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Spatial Inequalities in Early Childhood Developmental Vulnerability and Education and Care Provision Across Australian Local Government Areas

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Abstract. This article combines the data of the 2021 Australian Early Development Census with educational and nursing service records, regional socio-economic indexes, national quality standard ratings and public transportation accessibility measures. This study analyses the vulnerability of early childhood development and education and nursing in Australian local government areas (LGAs). This article uses descriptive statistics and visual analysis to assess whether the service capacity, quality and accessibility meet the local development needs. The results show that LGAs, which has a higher proportion of vulnerable children in two or more fields, tends to have greater socio-economic disadvantages and poorer public transportation accessibility. Compared with the child population, these local governments tend to have lower service capacity and a smaller proportion of high-rated services. In many highly vulnerable local government areas, inadequate capacity, quality and transportation exist at the same time, indicating that developmental vulnerability is correlated with overlapping space and service inequalities, rather than a single form of disadvantage. However, some highly vulnerable areas did not show substantial service barriers, indicating that broader socio-economic and community conditions also contributed to development outcomes. The results of the study support a local-based policy approach and help to combine service expansion, quality improvement, transportation assistance and broader socio-economic support in future practice. Because the analysis is descriptive and based on aggregated LGA-level data, the identified relationships should not be interpreted as causal.

Keywords: Early childhood development; Developmental vulnerability; Education and care services; Spatial inequality; Service accessibility; Socioeconomic disadvantage; Australia.

1. Introduction

The Australian Early Development Census (AEDC) [1], Preschool Education data, and Education Services data indicate the children's development achievements and education service provision. These datasets can be regarded as effective tools for identifying the areas of developmental vulnerability, assessing the distribution and accessibility of early childhood education services, and exploring broader inequalities across different Local Government Areas (LGAs).

The report first examines the proportions of children developmentally vulnerable in LGAs, which are divided into “vulnerable in one or more domains “(DV1) and “two or more domains” (DV2). Additionally, the socio-economic and regional profile of these LGAs provides a perspective on how developmental vulnerability varies according to Socioeconomic Indexes for Areas (SEIFA), remoteness, population size, and transport accessibility. These three main issues form a coherent analytical chain that ranges from identifying the spatial distribution of development vulnerability, analyzing the impact of service provision and accessibility on vulnerable groups, to discovering resource and quality gaps and proposing policy recommendations.

This report further analyses the relationship between AEDC outcomes, service availability, public transport accessibility, and National Quality Standard (NQS) [2] quality ratings to assess whether those regions with high vulnerability also have sufficient, accessible, and high-quality education services. Based on the above analysis of the data and understanding of policy issues, we suppose that the LGAs where high vulnerability overlaps with poor access or lower service quality are treated as priority policy areas.

Generally, the report relies on Python-generated visualizations to present the main analytical findings and aims to recognize the LGAs where early childhood education services are insufficiently aligned with developmental needs.

2. Data and Methodology

The data processing stage aimed to construct a consistent LGA-level dataset for analysing developmental vulnerability, service provision, accessibility and socioeconomic disadvantage. The primary data sources were the 2021 AEDC LGA dataset, education and care service records with transport measures, and the ABS SEIFA 2021 LGA indexes [3].

The AEDC workbook was used as the core outcome dataset. We extracted 2021 LGA-level records for DV1, DV2, the five AEDC domains, and children on track in all domains. Numerical codes for LGA were used to exclude state summary rows and non-LGA rows, while percentage variables were converted into numeric variables. The cleaned AEDC dataset contained 548 geographic records. After excluding records with missing 2021 DV2 values, 457 LGAs were retained for the main analysis.

The education services dataset contained 17663 service-level records covering service details, approved places, NQS ratings, coordinates, and public transport distances. Text fields were standardized, while the numeric variables were converted into analysis-ready formats, and NQS ratings were transformed into indicators such as high-quality services and working-towards-NQS services. The geometry and transport variables were checked for implausible values, while the median public transport distance was used in the LGA level analysis to reduce the effect of outliers.

Since the service data did not contain direct identifiers for the LGA variable, the services were linked to the LGA based on their suburb, state and postcode from an external database. Exact suburb-state-postcode matching was used first, followed by a fallback suburb-state match only where the pair mapped to one unique LGA. Overall, 17199 services were matched to LGAs, giving a match rate of 97.37%. Matched services were then aggregated to the LGA level to calculate service count, provider count, approved places, service quality shares, and median public transport distance.

SEIFA 2021 was cleaned to extract LGA code, LGA name, IRSD, and IRSAD indicators. SEIFA was merged into the master dataset using the LGA code to reduce naming-match errors. In total, 456 of 457 AEDC LGAs were successfully matched to SEIFA. The Google reviews were firstly cleaned and aggregated to the service-level before being aggregated to the Local Government Area (LGA). Google Review variables were treated as supplementary perceived-quality indicators, while NQS ratings were retained as the main formal service quality measure. The Preschool Education workbook was considered for contextual information; however, there was no need to merge it because of its incompatibility at the same LGA level.

The new dataset contains 457 LGAs and 83 variables. This new dataset includes AEDC developmental outcomes, supply of services, capacity of services, NQS quality variables, access to public transport, Google review variables, and SEIFA variables.

