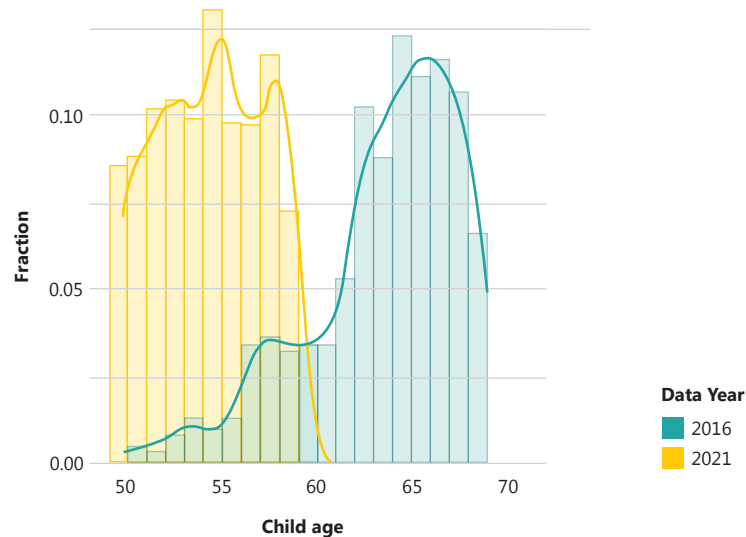
Perhaps the most notable difference between these two subsets relates to sample selection. Thrive by Five explicitly included only children who had exposure to ELPs (children were all enrolled in ELPs at the time of the study) whereas the 2016 Validation study sampled children from Grade R classes and included children who would have had prior ELP exposure and those without. In addition, the five-year time difference between 2016 and 2021 means that some of the observed differences between ELOM scores may be due to time-related factors other than Covid-19, notably, any general improvements or deterioration in the ECD space over time. The Covid-19 protocols would also have placed considerable constraints on the ECD centres and on the activities and interactions that otherwise would have occurred in the classroom.

The sample sizes for the 2016 and 2021 datasets were 1,243 and 5,222 respectively. Comparability was enhanced by restricting the Thrive by Five sample to KwaZulu-Natal, North West and Western

Cape, consistent with the 2016 Validation study. Other sources of comparability challenges are discussed below; it should be borne in mind that the approach taken to remove the effects of these factors from the ELOM scores before comparison,

as outlined in section 2.4, is designed to ensure comparability despite differences in distribution with respect to these key variables.

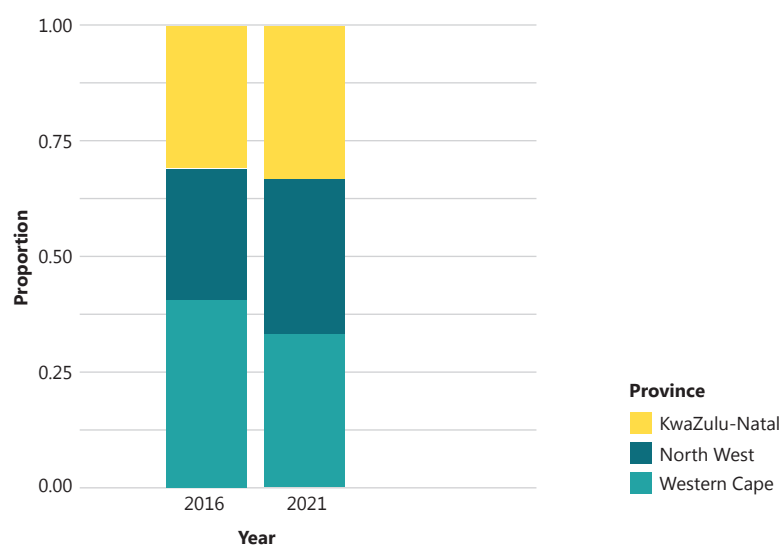
FIGURE 6: Age distribution in the 2016 Validation study vs the 2021 Thrive by Five study



The differences in children’s ages can be seen in the above graph. The 2016 study focused on children aged between 50 and 69 months, whereas the 2021 Thrive by Five study only included children aged between 50 and 59 months. This discrepancy

in age distribution reduces the comparability of the samples. However, the model does account for age effects, so the final comparison between the samples should be more accurate than a raw comparison of the ELOM scores.

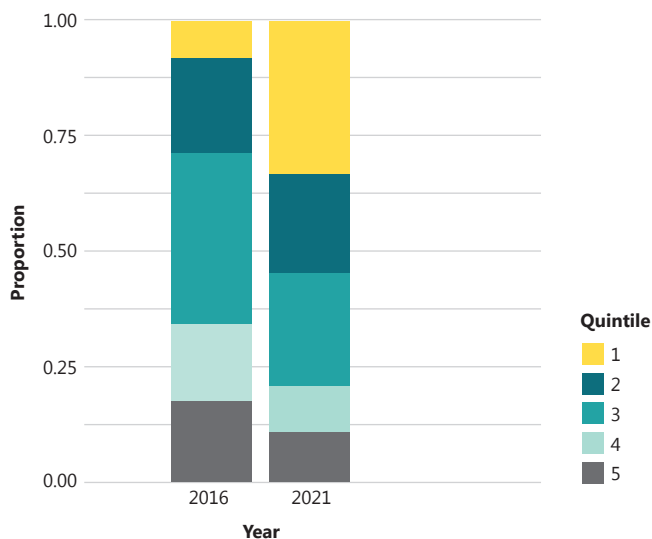
FIGURE 7: Province distribution in the 2016 Validation study vs the 2021 Thrive by Five study



The distribution of provinces in the comparison is relatively similar, with the 2016 sample having a slightly larger proportion of children in the Western

Cape and the 2021 sample having a slightly larger proportion of children in the North West and KwaZulu-Natal.

FIGURE 8: Quintile distribution in the 2016 Validation study vs the 2021 Thrive by Five study



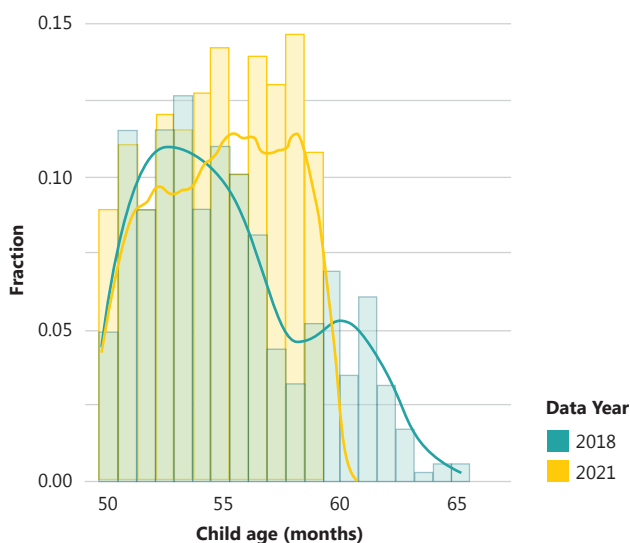
The quintile of the ELP was assigned using the Department of Basic Education (DBE) quintile of the nearest school.² As can be seen in the graph, there are more children in quintiles 3-5 in the 2016 sample, and more in quintile 1 in the 2021 sample. However, the application of the quintiles system to ELPs (as in the 2021 sample) is less accurate than the application to schools (2016 sample). This may account for some of the observed differences.

2.3.2 2018 ELPO study vs 2021 Thrive by Five study

The sample sizes for the 2018 and 2021 datasets

were 427 and 5,222 respectively. The Thrive by Five sample was limited to the Free State, KwaZulu-Natal, Mpumalanga and the Western Cape, for consistency with the ELPO study. Due to the low number of observations in the ELPO study, the results of this comparison may be less robust than other comparisons. Additionally, the ELPO study purposefully sampled ELPs that were of good quality, whereas the Thrive by Five Index randomly sampled the ELPs. The ELPO study was not a survey like the 2016 Validation study, 2019 Grade R study and 2021 Thrive by Five Index. The ELPO study was an evaluation of programme effects comparing play groups and centre-based models.

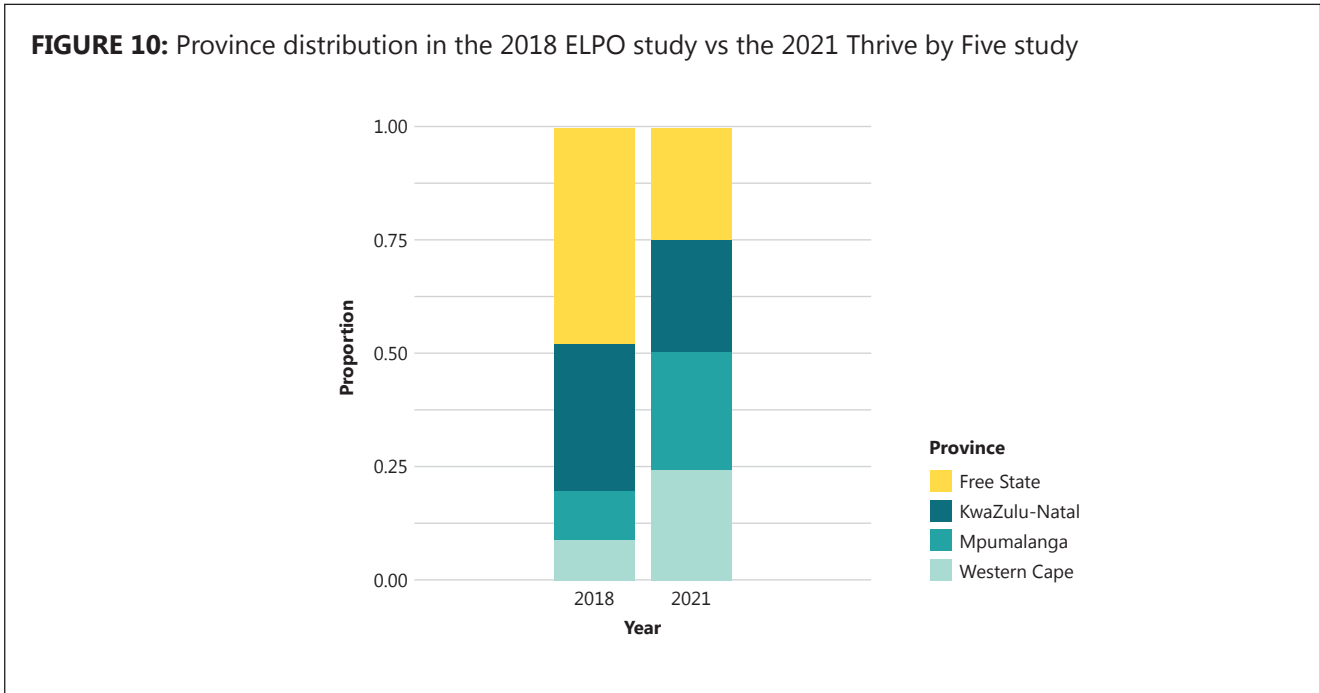
FIGURE 9: Age distribution in the 2018 ELPO study vs the 2021 Thrive by Five study



²Public schools are assigned to quintiles based on the demography of the area in which the school is situated, with the assumption that children from that area will likely attend the school. Quintiles 1-3 are no fee schools and receive a higher state subsidy than 4-5. See: <https://files.eric.ed.gov/fulltext/EJ1233473.pdf>

