

The importance of the neighbourhood built environment for Australian children's development. A report on a data linkage pilot project.

22 October 2019

Amanda Alderton^{1,2}

Karen Villanueva^{1,2}

Carl Higgs²

Hannah Badland²

Sharon Goldfeld^{1,2}



Acknowledgements

This data linkage project involves collaboration between researchers at Murdoch Children's Research Institute (the Royal Children's Hospital) and at the Centre for Urban Research, RMIT University.

Funding

The Australian Government Department of Social Services provided funding for linking the spatial measures to child development outcome data from the 2015 Australian Early Development Census. The Bernard van Leer Foundation Urban95 Challenge funded the development and pilot testing of the dataset. The Australian Government Department of Education and Training and the Social Research Centre provided in-kind access to the 2015 Australian Early Development Census data. Hannah Badland is supported by an RMIT Vice Chancellor's Senior Research Fellowship. Sharon Goldfeld is supported by a National Health and Medical Research Council (NHMRC) Career Development Fellowship (1082922).

Contributors

We would like to thank others who have supported and / or contributed to the project, including:

Organisations

- Bernard van Leer Foundation
- Australian Government Department of Social Services
- Australian Government Department of Education and Training
- Social Research Centre
- Australian Institute of Family Studies
- Murdoch Children's Research Institute¹
- RMIT University²

Associate researchers

- Dr Jonathan Arundel (formerly Centre for Urban Research, RMIT University)
- Ms Rebecca Roberts, Centre for Urban Research, RMIT University
- Ms Julianna Rozek, Centre for Urban Research, RMIT University
- Dr Meredith O'Connor, Murdoch Children's Research Institute
- Dr Claire Boulangé, Centre for Urban Research, RMIT University
- Prof Billie Giles-Corti, Centre for Urban Research, RMIT University

ISBN: 978-0-6483390-6-9

Suggested citation

Alderton A, Villanueva K, Higgs C, Badland H, Goldfeld S (2019). The importance of the neighbourhood built environment for Australian children's development. A report on a data linkage pilot project. Murdoch Children's Research Institute and RMIT University, Melbourne.

Contents

TABLES	5
FIGURES	5
ABBREVIATIONS	5
EXECUTIVE SUMMARY	6
PART 1 BACKGROUND	8
1.1 WHY EXPLORE THE RELATIONSHIP BETWEEN THE BUILT ENVIRONMENT AND CHILD DEVELOPMENT?	8
1.1 WHAT IS THE PURPOSE OF THIS DATA LINKAGE PROJECT?	9
1.1.1 Why is it better to calculate spatial measures around a child's home address?	10
1.1.2 Data linkage stages and processes.....	10
1.2 AIMS OF PILOT TESTING	12
1.3 RESEARCH TRANSLATION AND TARGET AUDIENCE	12
PART 2 DATASET AND MEASURES	13
2.1 DESCRIPTION OF THE GIS-AEDC LINKED DATASET	13
2.1.1 Measures included.....	13
2.2 CLEANING THE DATA	15
PART 3 ANALYTICAL STRATEGY	16
3.1 ANALYTICAL APPROACH	16
3.2 HOW DID WE ACCOUNT FOR SOCIOECONOMIC FACTORS AND DIFFERENCES BETWEEN URBAN AND REGIONAL AREAS?	16
PART 4 PILOT TESTING RESULTS	17
4.1 SAMPLE DEMOGRAPHICS	17
4.2 DESCRIPTIVE STATISTICS	18
4.3 LOGISTIC REGRESSIONS	19
PART 5 DISCUSSION	21
5.1.1 Strengths.....	21
5.1.2 Limitations.....	22
5.1.3 Conclusions and next steps.....	22
PART 6 REFERENCES	24
APPENDICES: DATA VISUALISATION (MAPS)	26

Tables

Table 1. Built environment measures for pilot testing	14
Table 2. Sample demographics, by child development outcomes	17
Table 3. Neighbourhood built environment characteristics, by child development outcomes	19
Table 4. Associations between neighbourhood built environment characteristics and child development outcomes	20

Figures

Figure 1. The built environment and child development: A conceptual framework	7
Figure 2. Steps in the data linkage process.....	12