Descriptive statistics, group comparisons and graphical analyses were used to examine the spatial alignment between DV2, socioeconomic disadvantage, service capacity, formal quality and transport accessibility. The analysis was descriptive and was not designed to estimate causal effects.

3. Developmental Vulnerability and LGA Profiles

The following section examines the LGAs that have the highest proportion of children that are developmentally vulnerable in two or more AEDC domains (DV2), while providing comparisons on their socio-economic, demographic, service capacity, and accessibility characteristics. The use of DV2 percentage as the ranking criteria was determined since it captures the extent of vulnerability in relation to each LGA, unlike just its size.

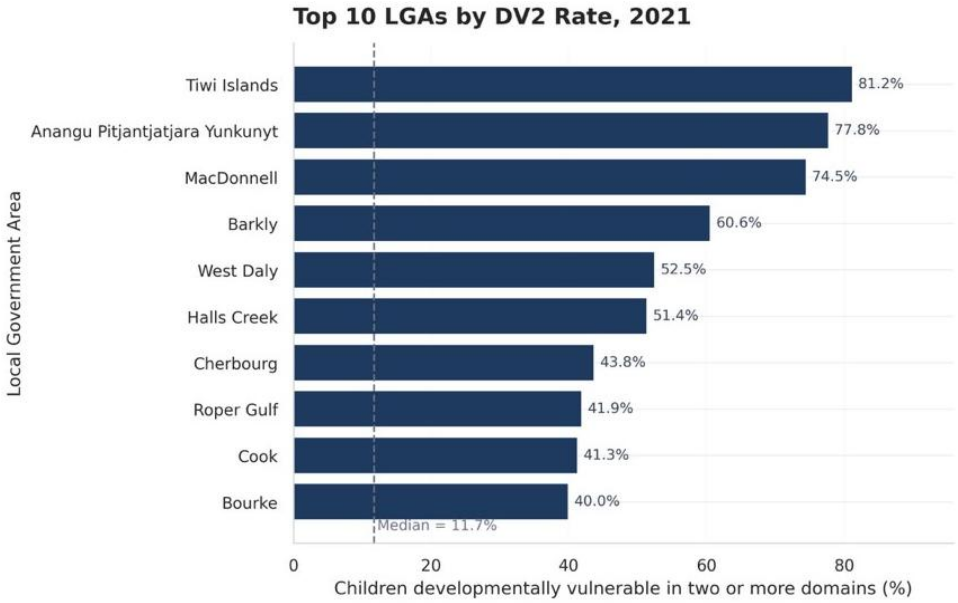

Figure 1. Top 10 LGAs by DV2 Rate, 2021

Note. DV2 refers to the percentage of children developmentally vulnerable in two or more AEDC domains. The dashed line shows the median DV2 rate across LGAs in the cleaned analytical dataset.

Figure 1 shows the ten LGAs with the highest DV2 rates in 2021. Tiwi Islands recorded the highest DV2 rate at 81.2%, followed by Anangu Pitjantjatjara Yankunytjatjara at 77.8% and MacDonnell at 74.5%. These rates are far above the overall median DV2 rate of 11.7%, indicating that developmental vulnerability is highly concentrated in a small number of LGAs. Other high-DV2 LGAs, including Barkly, West Daly, Halls Creek, Cherbourg, Roper Gulf, Cook, and Bourke, also recorded DV2 rates between 40.0% and 60.6%. This suggests that early childhood developmental vulnerability is not evenly distributed but is concentrated in specific regional and remote communities.

The use of the DV2 percentage is important because several high-ranked LGAs have relatively small AEDC child cohorts. Ranking by the number of vulnerable children alone would risk overlooking smaller communities where the proportion of vulnerable children is extremely high. Therefore, Figure 1 identifies the areas where vulnerability is most intense, while the following figures add context on population size, SEIFA, and accessibility.

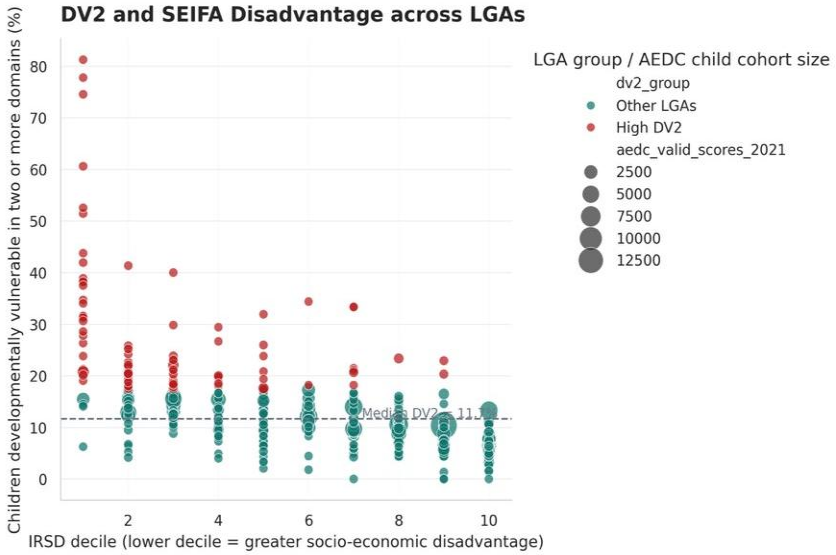

Figure 2. DV2 and SEIFA Disadvantage across LGAs

Note. Lower IRSD deciles indicate greater socio-economic disadvantage. Bubble size represents the AEDC child cohort size.