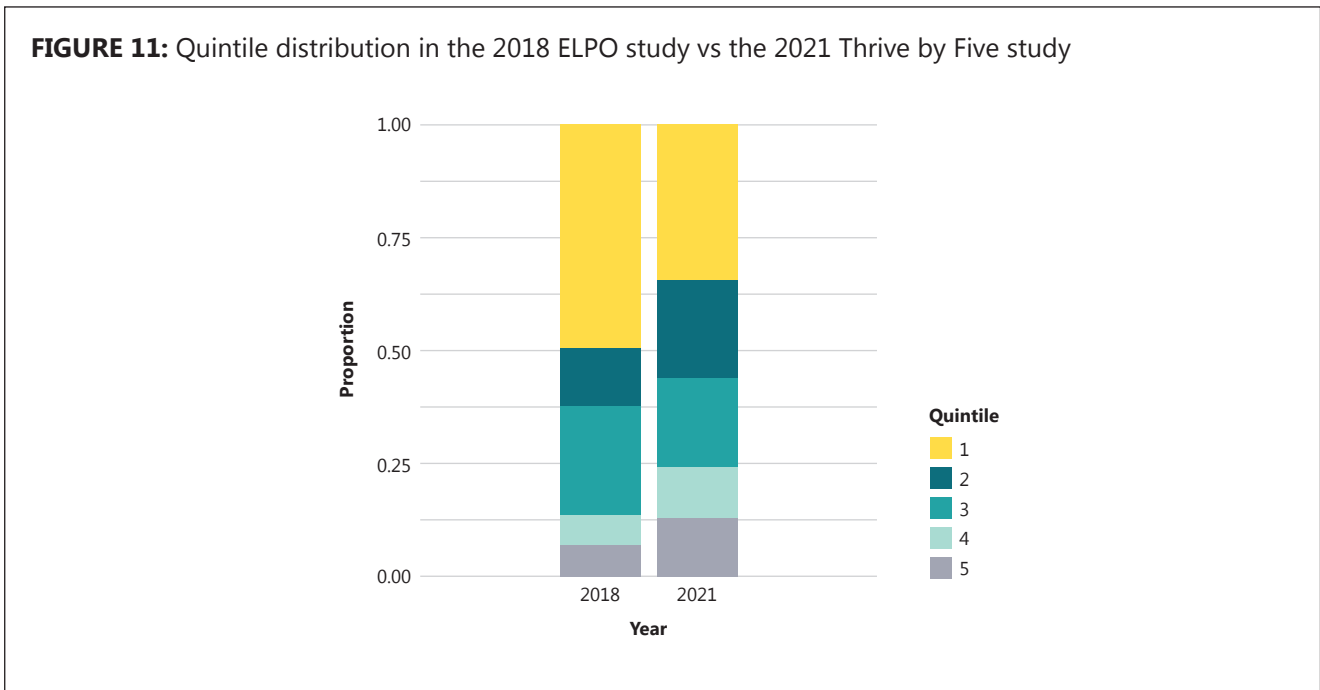
The overlap of ages in this comparison is much better than the previous comparison. Although there are some outliers, most of the children in

both the 2018 and 2021 studies are between 50 and 59 months old.



The province distribution is different in the 2018 and 2021 samples. There is quite a large proportion of children in the Free State and KwaZulu-Natal

in the 2018 sample, whereas there is an even split between the four provinces in the 2021 sample.



The quintile distribution between the two studies differs. There is a larger proportion of children in quintiles 1 and 3 in the 2018 sample, with a relatively high proportion of children in the lower quintiles, and a larger proportion in quintiles 2, 4 and 5 in the 2021 sample. This is a function

of the ELPO study's targeting of lower-quintile children. The correction made by the model for the effect of socio-economic quintile facilitates comparison between these samples, despite this stark difference.

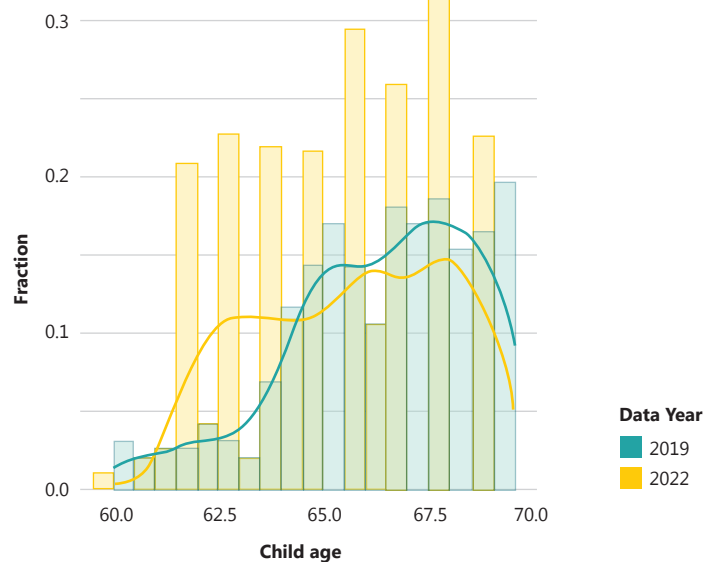
2.3.3 2019 Grade R study vs 2022 Roots and Shoots study

The primary weakness of this comparison is that 2022 followed the worst of the pandemic, so the comparison may still not be a true reflection of the influence of Covid-19 on the ELOM scores. However, it was retained on the ground that any cumulative negative effects on early learning due to Covid-19 would still be present to some extent in 2022. These are likely to have been significant – a combination of pandemic and lockdown restrictions on the ability to attend programmes

and the economic impacts on family resources, at a particularly sensitive developmental time (between 3 and 5 years old) would certainly have left a material residue beyond the 2020-21 period.

All the children in this comparison were sampled from Grade R classes at similar times of the school calendar. This comparison includes only the Western Cape province and children aged 60 months and older. This was to maintain comparability between the two datasets as far as possible. The sample size for the 2019 dataset was 1,792 and 586 for the 2022 dataset.

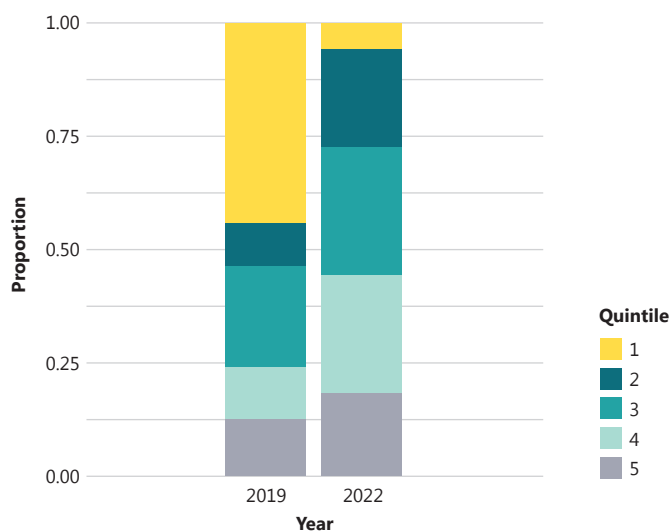
FIGURE 12: Age distribution in the 2019 Grade R study vs the 2022 Roots & Shoots study



The age distribution for the 2019 and 2022 studies are very similar between 60 and 69 months with a

larger proportion of children in the slightly older age groups.

FIGURE 13: Quintile distribution in the 2019 Grade R study vs the 2022 Roots & Shoots study



There are significantly more children in quintile 1 in the 2019 sample and more children in quintiles 2-5 in the 2022 sample. Almost 50% of the children in the 2022 sample are in quintiles 4-5, whereas these quintiles comprise only around 25% of the 2019 sample.

2.4 Model Methodology

2.4.1 Description of the model

This analysis used Generalised Additive Models (GAMs) in the modelling process. The rationale behind using GAMs is that they have the ability to handle complex, non-linear relationships and can also easily accommodate both numerical and categorical variables.

A training dataset (a subset of the data that the model learns from in order to make predictions) was chosen as a random selection of 75% of the 9,270 observations, with the remaining 25% used as a test set. This train-test split was stratified such that 75% of each data source was chosen in the training set. Model selection was performed based on Root Mean Squared Error (RMSE) on the test set, to ensure that the model's performance is evaluated on unseen data which provides a more realistic estimate of how well it generalises to new observations.

2.4.2 Variables used in the model

The following variables, which were explored in section 2.2, were used in the model:

1. Quintile (grouped into 1, 2-3, 4-5 across domains)
2. Age
3. Gender
4. Stunting (stunted_feature – whether child was stunted or not stunted)
5. Province

These variables were identified in previous research and described above as having a large influence on ELOM scores and so were modelled to control for their effects when comparing results before and after Covid-19 (Strugnell, Gomes, and Vale, 2023). Variables were kept consistent and did not change between domains or between the primary collated dataset and the TLI analysis. This was to ensure comparability between the model results and meaningful interpretation of the results.

2.4.3 Notes on the modelling process

The model was run on the training data which was a randomised subset of the primary collated dataset. The model predictions were then applied to both the collated dataset and the TLI data. A separate model was not run on the TLI data.

The model was run on each ELOM domain score separately and the best model was chosen for each domain based on the criteria of minimised RMSE. Once the best models were chosen, residuals were calculated between the model predictions and each ELOM domain score. These residuals, by definition, the ELOM score unaccounted for by the conditioning variables included in the model, then constitute excess ELOM scores which are used for comparison between subsets.

Statistical significance was assessed by means of t-tests conducted on the difference between means of the pre-and post-Covid-19 comparators' excess ELOM scores. The results of the t-tests are presented below.

2.5 Model results

For each of the comparisons, the pre-and post-Covid-19 excess ELOM scores were compared. The excess ELOM score, being part of the ELOM score that is not explained by the factors accounted for in the model, can be either positive or negative.

The R^2 and Adjusted R^2 results from the primary dataset model are displayed in Table 2 below. Although the model incorporating the factors as stated in Section 2.4.2 explains some of the variation in domain ELOM scores, the majority of the variation is still unexplained. This is unsurprising given the nature of the data: most variation will arise from individual, idiosyncratic factors.

TABLE 2: R^2 AND ADJ. R^2 RESULTS FROM THE MODEL (TRAINING SET DATA)

Domain	R^2	Adj. R^2
Gross Motor Development	0.113	0.112
Fine Motor Coordination and Visual Motor Integration	0.246	0.244
Emergent Numeracy and Mathematics	0.108	0.106
Cognitive Executive Functioning	0.151	0.145
Emergent Literacy and Language (n=6,711)	0.080	0.078

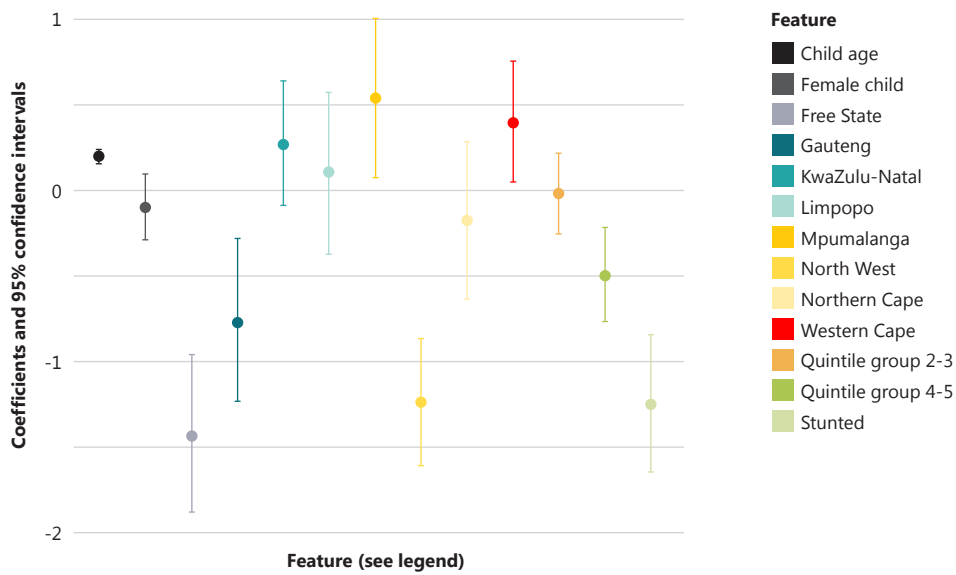
2.5.1 Domain 1: Gross Motor Development

The domain 1 (GMD) coefficients can be seen in Figure 14. Some variables that have negative coefficients are being in the Free State, Gauteng or North West provinces, going to a school that is categorised as quintiles 4-5 (relative to quintile 1) and being stunted. Variables with positive coefficients and thus positive effects on the gross motor ELOM scores are age and being in the Mpumalanga or Western Cape provinces.

Recent studies have shown that it is not surprising that children in poorer quintiles perform better in

GMD than those in the higher quintiles. A study using the Test of Gross Motor Development-2 (TGMD-2) showed that children in low-income contexts spend more time being active, therefore, it makes sense that they would naturally develop gross motor skills (Simone A., Tomaz et al. 2020). In another study also using the TGMD-2, it was explicitly found that children in lower income contexts had higher gross motor skill proficiency (Simone A., Tomaz et al., 2019). It seems that this increased time spent in free play and moving around may play a role in the development of their gross motor skills.