Figure 2 compares DV2 rates with IRSD deciles. Lower IRSD deciles represent greater socioeconomic disadvantage. The bubble scatter plot shows that many high-DV2 LGAs are concentrated in the lowest IRSD decile, suggesting an overlap between developmental vulnerability and socioeconomic disadvantage. However, the pattern is not perfectly linear, as some LGAs outside the lowest SEIFA decile also show elevated DV2 rates. This indicates that SEIFA is an important contextual factor, but it does not fully explain developmental vulnerability on its own.

Bubble size represents the AEDC child cohort size. The distinction will serve as an effective tool for understanding policies. In cases where the LGA has a relatively small population along with a high DV2 rate, then intervention might need to be placed at the local level, but if the LGA has a relatively large population and is experiencing a moderate to high DV2 rate, then a broader approach may be necessary.

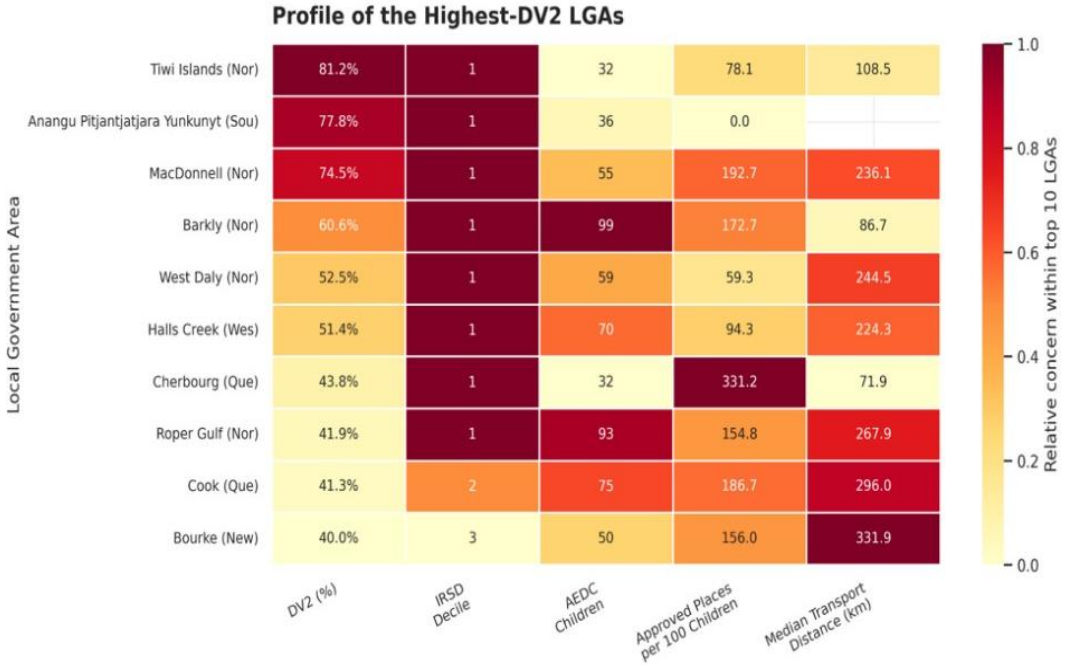

Figure 3. Profile of the Highest-DV2 LGAs

Note. Darker color indicates greater relative concern within the top 10 DV2 LGAs. IRSD decile was reverse scaled in the heatmap so that lower SEIFA deciles appear as higher concern.

Figure 3 shows the top ten LGAs by their DV2 values in relation to DV2 rate, IRSD decile, AEDC child cohort size, approved places per 100 AEDC children, and median public transport distance. As can be seen from the figure, a lot of the LGAs which have high DV2 values belong to IRSD deciles that are relatively low. The figure also shows variation in service capacity and public transport accessibility across the highest-DV2 LGAs.

Accessibility to transport facilities is a crucial differentiator. There is significant distance from public transport facilities in LGAs like MacDonnell, West Daly, Halls Creek, Roper Gulf, Cook, and Bourke. Though distance to transport is an indirect indicator, it can help in estimating the availability of such facilities. It is thus important to assess the accessibility to such services, which can be gauged through their distance.

Overall, this section shows that high developmental vulnerability is concentrated in a small group of LGAs and often overlaps with lower SEIFA deciles and weaker transport accessibility. The results suggest that development vulnerability must take into consideration factors like proportion of vulnerability, SEIFA score, child cohort size, and accessibility, rather than just the number of people and services. This establishes the demand-side profile for the following analysis of whether education service distribution and quality align with areas of higher developmental need.

4. Service Distribution vs AEDC Outcomes

This section examines whether service capacity, transport accessibility and NQS quality align with DV2 across 423 LGAs.

4.1. Transport Accessibility and Developmental Vulnerability

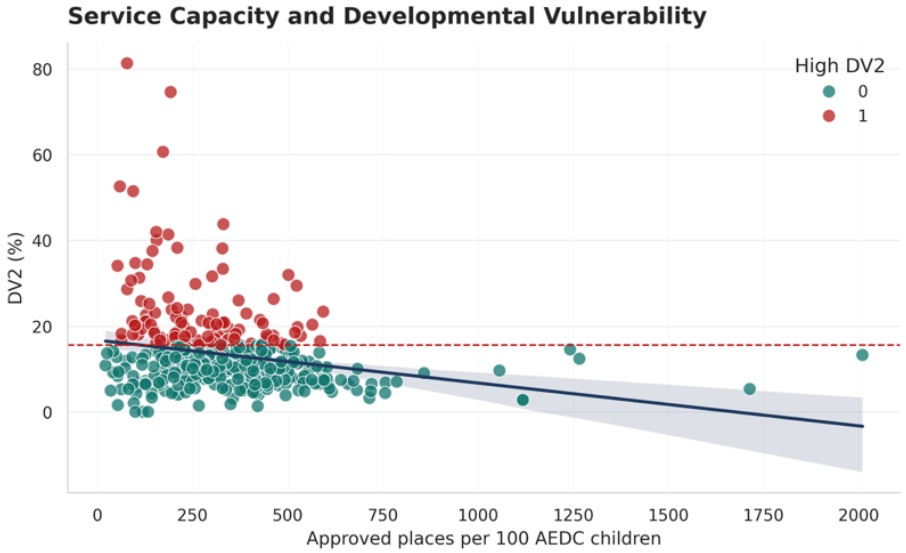

Figure 4. Distribution of Transport Accessibility across LGAs

Note. The histogram reports the distribution of each LGA's median distance from ECEC service locations to the nearest public transport option. The grey and red dashed lines mark the sample median (3.89 km) and the 75th percentile (33.60 km), respectively. The analysis includes 423 LGAs with matched service data.

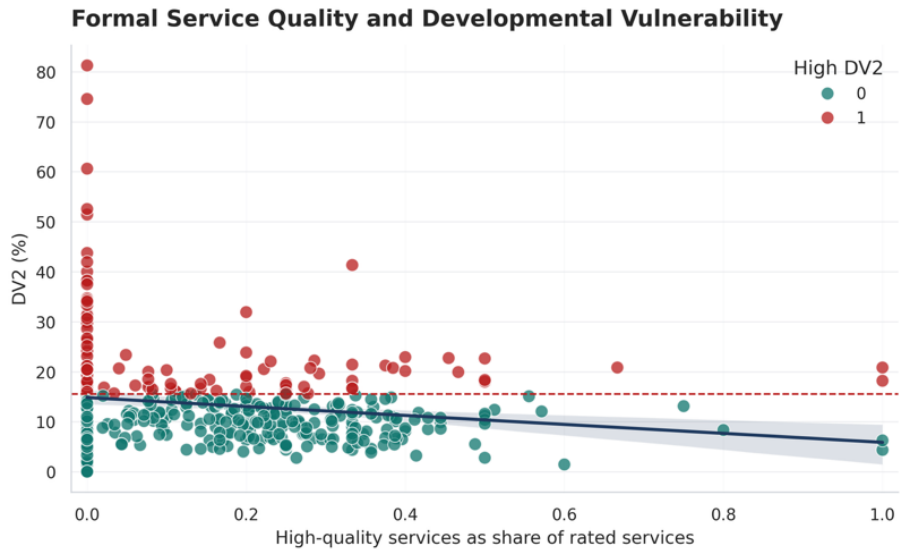

Figure 5. LGAs with the Poorest Transport Accessibility

Note. Bars show the ten LGAs with the greatest LGA-level median distance from ECEC service locations to the nearest public transport option. Values are reported in kilometres; greater distances indicate poorer accessibility.

Previous research has identified substantial spatial inequalities in childcare accessibility across Australia, particularly in regional and remote communities [4]. Figure 4 and Figure 5 show transport accessibility is highly uneven across Australian LGAs. The distribution is strongly right-skewed: although the median distance was only 3.89 km, the upper-quartile threshold reached 33.60 km. This

contrast shows that a relatively small group of LGAs accounts for much of the observed geographic disadvantage and that a national average would conceal substantial local access constraints.

The least accessible LGAs were concentrated in remote northern and western Australia. Weipa recorded the greatest median distance (568 km), followed by Northern Peninsula Area (520 km), Torres (479 km), East Arnhem (445 km) and Torres Strait Island (434 km). These extreme values indicate that physical proximity to transport is a qualitatively different challenge in some remote LGAs, rather than simply a modest variation around the national distribution.