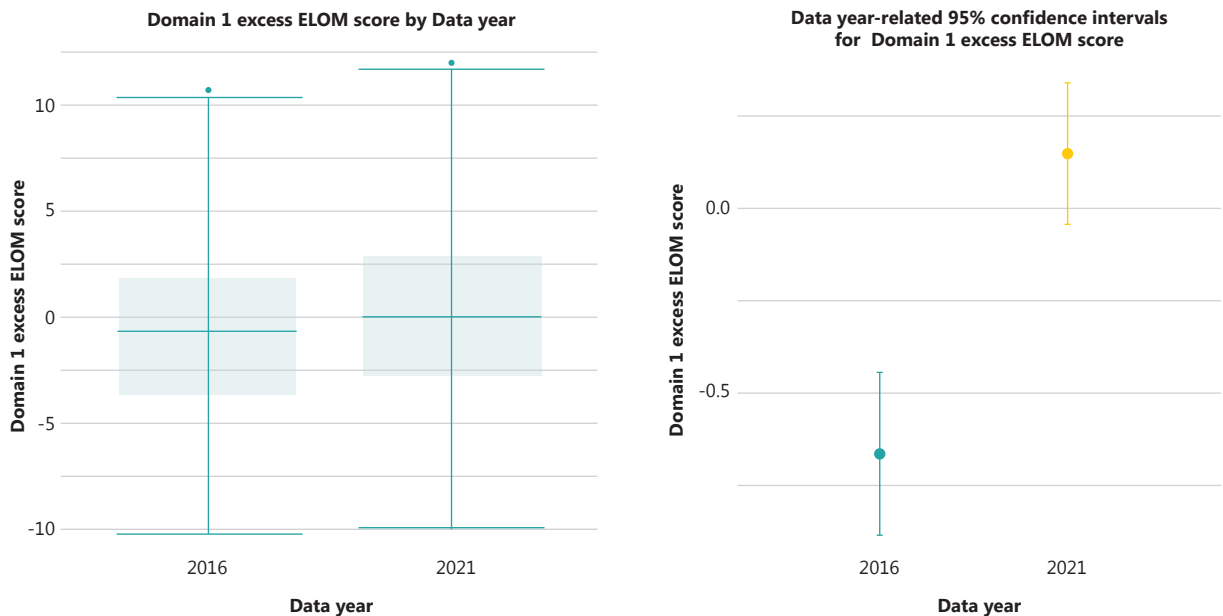
FIGURE 14: Domain 1 (GMD) model coefficients (all data)



The excess ELOM scores (those not explained by the factors in the above graph), are seen in the below mean-standard error (se) graph for the

2016/2021 comparison as being higher in the post-Covid-19 (2021) study.

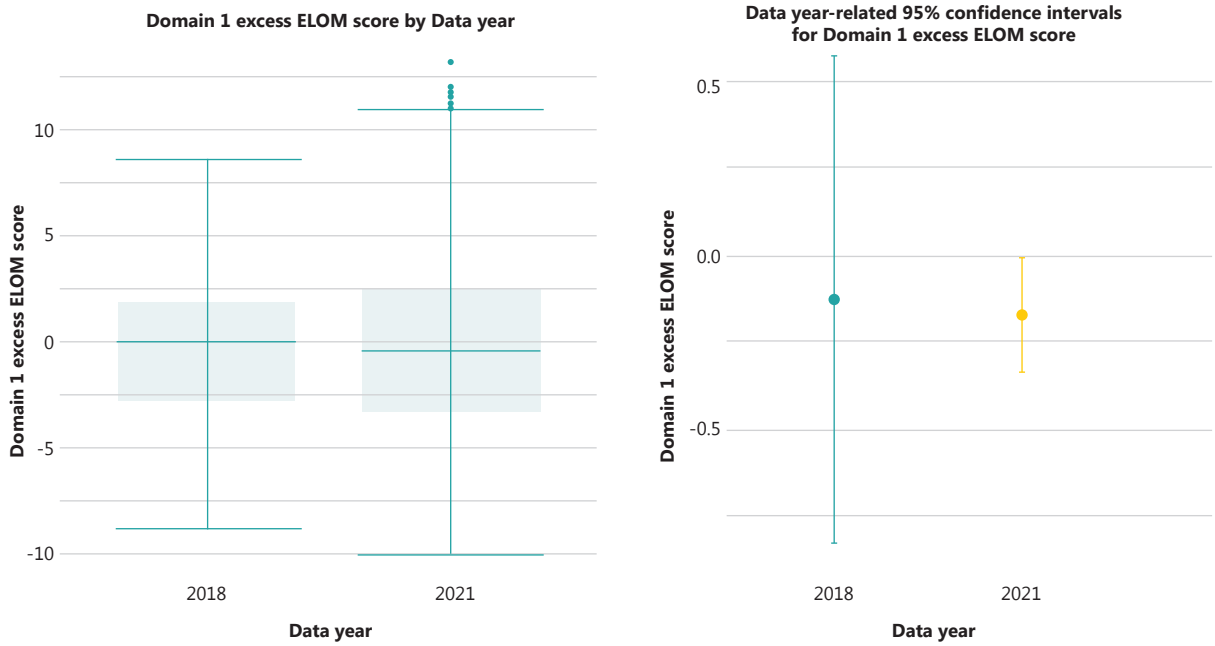
FIGURE 15: 2016 Validation study vs 2021 Thrive by Five excess domain 1 (GMD) scores and mean-se graphs



The t-test p-value on the difference between the means of the above two comparator studies was <0.001. The domain 1 (GMD) excess ELOM scores are significantly higher post-Covid-19 in this comparison.

By contrast, there is no significant difference in the means between the ELPO (Baseline) and Thrive by Five studies.

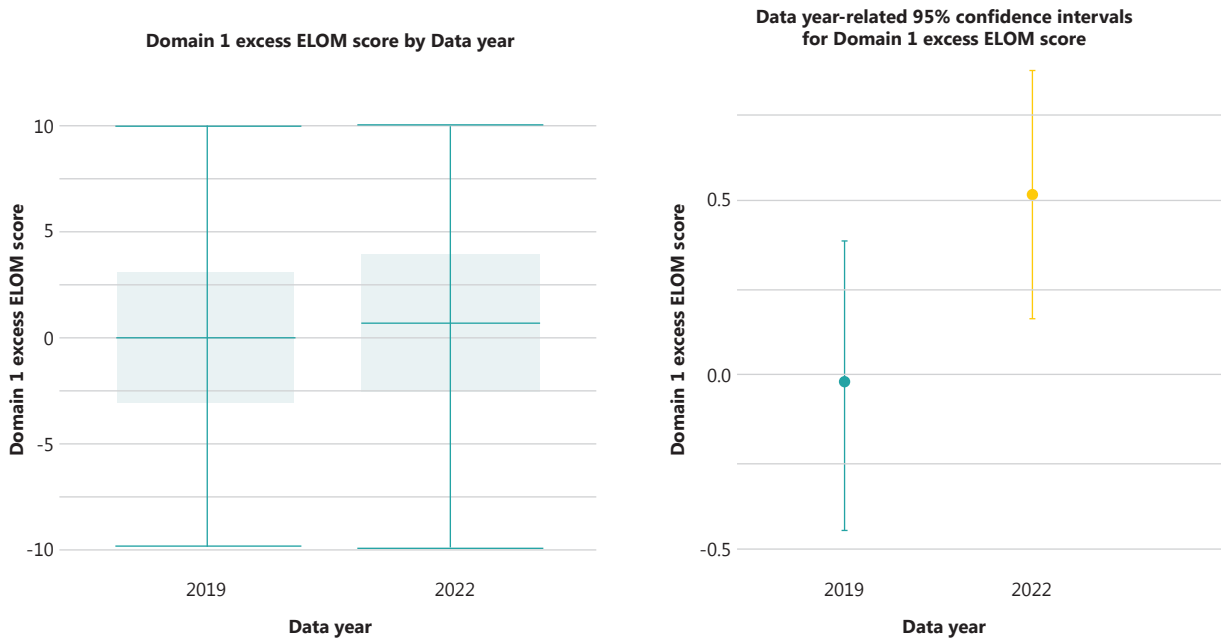
FIGURE 16: 2018 ELPO study vs 2021 Thrive by Five excess domain 1 (GMD) scores and mean-se graphs



The 2019/2022 Grade R comparison also had significant results in the t-test on the difference between the means of the two studies.

The p-value of the test was 0.037, i.e. $p < 0.05$. The mean ELOM score was higher post Covid-19.

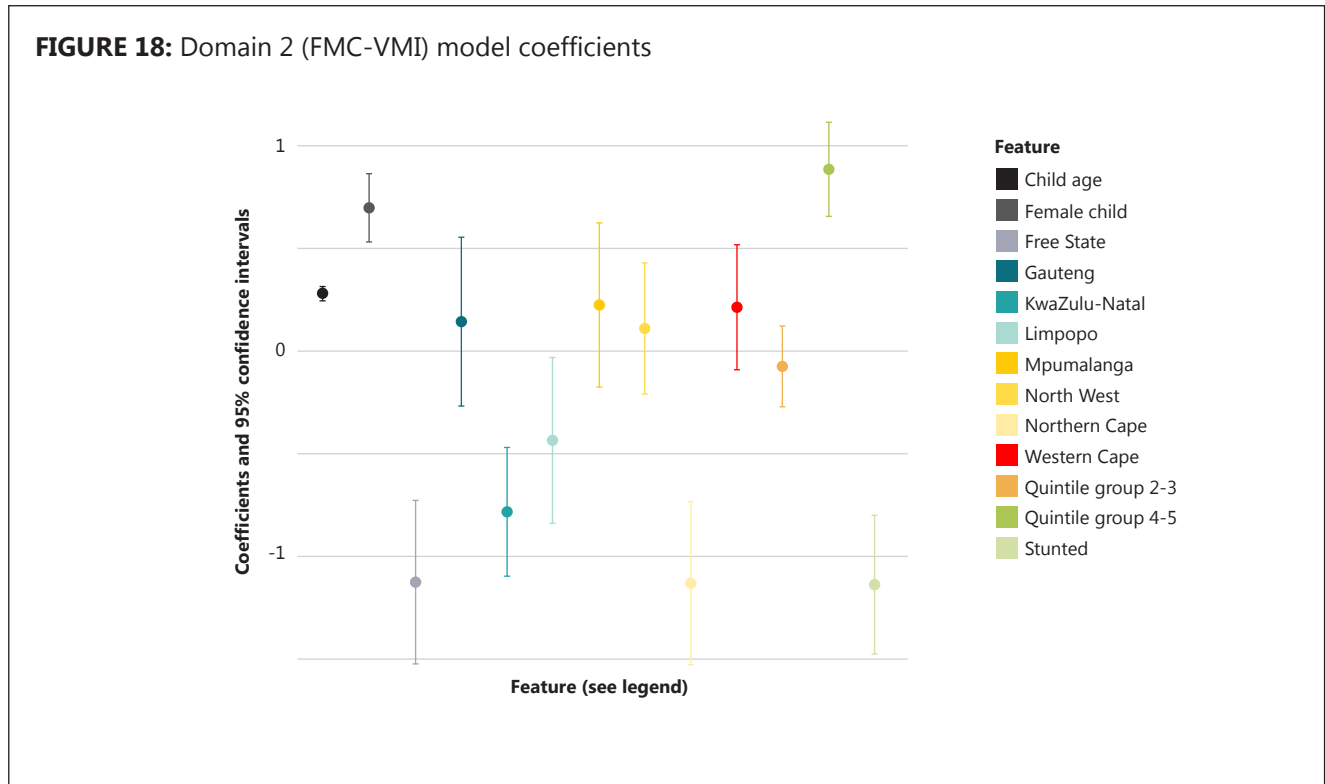
FIGURE 17: 2019 Grade R study vs 2022 Roots & Shoots excess domain 1 (GMD) scores and mean-se graphs



2.5.2 Domain 2: Fine Motor Coordination and Visual Motor Integration (FMC-VMI)

Domain 2 (FMC-VMI) ELOM scores measured children's fine motor coordination and visual-motor integration. Variables that were found to have negative effects on the domain 2 (FMC-VMI) ELOM

scores were being in the Free State, KwaZulu-Natal, Limpopo and Northern Cape provinces and being stunted. Variables with positive coefficients were the child's age, being female and being in quintiles 4-5 relative to quintile 1.



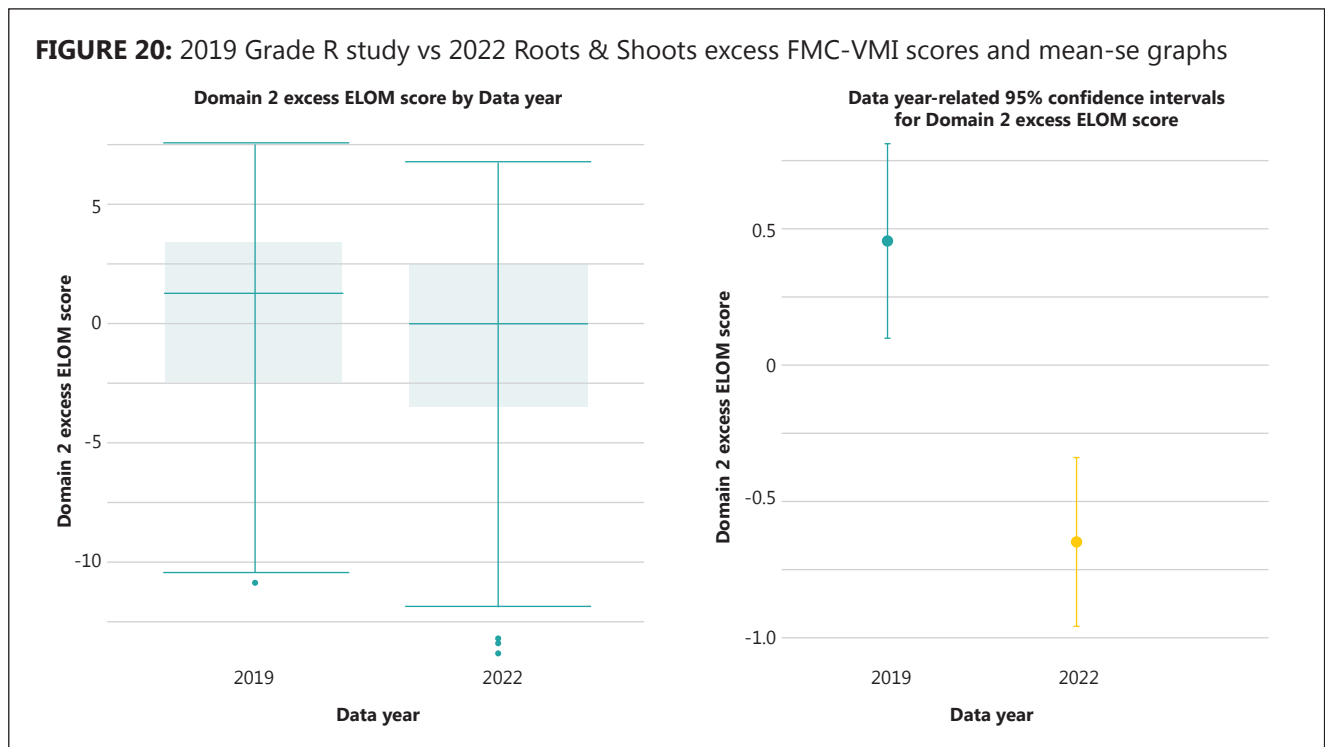
The 2016/2021 comparison showed a significant difference between the means of the excess ELOM scores in the two years. The t-test had a p-value

<0.001. The ELOM scores were higher in the post Covid-19 year (2021).



The opposite result was found in the 2019/2022 comparison. The t-test p-value was <0.001.

The mean excess fine motor FMC-VMI score was found to be lower in the post Covid-19 period (2022).

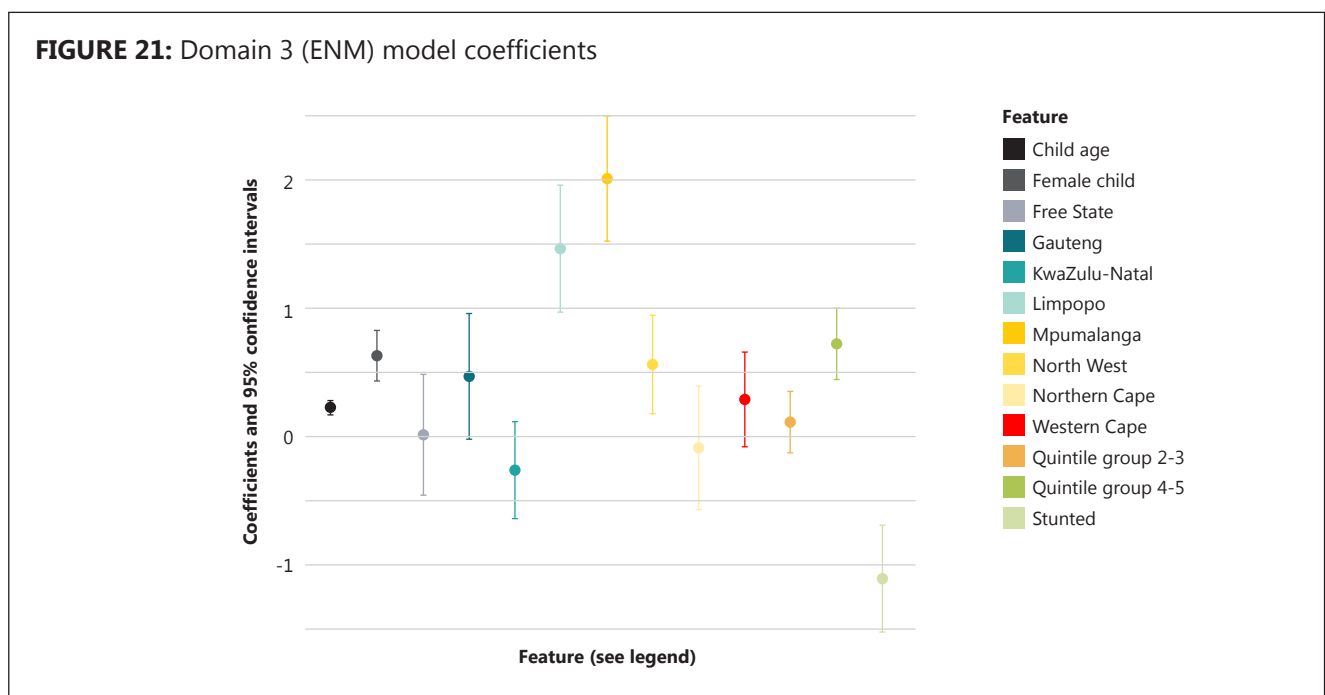


The 2018/2021(ELPO vs Index) comparison showed no significant difference in the means of the excess FMC-VMI scores between the two periods.

2.5.3 Domain 3: Emergent Numeracy and Mathematics

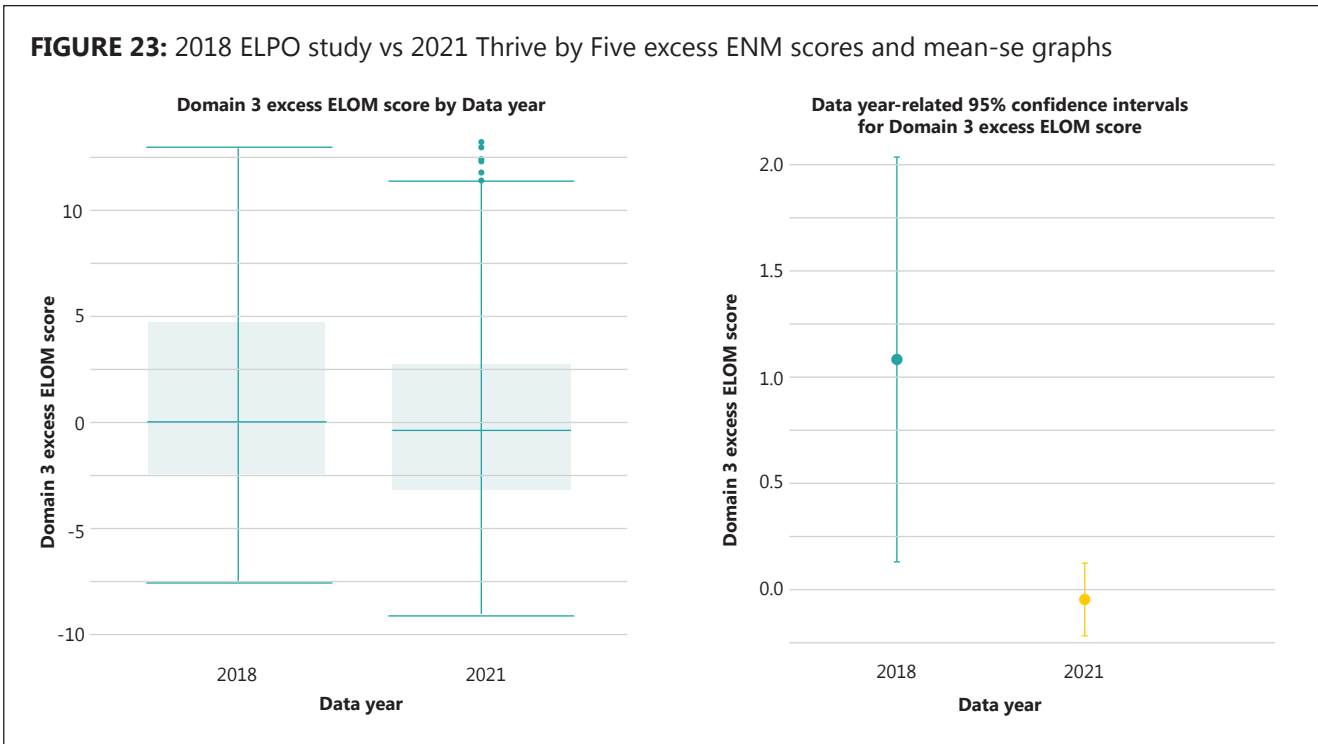
Domain 3 (ENM) ELOM scores reflect the child's

performance in numeracy and mathematics. The variable found to negatively affect this domain's scores was being stunted. Variables that positively affected this domain's ELOM scores were the child's age; being female; being in the Limpopo, Mpumalanga and North West provinces and being in quintiles 4-5 relative to quintile 1.