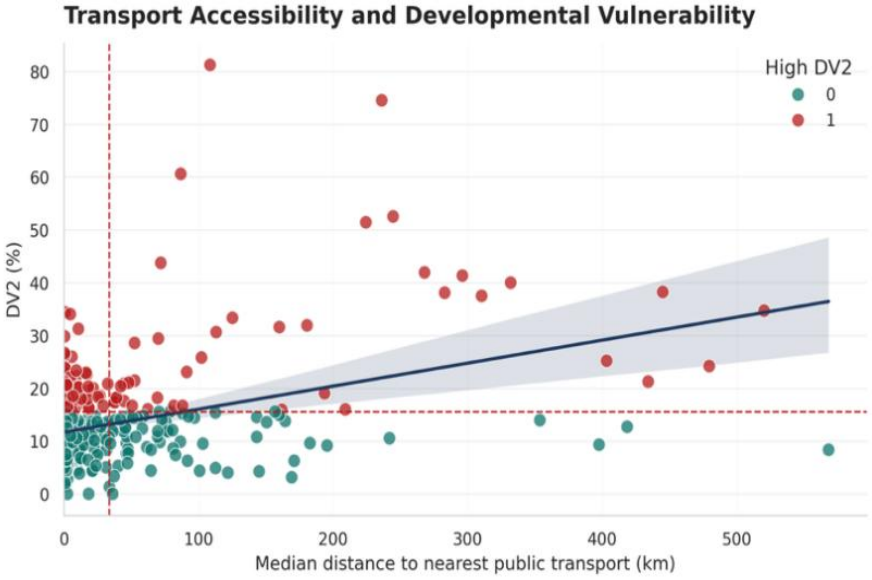

Figure 6. Transport accessibility and developmental vulnerability

Note. The x-axis is the median distance to the nearest public transport hub, and the y-axis is DV2 (%). Each point is one LGA. Color separates high-DV2 LGAs, while the fitted line summarizes the trend.

Figure 6 tests whether transport distance is associated with DV2. The positive slope shows that longer transport distance is associated with higher DV2. High-DV2 LGAs have a median transport distance of 14.58 km, compared with 3.22 km for other LGAs. This suggests that high-vulnerability areas often have services that are harder to reach.

On the contrary, the substantial dispersion around the fitted line is equally important. Some high-DV2 LGAs remain relatively close to transport, while some geographically isolated LGAs record lower DV2 rates. Transport accessibility should therefore be interpreted as one contextual correlate of developmental vulnerability rather than a sufficient explanation of local outcomes. The positive relationship may also be influenced by a small number of very remote observations.

4.2. Service Availability and Capacity

After transport accessibility, this section examines whether service capacity is sufficient relative to local child populations and how this relates to AEDC outcomes.

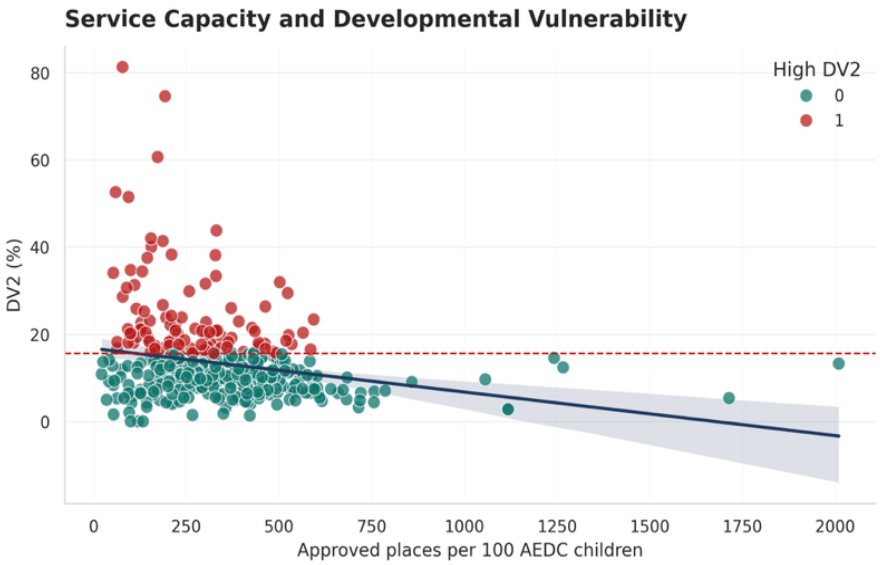

Figure 7. Service capacity and developmental vulnerability

Note. The x-axis is approved places per 100 AEDC children, measuring supply relative to the local child population, and the y-axis is DV2. Each dot is an LGA, coloured by high-DV2 status.

Figure 7 tests whether service capacity follows a similar pattern. The fitted line slopes downward, showing a weaker negative association between capacity and DV2. High DV2 LGAs have a median of 236.38 approved places per 100 AEDC children, compared with 346.56 for other LGAs. This shows that high developmental needs are often paired with lower service capacity.

4.3. Service Quality and NQS-Ratings

Service access and capacity do not fully explain developmental outcomes, so this section also examines whether formal service quality aligns with DV2.