This domain also had conflicting results regarding whether the ELOM scores were higher or lower in the post Covid-19 period. For the 2016/2021 comparison, the results showed that the excess ELOM scores were higher in the post Covid-19

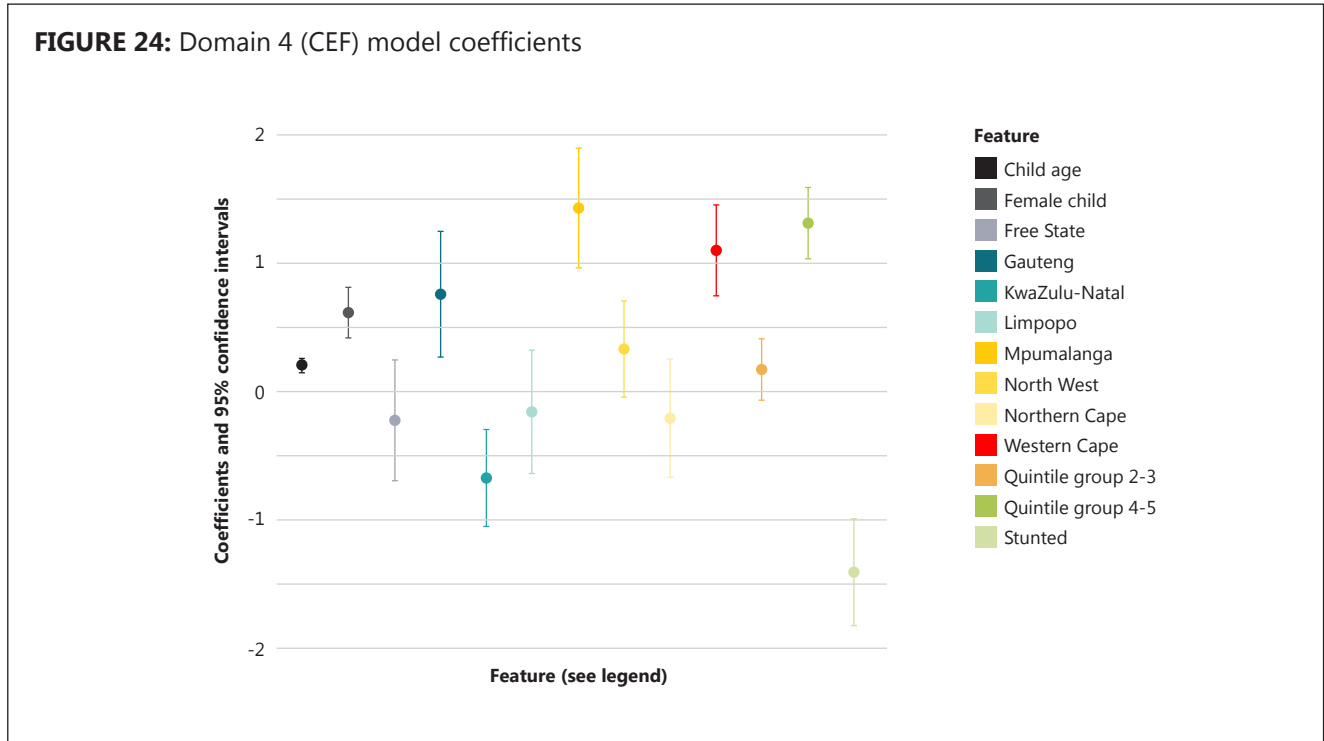
period ($p < 0.001$), however in the 2018/2021 comparison, the results showed that the scores were lower in the post Covid-19 period ($p = 0.018$). The 2019/2022 comparison showed no significant difference in the means between the two periods.



2.5.4 Domain 4: Cognitive and Executive Functioning

For domain 4, the domain measuring cognitive and executive functioning (CEF), there were two variables that were found to negatively affect the

scores-being in the KwaZulu-Natal province and being stunted. Variables that had positive effects on the domain 4 (CEF) ELOM scores were the child's age; being female; being in the Gauteng, Mpumalanga and Western Cape provinces and being in quintiles 4-5 relative to quintile 1.

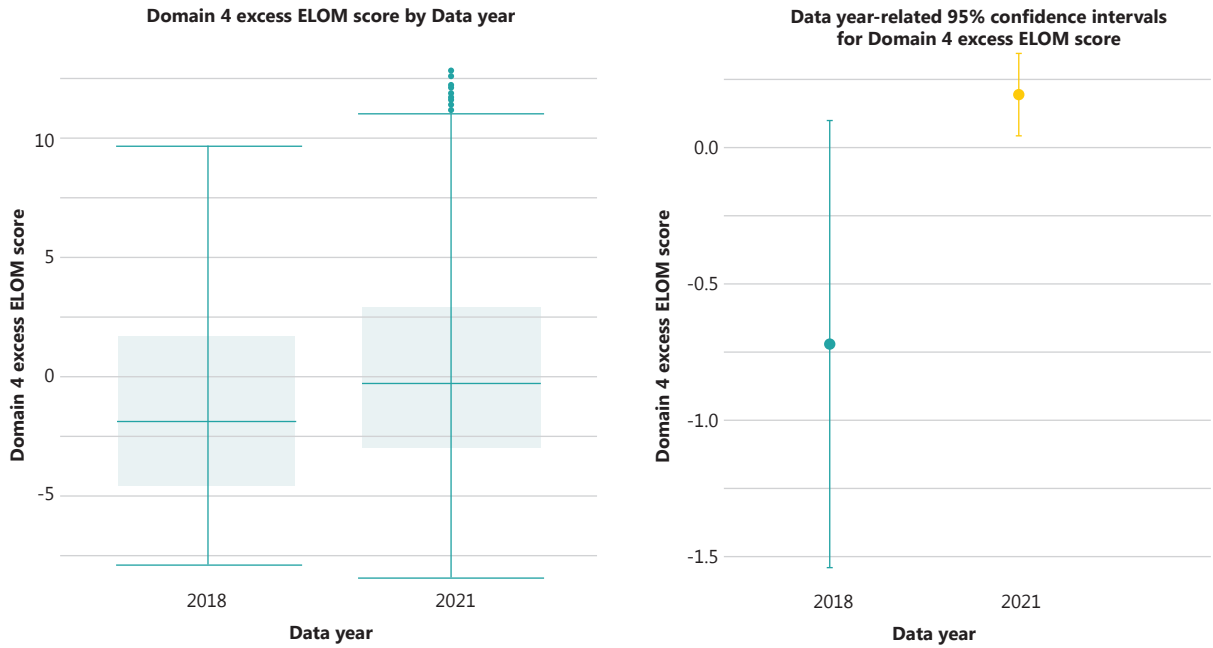


This domain consistently showed that the excess ELOM scores were higher in the post Covid-19 periods. In the 2016/2021 comparison, the t-test p-value was $p < 0.001$. For the 2018/2021 comparison, the p-value was $p = 0.031$, with

scores being higher post Covid-19. The 2019/2022 comparison showed no significant difference in the means of the excess ELOM scores in the two periods.



FIGURE 26: 2018 ELPO study vs 2021 Thrive by Five excess CEF scores and mean-se graphs

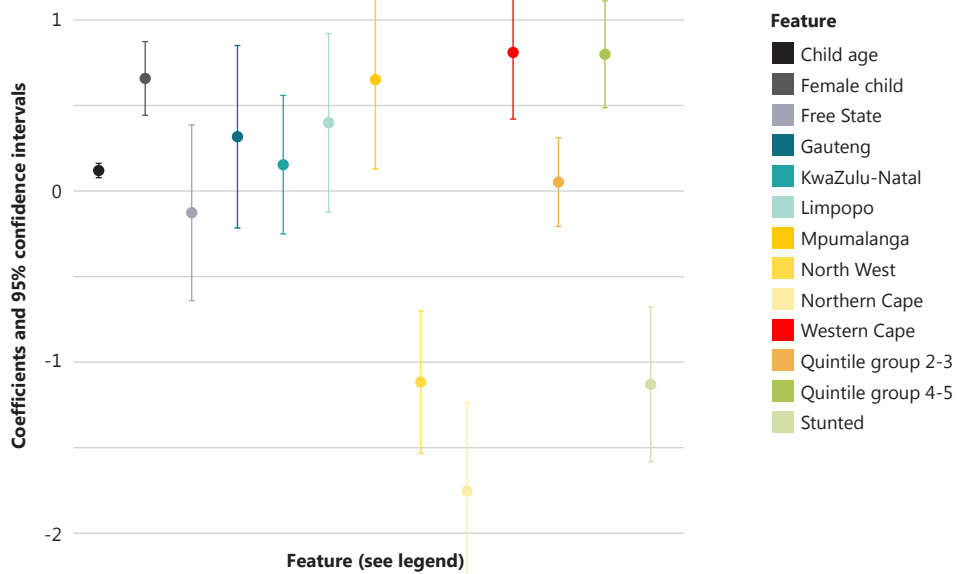


2.5.5 Domain 5: Emergent Literacy and Language

The literacy and language domain (domain 5) showed three variables as having negative effects on the literacy ELOM scores. These variables were being in the North West and Northern Cape

provinces and being stunted. The variables that were found to have positive effects on the ELOM scores were the child's age; being female; being in the Mpumalanga and Western Cape provinces and being in quintiles 4-5 relative to quintile 1.

FIGURE 27: Domain 5 (ELL) model coefficients



Domain 5 was the only domain in which all three comparisons had significant p-values in the t-tests for the differences between the means in the ELOM scores. Additionally, all the comparisons showed that the ELOM scores were higher in the post

Covid-19 periods. For the 2016/2021 comparison, the p-value was $p < 0.001$. In the 2018/2021 comparison, the p-value was $p = 0.024$. Finally, in the 2019/2022 comparison, the p-value was $p = 0.004$.

FIGURE 28: 2016 Validation study vs 2021 Thrive by Five excess ELL scores and mean-se graphs

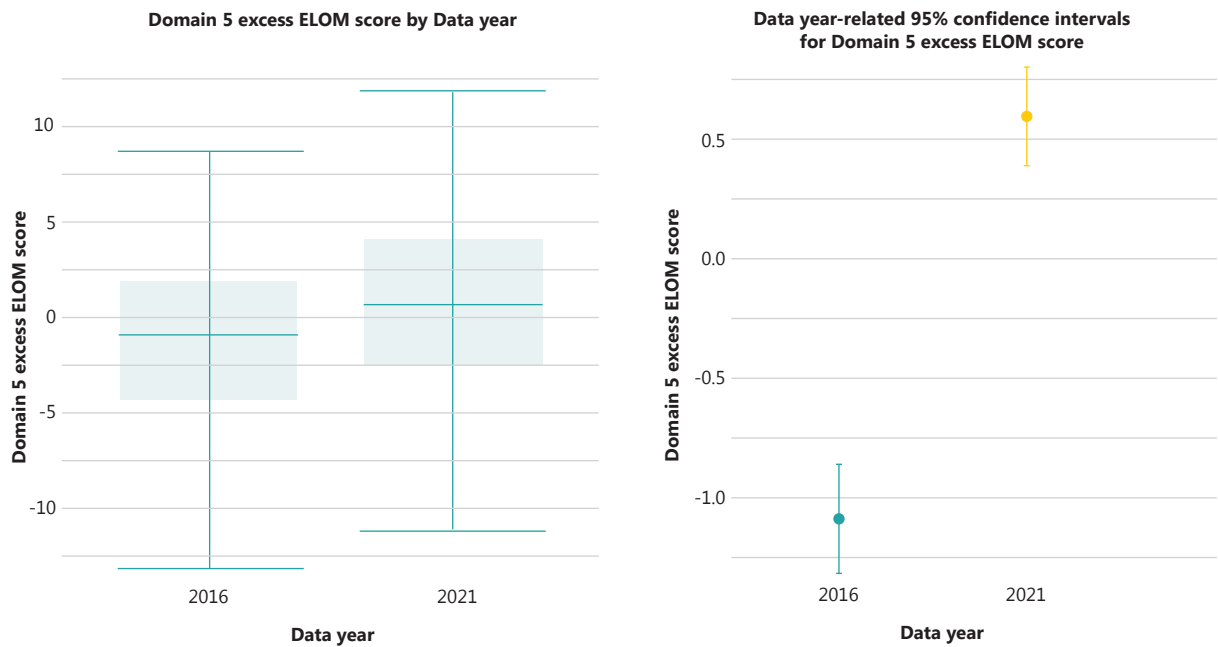
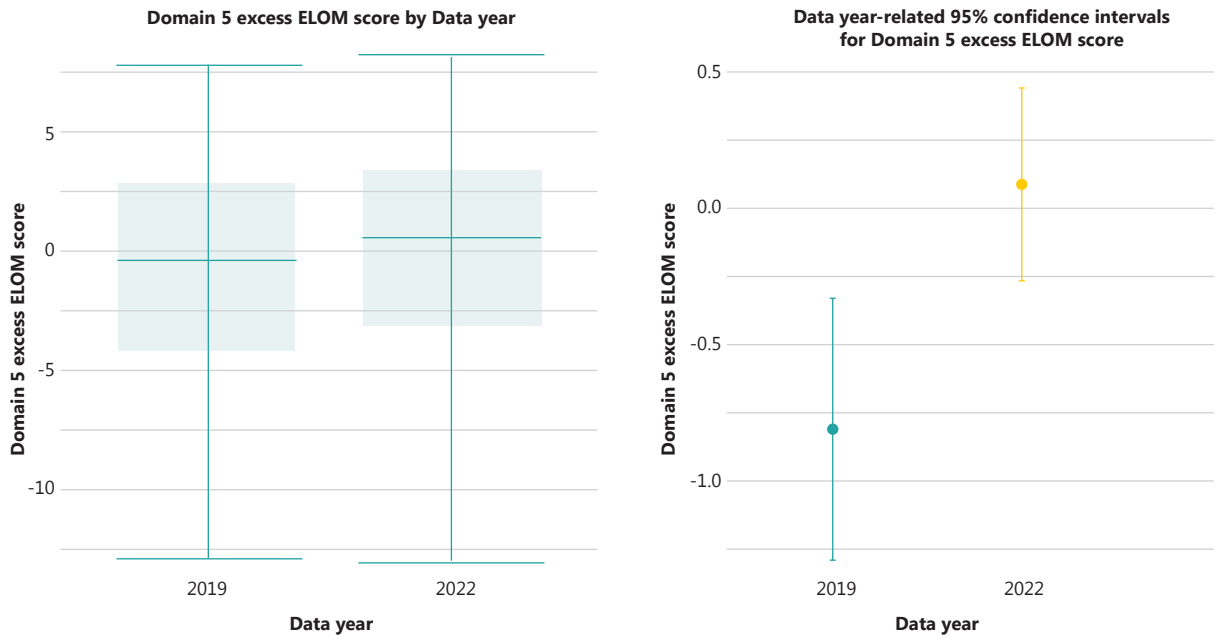