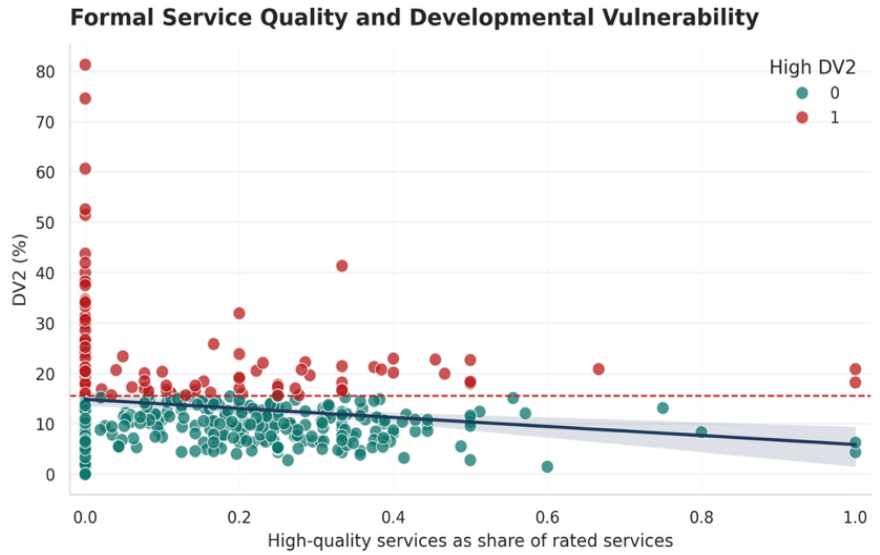

Figure 8. Formal service quality and developmental vulnerability

Note. The x-axis is the share of rated services classified as high quality under the NQS framework, and the y-axis is DV2. Each point is one LGA, and the fitted line shows the direction.

Figure 8 examines whether formal service quality aligns with DV2. The negative slope is modest but significant: high-DV2 LGAs tend to have a lower share of high-quality rated services. Their median high-quality share is 3.7%, compared with 17.2% in other LGAs. This adds a quality dimension: high-need communities may have less access to strong service environments.

The relationship is weak and heterogeneous. LGAs with both high and low DV2 appear across much of the quality range. This indicates that formal quality ratings alone do not explain developmental outcomes. The concentration of observations at zero is also important: for many LGAs, none of the rated services was classified as Exceeding NQS or Excellent. This measure may be unstable where an LGA contains only a small number of rated services, so it should be interpreted as a regional quality profile rather than a complete assessment of children's service experiences.

4.4. Priority LGAs and Policy Implications

Figure 9. Priority matrix for service gaps

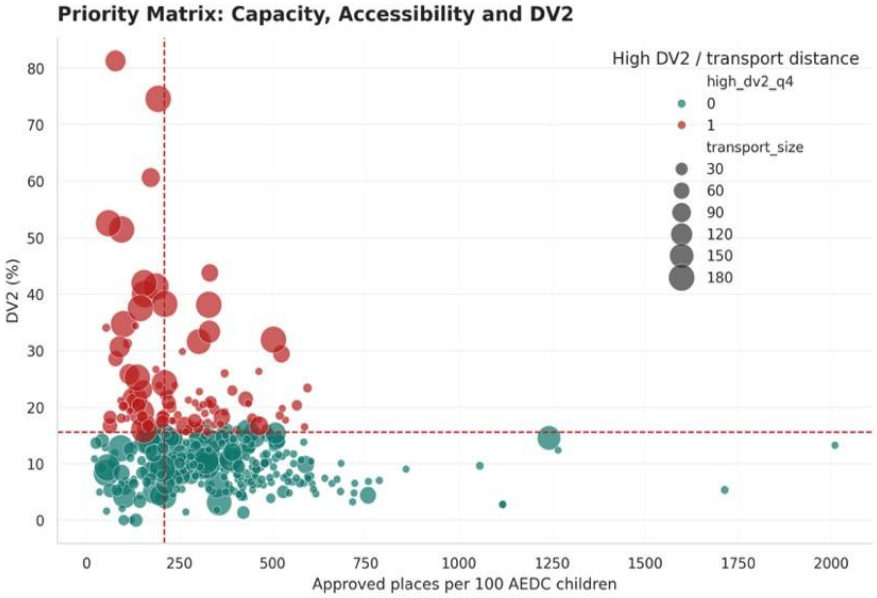

Figure 9. Priority Matrix for Service Gaps

Note. The x-axis shows approved places per 100 AEDC children, so LGAs further left have lower relative capacity. The y-axis is DV2, so LGAs higher on the chart have greater vulnerability.

Figure 9 combines the indicators into a targeting matrix. Bubble size represents transport distance, and color highlights LGAs that are both high-DV2 and high transport-distance. The figure identifies where the disadvantages overlap. Priority LGAs include Tiwi Islands, Barkly, West Daly, Halls Creek, Bourke, Northern Peninsula Area, Derby-West Kimberley and Woorabinda. For these areas, policy should address transport connectivity, outreach delivery and quality improvement, not only in extra places.

The matrix also shows why priority setting should not rely on capacity alone. Several high-DV2 LGAs lie close to or to the right of the capacity threshold but still have very large transport bubbles. Conversely, some high-DV2 and low-capacity LGAs have comparatively small transport bubbles. These contrasting profiles indicate that similar DV2 outcomes may coexist with different service constraints and therefore require different policy responses.