FIGURE 29: 2018 ELPO study vs 2021 Thrive by Five excess ELL scores and mean-se graphs



FIGURE 30: 2019 Grade R study vs 2022 Roots & Shoots excess ELL scores and mean-se graphs



To summarise the findings of the model for the three master dataset comparisons, it was found, for the most part that being in the provinces of Mpumalanga with the exception of domain 2 (FMC-VMI) and the Western Cape with exception of domain 2 (FMC-VMI) and domain 3 (ENM); as well as being in quintiles 4-5 relative to quintile 1 with the exception of domain 1 (GMD); being female

and being older resulted in higher ELOM scores. Being in the Free State, KwaZulu-Natal, Northern Cape and North West provinces (each of which have negative coefficients in 2 domains) and being stunted generally had negative effects on the ELOM scores. Comparisons between excess ELOM scores showed mixed results.

TABLE 3: SUMMARY TABLE OF PRIMARY DATASET RESULTS

Comparison	Significant domains	Comments
2016 Validation study vs 2021 Thrive by Five Index	All domains: higher in 2021	Rather than being indicative of a “Covid-19 boost”, the most likely interpretation of these results, in our opinion, is that selection effects and general improvements in the sector are likely to have more than offset the expected negative influence of the pandemic. Selection effects stem from the fact that those selected for the Thrive by Five sample have had some prior exposure to ELPs. However, fewer (32%-61% of children in KwaZulu-Natal, North West and Western Cape) of those in the 2016 study would have had such prior exposure (Statistics South Africa, 2016) so this may be part of the explanation. The data does not, of course, support any deeper investigation of contributing themes.
2018 ELPO vs 2021 Thrive by Five Index	Domain 3 (ENM): higher in 2018 Domain 4 (CEF): higher in 2021 Domain 5 (ELL): higher in 2021	Despite the small size of the comparable ELPO study, its comparison with Thrive by Five yielded significant results in domains 3, 4 and 5, with lower excess scores post Covid-19 only in domain 3 (ENM). The scores in domains 4 (CEF) and 5 (ELL) were higher in 2021.
2019 vs 2022 Grade R studies	Domain 1 (GMD): higher in 2022 Domain 2 (FMC-VMI): higher in 2019 Domain 5 (ELL): higher in 2022	The comparison of the 2019 and 2022 studies showed significant results in domains 1, 2 and 5, with lower excess scores post Covid-19 in domain 2 (FMC-VMI).

The latter comparisons produce mixed signals at best and little can be said about the Covid-19 influence on school preparedness from these analysis. This is unsurprising given the residual uncontrollable heterogeneity between datasets

and emphasises the importance for future studies of building up multiple generations of comparable data, e.g. through repetitions of the Thrive by Five data collection.

THE LEARNING INITIATIVE ANALYSIS

The Learning Initiative (TLI) data was provided in a separate data frame from the other data. The TLI data had 1,037 observations in total. This analysis is separate from the master collated dataset analysis as it is a single source of data spanning the entire pre and post Covid-19 period and is thus suitable

for a separate, standalone analysis comparing the ELOM scores resulting from this study only. It has, in principle, fewer sources of heterogeneity and thus presents perhaps our best opportunity for meaningful insights into the influence of the pandemic.

3.1 Notes on the data source and programme structure

INFO BOX 6: INFORMATION ON THE LEARNING INITIATIVE DATA

The Learning Initiative typically targets children who are at risk of developmental delays. As a result, it should be stressed that this sample is therefore not representative of the population. TLI uses the ELOM 4&5 Targeting tool and clinical screening, which is carried out by registered Occupational Therapists (OTs) and Speech Therapists to select children into the programme. It was a requirement that these professionals were registered with the Health Professionals' Council of South Africa (HPCSA). Another programme pre-requisite was that the preschools in which the programmes were run needed to be registered and have a minimum of 15 children in the 4 to 5 year age group in quintiles 2-3. The schools needed to have space where the health professionals could work and the school had to want to be part of the programme. All children at the selected ELPs took part in the programme. Specifically, the children who were identified to have developmental delays were enrolled in groups, and the other children were sent quarterly stimulation packs and benefitted from teacher training (TLI, 2023, personal communication, 21 July 2023).

The OTs and speech therapists ran the 60-session Blocks4Growth curriculum at the pre-schools and would teach the groups of children twice a week for 45-minute sessions. The groups would range from 4-5 children to 9-10 children. Groups could be structured according to children's abilities, i.e. children could be grouped according to their stronger or weaker abilities, or the groups could be formed with children of varying abilities.

The programme focuses on holistic child development, including focusing on specific skills for children who have learning disabilities. In the initial years of the programme, the gross motor and numeracy ELOM scores were quite low. This caused the programme administrators to focus more attention on these areas of development. The initial focus of the programme was literacy.

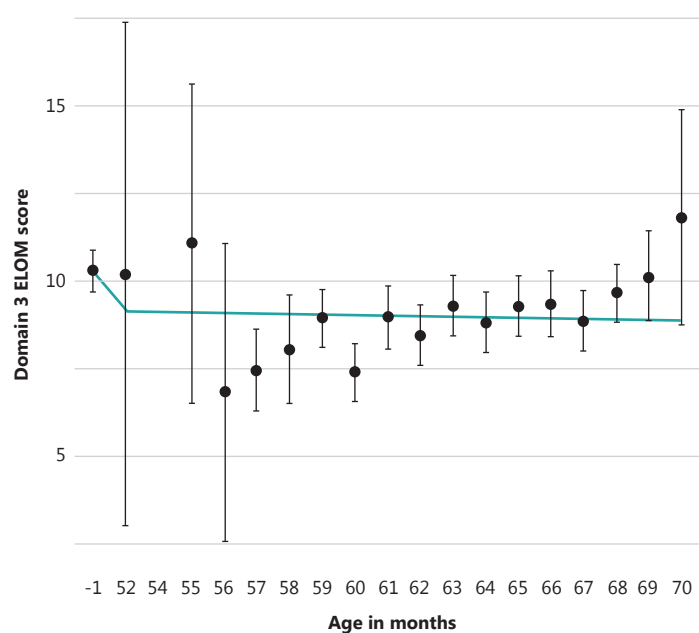
During the Covid-19 period, the programme sent out stimulation packs to the parents to help them engage their children at home. During this time, the full 60 sessions of the programme were unable to be run, thus the dosage varied over the years. Materials such as puzzles, playdough, balls, reading books, DIY recipes and lists of developmental milestones were sent to the children's homes. Additionally, the therapists met with teachers weekly or bi-weekly for mentoring and coaching to ensure the transference of skills.

The programme was primarily administered in Afrikaans and isiXhosa areas, and was offered in the children's home language. The sessions were therefore offered in English, Afrikaans or isiXhosa, depending on the child's home language.

The programme was initially limited to sites in Philippi and Khayelitsha but has since moved to over 83 schools in the Western Cape. The sample of children in the study is reflective of the expansion of the intervention to additional areas. However, the sampling method has not changed.

3.2 Initial exploratory data analysis

FIGURE 31: Domain 3 (ENM) ELOM scores by age in months (TLI dataset)



Domain ELOM scores by age had a strong positive linear relationship in the primary dataset, however, in the TLI data, age did not play as much of a role and had mostly no relationships with the ELOM scores (see an example for domain 3 (ENM) in Figure 31) which is contradictory to expectations. Additionally, age data was missing for 193 observations in the TLI data. These missing observations were all in the 2019 data year. There were slight reductions in average age by year: 2020 had an average age of 63.9 months, 2021 had an average age of 63.5 months and 2022 had an average age of 63.2 months.

The Learning Initiative specifically targets children at risk of failing to meet required standards and hence in need of additional early learning support. It is likely that this selection philosophy is the primary reason for the lack of variation by age. In other words, the learning difficulties the children in this sample exhibit may outweigh any improvements in scores due to age. Additionally, stunting data was not collected prior to 2022. As a result, excess ELOM scores were calculated by considering only the contributions of the other three conditioning variables (province, quintile, and gender).

The TLI data also had missing quintiles for some observations – the only quintiles seen in the data were 2 and 3. Consequently, unknowns were

assumed to also be 2-3, an assumption which was confirmed by TLI.

All observations were in the Western Cape.

Plotting the ELOM scores against gender showed similar results for TLI as that of the primary dataset. Generally, females had higher ELOM scores than males, except for domain 1 (GMD) where the relationship was reversed.

For this comparison, the stunting variable was ignored by setting the stunting observations to “Unknown”. This was due to only having observations in 2022 for the TLI data. Therefore, this variable could not be used in the analysis over the full time period.

3.3 Model methodology

The model methodology and variables used in the TLI analysis are the same as that used for the master collated dataset. The model was trained on the master dataset and then applied to the TLI dataset to get model predictions and thus excess ELOM scores for this data (excluding the age variable, as discussed above).

3.4 Model results

Multiple comparisons are made for each domain:

Comparison	Rationale
2019 vs 2020-2022	Pre Covid-19 vs in/post Covid-19
2019 vs 2020-2021	Pre Covid-19 vs in Covid-19
2020 vs 2019, 2021-2022	Worst Covid-19 year vs the rest
2020 vs 2021-2022	Worst Covid-19 year vs later years
2020-2021 vs 2019, 2022	In Covid-19 years vs pre- and post-Covid-19
2020 vs 2021	In Covid-19 comparison

Each of the domain results below outlines the t-test p-values of these comparisons.

3.4.1 Domain 1: Gross Motor Development

The domain 1 (GMD) ELOM scores were found to be higher in the post Covid-19 period (2020-

2022). The comparisons and p-values for the t-tests measuring the significance of the differences in the means between the excess ELOM scores are found in Table 4.