LGAs combining high DV2, low relative capacity and long transport distance may warrant integrated responses involving service expansion, outreach or mobile provision, workforce support and transport assistance. Where only one constraint is evident, a more targeted intervention may be appropriate. Figure 9 should be treated as a screening tool rather than a definitive ranking, thresholds are relative to the study sample, approved places do not measure actual vacancies or affordability, and the descriptive patterns do not establish causal relationships.

5. Critical Gaps and Policy Recommendations

Previous analysis showed that high DV2 levels are often linked with socio-economic disadvantage, poorer transport accessibility, lower service capacity, and lower formal service quality. Based on the findings above, this section further identifies the service barriers that most commonly overlap in high-DV2 LGAs and discusses which areas may require higher policy priority.

5.1. Patterns of Overlapping Service Barriers

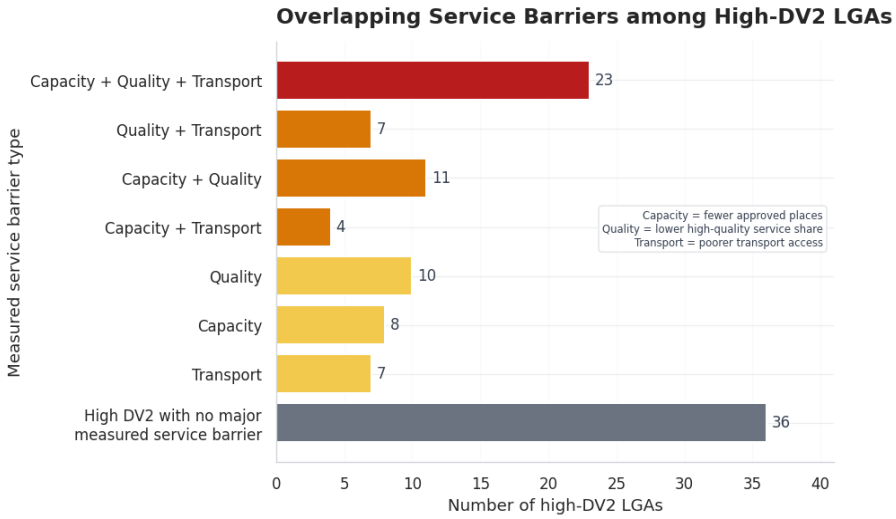

Figure 10. Overlapping service barriers among high-DV2 LGAs

Note. Capacity refers to the lower approved places relative to the AEDC child population. Quality refers to a lower share of high-quality services. Transport refers to poorer public transport accessibility.

Using the quartile-based definitions specified in the methodology, Figure 10 examines how capacity, quality and transport barriers overlap across the 106 high-DV2 LGAs with complete service data. 66% of LGAs experienced at least one measured service barrier, while 42.5% experienced two or more. The most severe pattern was observed in 23 LGAs, where limited relative capacity, the absence of highly rated services and poor transport accessibility occurred simultaneously.

The second largest group included LGAs with both Capacity and Quality barriers (17 LGAs). This indicates that even without a clear Transport barrier, some high-DV2 areas may still experience educational inequality due to insufficient service availability and a lower proportion of high-quality services. In comparison, only 7 LGAs showed a Transport barrier alone, suggesting that transport issues are less likely to appear independently and more likely to occur alongside capacity or quality problems.

Furthermore, no major service barriers were found in the 36 of high DV2 LGAs. This indicates that 36 high DV2 LGAs (34.0%) were not classified as major obstacles to any of the three measures. This is an important correspondence point of the overlapping mode. The statistic shows that a high degree of developmental vulnerability is not equivalent to the disadvantage of early childhood education and care. Development outcomes may also be influenced by other factors such as family economic conditions, housing conditions, access to health care, cultural and linguistic factors, population mobility and community infrastructure. In addition, since the barrier is based on the definition of the current research sample, the lack of classification barrier should not be interpreted as strong evidence that the service is fully provided.

5.2. Policy Implications for Equitable Access

Based on the results above, policy recommendations can be designed hierarchically according to the degree of overlap of service barriers. For high DV2 areas that are facing multiple barriers at the same

time, comprehensive intervention measures should be prioritized; for areas mainly affected by specific service gaps, more targeted policy tools can be adopted.

5.2.1. Prioritize Integrated Support in LGAs with Overlapping Barriers

High DV2 LGAs with capacity, quality, and transport barriers may warrant policy attention. These regions often face problems with service supply, service quality, and transport access at the same time, which coincide with high levels of developmental vulnerability. Therefore, only increasing approved places may not be enough to improve child development outcomes. A more comprehensive intervention strategy might be more effective, such as improving service capacity, transport support, and service quality together.

Specific measures include establishing integrated early childhood hubs, improving community transport support, increasing high-quality NQS service funding, and providing additional incentives for educator retention in remote areas. Australian Government Productivity Commission (2024) also pointed out that regional and remote areas often face insufficient service supply, access barriers, and workforce constraints at the same time, which shows that overlapping barriers usually require more comprehensive policy interventions.

5.2.2. Strengthen Service Capacity and Quality

For regions with both capacity and quality barriers, but without obvious transport barriers, the policy focus should be on improving service capacity and quality.