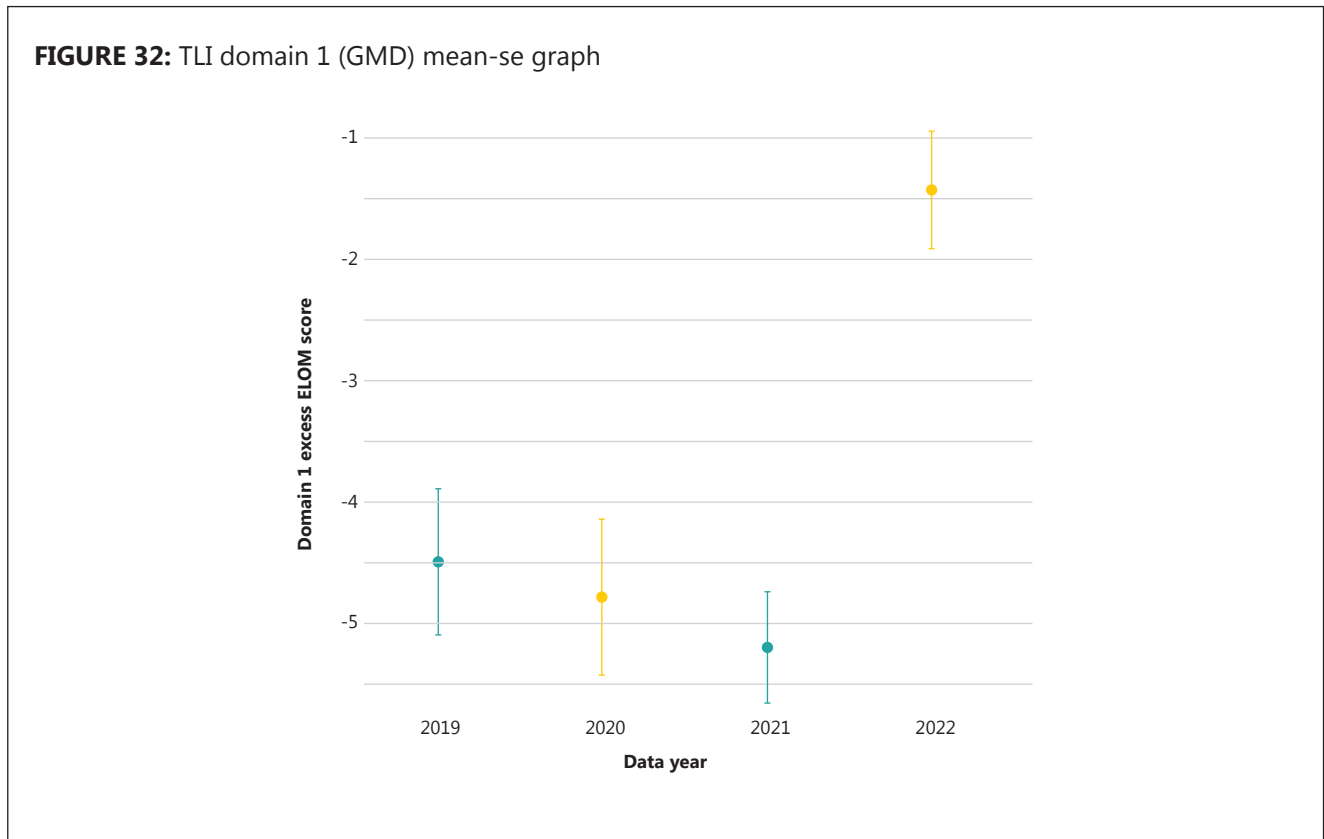


TABLE 4: TLI DOMAIN 1 (GMD) MODEL P-VALUES FOR COMPARISON SCENARIOS

Comparison	P-Value
2019 < 2020-2022	0.003
2019 > 2020-2021	0.126
2019, 2021-2022 > 2020	<0.001
2021-2022 > 2020	<0.001
2019, 2022 > 2020-2021	<0.001
2021 < 2020	0.300

Significant results were not found for a comparison of 2019 with the in Covid-19 years, or between 2020 and 2021; all other comparisons were highly

significant. It is clear that the significant increase in excess ELOM scores in 2022 is the primary driver of these.

3.4.2 Domain 2: Fine Motor Coordination and Visual Motor Integration

All comparisons show significant results at the 5% level. There is evidence of a “hockey stick” shape

which is also present in all subsequent domains: a dip from 2019 to 2020 as Covid-19 hit, a partial recovery in 2021 and a significant increase in 2022.

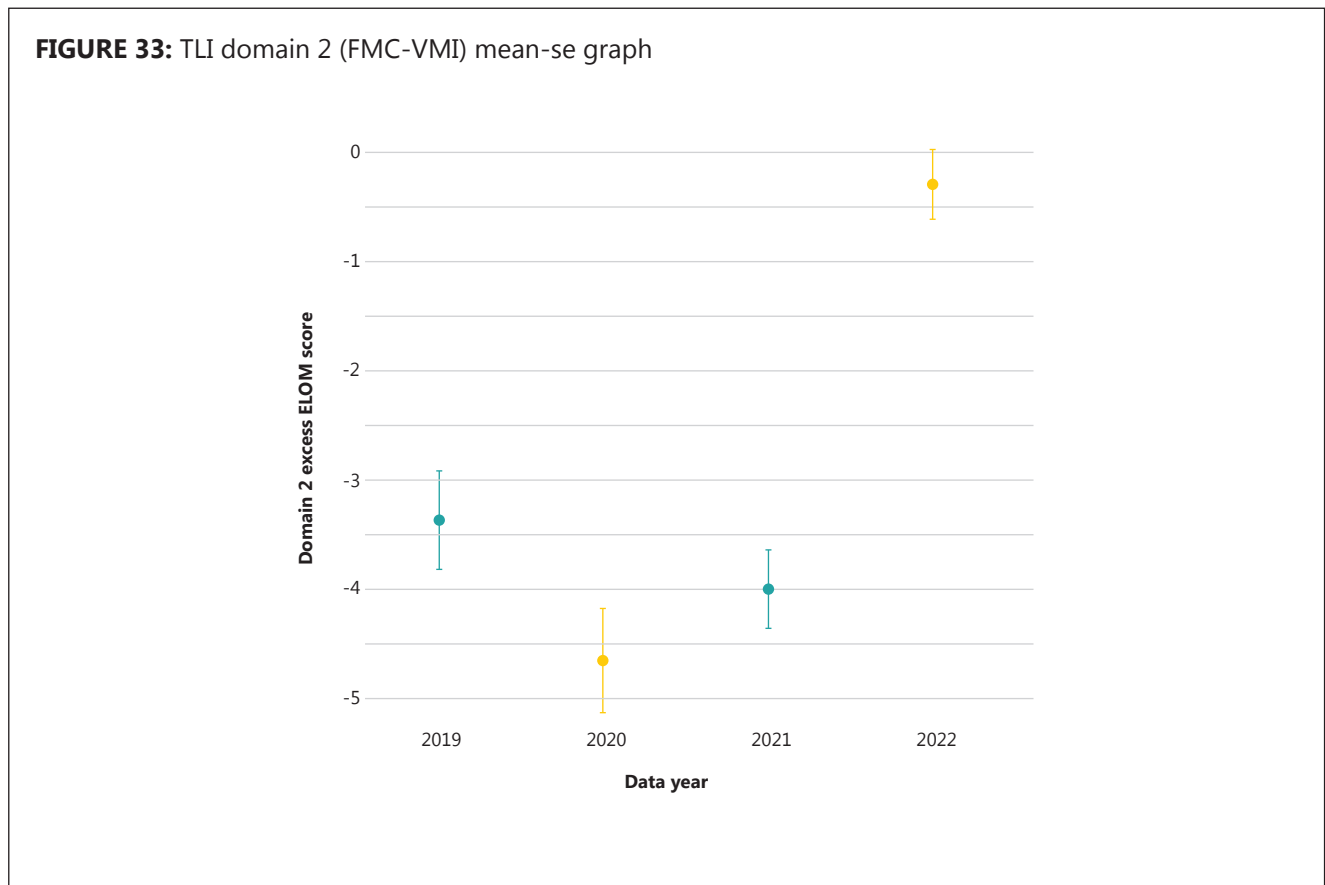


TABLE 5: TLI DOMAIN 2 (FMC-VMI) MODEL P-VALUES FOR COMPARISON SCENARIOS

Comparison	P-Value
2019 < 2020-2022	0.002
2019 > 2020-2021	0.002
2019, 2021-2022 > 2020	<0.001
2021-2022 > 2020	<0.001
2019, 2022 > 2020-2021	<0.001
2021 > 2020	0.032

3.4.3 Domain 3: Emergent Numeracy and Mathematics

sharp dip in 2020 means that the comparison of 2019 with later years is not significant.

While exhibiting a similar shape to domain 2, the

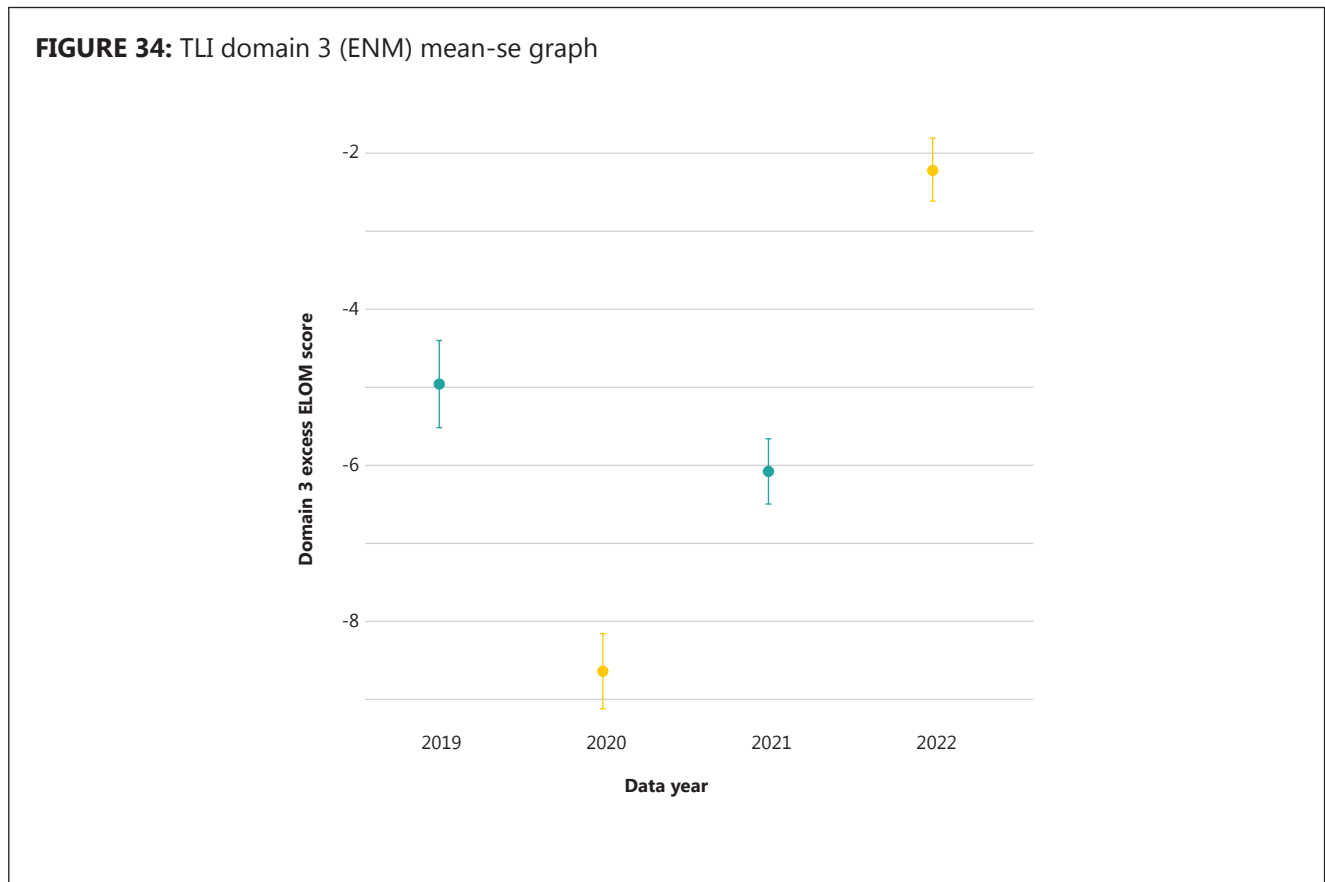


TABLE 6: TLI DOMAIN 3 (ENM) MODEL P-VALUES FOR COMPARISON SCENARIOS

Comparison	P-Value
2019 < 2020-2022	0.899
2019 > 2020-2021	<0.001
2019, 2021-2022 > 2020	<0.001
2021-2022 > 2020	<0.001
2019, 2022 > 2020-2021	<0.001
2021 > 2020	<0.001

3.4.4 Domain 4: Cognitive and Executive Functioning

Similar to domain 3, the comparison between 2019

and later years is not significant, and the 2020 comparison to 2021 is only significant at the 6% level; all other results are however significant.

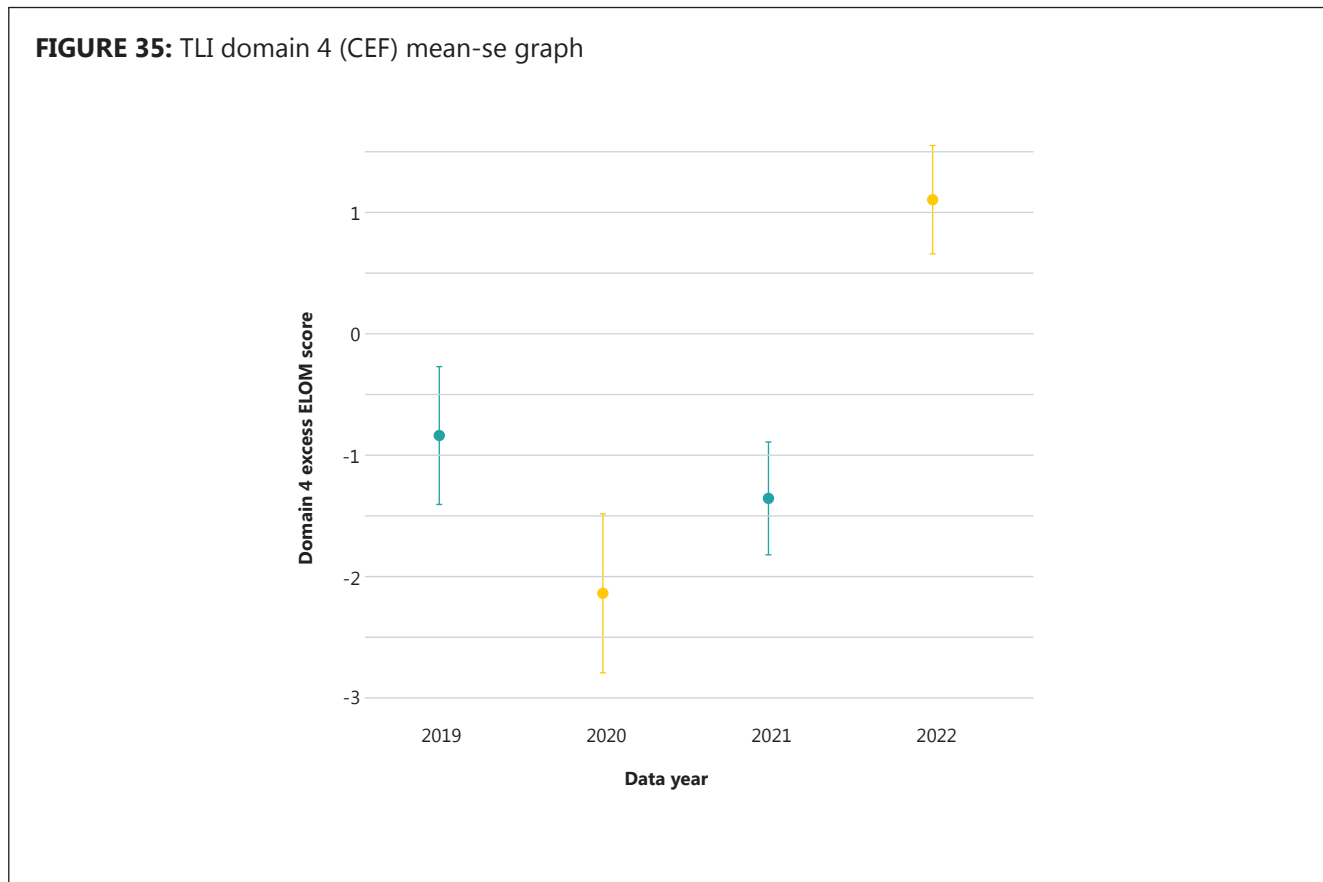


TABLE 7: TLI DOMAIN 4 (CEF) MODEL P-VALUES FOR COMPARISON SCENARIOS

Comparison	P-Value
2019 < 2020-2022	0.213
2019 > 2020-2021	0.023
2019, 2021-2022 > 2020	<0.001
2021-2022 > 2020	<0.001
2019, 2022 > 2020-2021	<0.001
2021 > 2020	0.058

3.4.5 Domain 5: Emergent Literacy and Language

For this domain, all the results are significant.

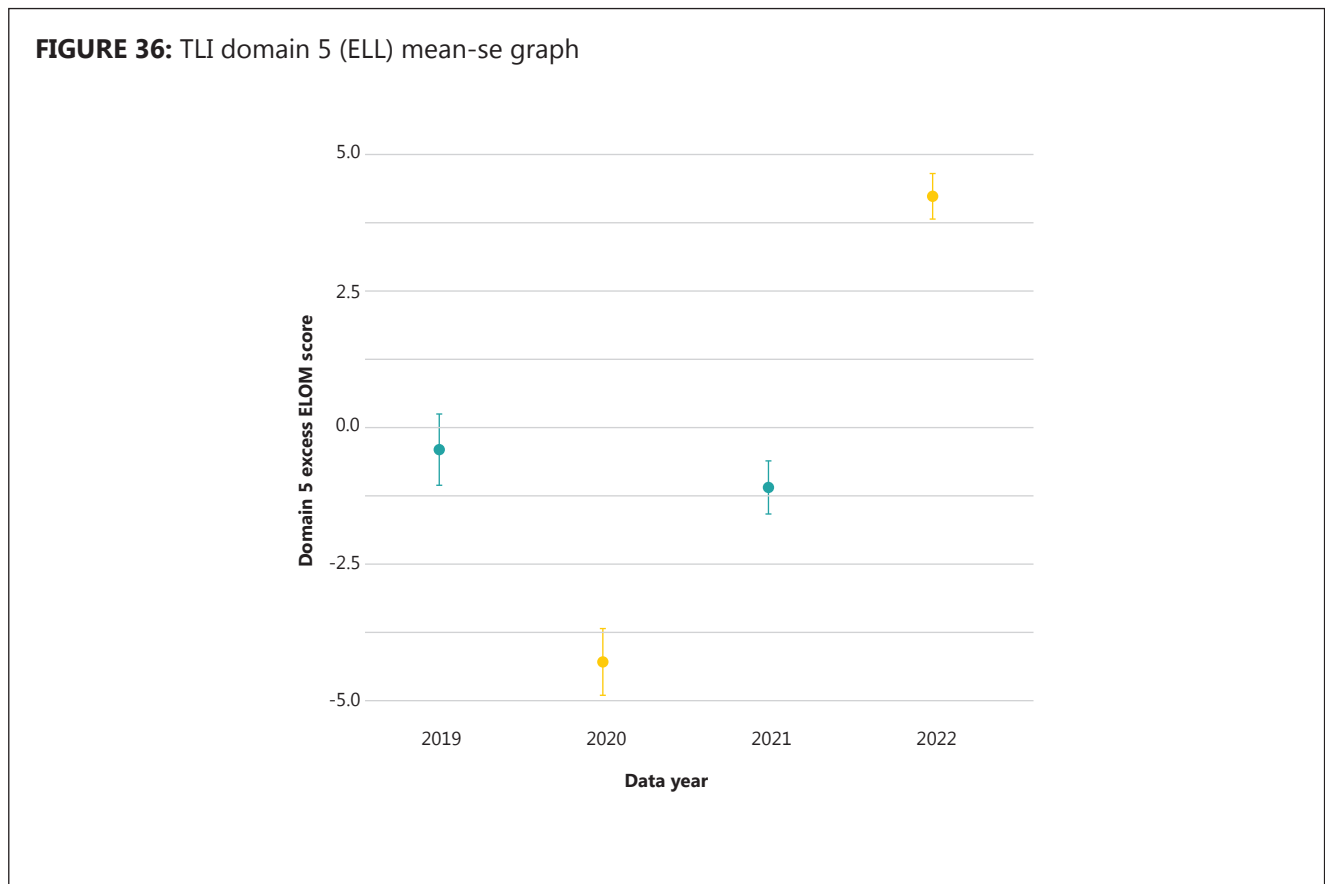


TABLE 8: TLI DOMAIN 5 (ELL) MODEL P-VALUES FOR COMPARISON SCENARIOS

Comparison	P-Value
2019 > 2020-2022	0.011
2019 > 2020-2021	<0.001
2019, 2021-2022 > 2020	<0.001
2021-2022 > 2020	<0.001
2019, 2022 > 2020-2021	<0.001
2021 > 2020	<0.001

DISCUSSION

There is little that can be said conclusively from the master dataset subset comparisons. The 2021 Thrive by Five Index comparison showed higher excess ELOM scores across all domains compared to the 2016 validation study. The evidence from other comparisons was however mixed. The 2018 ELPO study showed higher scores for domain 3 (ENM) than Thrive by Five, but the reverse applied in domains 4 (CEF) and 5 (ELL). The Grade R study comparison displayed higher domain 2 (FMC-VMI) scores in 2019 while scores for domains 1 (GMD) and 5 (ELL) were higher in 2022. Further exploration of these dynamics may be interesting. Where there is the longest time lag between datasets (2016 Validation study vs 2021 Thrive by Five), post Covid-19 excess scores exceed pre Covid-19 significantly – albeit by a relatively small absolute magnitude. This is also the most credible sub-sample of the three comparisons from the master dataset.

A bold observer might say that this is consistent with the narrative of a rising tide in the sector overwhelming the likely dampening effects of the pandemic. We should however be cautious of making even weak claims that could be over-interpreted. Signals from other comparisons were mixed at best. The caveats to these comparisons highlight the importance of ensuring consistency and comparability in future data collection (e.g. Thrive by Five) to allow for stronger inferences about changes over time and eventual effects.

For TLI, where there should in principle be the lowest degree of heterogeneity between time periods, there is clearer evidence of a Covid-19 effect on ELOM outcomes. The excess ELOM scores are highly significantly lower across all domains when comparing 2020, or 2020-2021, to other years. Literacy (domain 5) was the initial focus of the programme, so that may explain why 2019 literacy scores are higher, compared to 2020-2022. The 2019 and 2022 scores are consistently the second highest (2019) and highest (2022) scores, across the domains.

It is hard to know how much of the big upward shifts in domain scores in 2022 are due to a post-Covid-19 bump. Other factors are also at play: for example, the curriculum is more established than in previous years and has moved away from a focus on literacy (Emergent Literacy and Language) to a focus on maths (Emergent Numeracy and Mathematics) and gross motor (Gross Motor

Development) skills in later years, as well as more sessions being offered which focus on these domains. The programme also sent stimulation packs to children's homes during Covid-19 to get more parental engagement. This is something that the programme has continued to do, due to its impact on the children and the reported usefulness to both parents and teachers. Attendance has also been good in recent years.

A caveat to the TLI analysis is that the actual sample of children, schools and areas also changed over the years. The programme, having started fairly small and then expanded to 83 schools, has grown and changed since its inception and since the start of the ELOM measurements in 2019. Only after the start of 2021 were areas such as Atlantis, Strandfontein, Worcester, Bishop Lavis and Elsiesrivier included in the programme. The shift in locations and expansion of the programme after the start of programme suggests that, in particular, 2019 is not perfectly comparable to later years, and in fact there will be effects across the years due to expansion (stemming from variations in selection criteria, geography and programme implementation) that are impossible to separate from pandemic effects in the current data. There were also differences in implementation of the programme within schools: the mix of children to be taught in each group was not prescribed. The OT/speech therapist could either group all the academically weaker children together, all the stronger children together, or have a mix of both in each group. This may have influenced the way the children learned in each school.

These caveats mean that the results of the TLI analysis need to be interpreted with caution; more detailed data may make it possible to make more conclusive pronouncements. Nevertheless, we think it is reasonable to infer from the above results that the pandemic most likely had a significant dampening effect on ELOM scores in domains other than Gross Motor Development and that the easing of the pandemic's severity and the harshness of lockdown responses in 2021 were associated with a slight increase in scores, with a significant increase coming in 2022 as the country emerged from the grips of Covid-19. The recovery is pleasing, but the implications of the influence of the pandemic on school preparedness for those entering school in 2021 and 2022 are worthy of deeper investigation.

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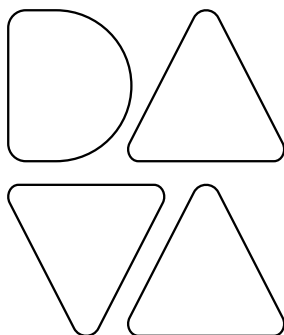
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