In addition to expanding approved places, policies should also pay more attention to the quality improvement of formal early childhood education services [5]. found that higher-quality ECEC services are often associated with lower developmental vulnerability and better child development outcomes. Therefore, relevant policies can also include improving the educator-to-child ratios, providing more support for services working towards NQS standards, and increasing regional educator training and workforce support.

5.2.3. Consider Accessibility within Broader Service Planning

Figure 10 shows that transport barriers rarely occur alone, but more often coexist with service capacity or quality problems. This shows that transport accessibility should be incorporated into broader early childhood education and care service planning rather than treated as an isolated infrastructure issue. As a result, future policy planning may pay more attention to improving public transport connectivity, providing community shuttle services, and prioritizing transport disadvantaged areas in the new service layout.

5.2.4. Address Broader Socio-economic Disadvantage beyond Service Provision

Figure 10 also shows that some high DV2 LGAs did not show obvious service barriers. This shows that the vulnerability of children's development cannot be explained entirely by service supply, service quality, or traffic accessibility. Therefore, in addition to improving the education service itself, future policies should also consider factors such as family economic pressure, housing instability, and regional disadvantaged backgrounds. In other words, improving the supply of education services alone may not be enough to fully alleviate the development vulnerability of some regions.

6. Limitations

6.1. Data Linkage and Coverage

There may still be a few errors in the data integration process of this study. Since the education services dataset does not contain direct LGA identifiers, the services need to be matched through suburb, state, and postcode, which may lead to slight mapping errors in some regions.

In addition, transport accessibility is mainly measured by the median public transport distance. Although the median can reflect the overall accessibility, it cannot fully represent the actual travel time, traffic frequency, or traffic cost of each family.

Although 17199 of 17663 service records were matched (97.37%), residual linkage error may remain. Service-side analyses covered 423 of the 457 LGAs with valid DV2 data, and the Figure 10 overlap analysis used 422 complete cases. Findings about service capacity, quality and accessibility should therefore not be generalised uncritically to LGAs without matched or complete service data.

6.2. Measurement Constraints

Every service indicator cannot fully represent the real experience of children and families. The corresponding approved school quota for every 100 early childhood education and care currently used is based on the registered service capacity, not the actual utilization rate, vacancy, affordability, opening hours, or the full population size of all eligible children. At the same time, families may also use services outside the LGA of residence. Therefore, this indicator is more suitable to be understood as a relative service supply capacity than a direct measurement result that does not meet the demand. The official quality indicator is based on the proportion of services rated as "exceeding NQS" or "excellent". Due to the small number of services rated in some LGAs, this ratio may not be stable enough; at the same time, it cannot reflect the differences within the NQS categories or other aspects of service quality that the rating system cannot cover. When dividing high-quality service categories, the cut-off point of the low quartile is zero, which deliberately distinguishes between LGA with "high-quality service" and "no high-quality service at all", but this distinction is relatively strict and rough.

Traffic accessibility is measured by the median distance from the service location to the nearest public transportation station. This indicator does not consider the actual travel time of the family from the residence to the service point, the frequency of public transportation, operating time, travel cost, vehicle accessibility, road conditions, or the special barrier-free needs of individual families. In addition, the median may cover up the large spatial differences within the LGA, especially in the geographically large or remote LGA.

6.3. Analytical Limitations

This study mainly analyzed the relationship between DV2 and educational services through descriptive statistics and visualizations. Therefore, the results can only indicate that there is a certain correlation between these variables but cannot prove that there is a direct causal relationship between them. For example, low service capacity, poor transport accessibility, and low service quality are common in high DV2 regions. However, it cannot be determined that these factors will directly lead to an increase in children's developmental vulnerability.

In addition, this study mainly used aggregated data at the LGA level, which is more suitable for observing overall regional trends, but cannot reflect the differences between different communities within the same LGA. At the same time, this study mainly used scatter plots, heatmaps, and comparison charts to present the results, and did not use maps as the main visualization method. Therefore, some spatial distribution and aggregation features may not have been fully presented.

7. Conclusion

This study linked the 2021 Australian Early Development Census with LGA-level indicators of socioeconomic disadvantage, ECEC capacity, formal service quality and public transport accessibility. The descriptive patterns show that developmental vulnerability is spatially concentrated and frequently coincides with socioeconomic and service disadvantage. High-DV2 LGAs generally displayed lower relative capacity, a smaller share of highly rated services and poorer transport accessibility than other LGAs, although the strength and combination of these conditions varied across places.

The revised overlap analysis sharpens this conclusion. Among 106 high-DV2 LGAs with complete service data, 70 experienced at least one measured barrier, 45 experienced multiple barriers and 22 experienced capacity, quality and transport barriers simultaneously. These findings support differentiated place-based responses: integrated intervention where disadvantages accumulate, targeted improvement where one service constraint predominates, and broader social and community support where high vulnerability is not accompanied by the measured service barriers.

The results should be interpreted as evidence of geographic alignment rather than causal effects. Nevertheless, they demonstrate the value of combining developmental, socioeconomic and service indicators when identifying priorities for early childhood policy. Improving equitable access is likely to require coordinated attention to service availability, quality, practical accessibility and the wider conditions in which children and families live.

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