Abbreviations

ABS	Australian Bureau of Statistics
ACECQA	Australian Children’s Education & Care Quality Authority
AEDC	Australian Early Development Census
AIFS	Australian Institute of Family Studies
DV1	Developmentally vulnerable on at least one AEDC domain
ECD	Early child development
ECEC	Early childhood education and care
GIS	Geographic information systems
HREC	Human Research Ethics Committee
KICS	Kids in Communities Study
MAUP	Modifiable Areal Unit Problem
MCRI	Murdoch Children’s Research Institute
NHSD	National Health Services Directory
NQS	National Quality Standard
POS	Public open space
RCH	Royal Children’s Hospital
RMIT	Royal Melbourne Institute of Technology
SA1	Statistical Area 1 (from ABS)
SEIFA-IRSD	Socio-economic Index for Areas - Index of Relative Socio-economic Disadvantage
SRC	Social Research Council
UNICEF	United Nations Children’s Fund

Executive Summary

Background

Good early child development is important for children's wellbeing; it is likely shaped by multiple factors, including children's individual characteristics, family lives, and the social and physical environments in which they are raised. Children who are exposed to positive, stimulating environments in their first eight years lay optimal foundations for their ongoing physical, social, emotional, and cognitive development.

The neighbourhood built environment (e.g. local parks; footpaths and cycling paths; local services, shops, and destinations) is increasingly being recognised as providing important experiences for child development. Yet, most of the existing studies on the factors that promote good child development have focused on family- and school-related factors, while neighbourhoods remain under-explored.

Methods

This data linkage project developed and pilot tested a world-first national dataset that can be used to determine which features of the neighbourhood built environment are associated with child development in the Australian urban context, with potential for comparison with other cities globally. Existing survey data on child development outcomes from the 2015 Australian Early Development Census (AEDC) were linked to geographic information systems (GIS) data on the neighbourhood built environment. Three potential ways that neighbourhood features support or hinder early child development are proposed in Figure 1 (housing, local destinations and services, and public open space), and guided the selection of the neighbourhood built environment measures explored in this pilot project. Six neighbourhood built environment measures of likely importance were count of and distance to public open space, count of and distance to early childhood and education care services (any type and those meeting Australian quality standards), and dwelling density. These measures were identified through an ongoing program of work and tested for associations with child development.

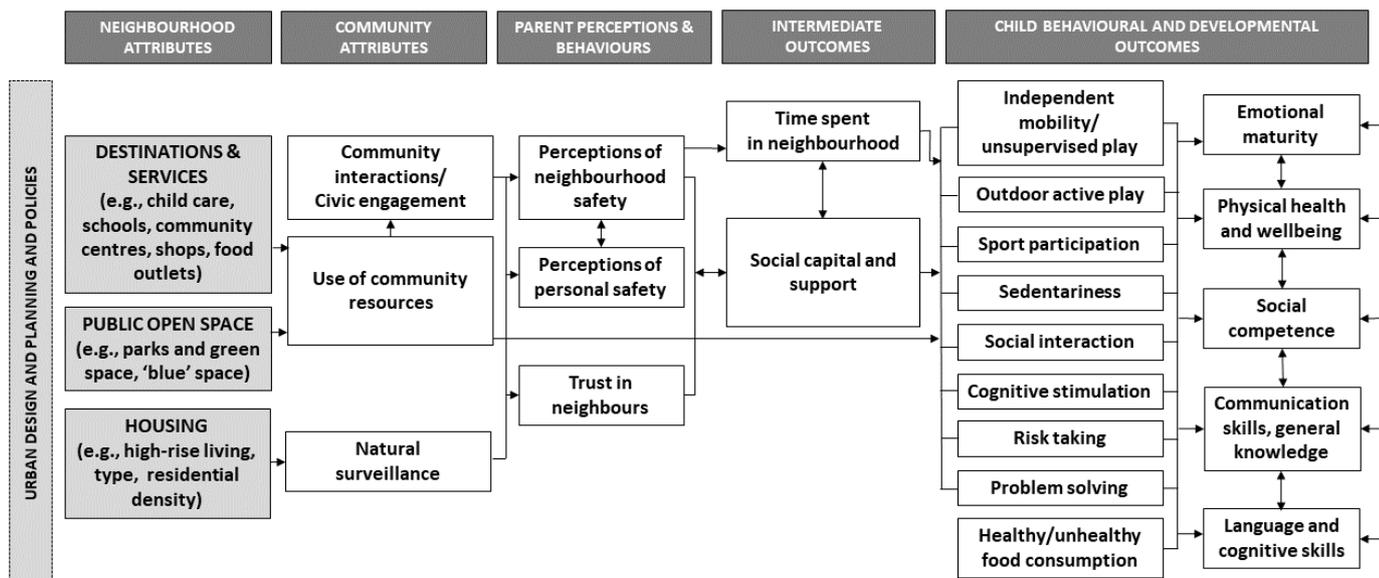


Figure 1. The built environment and child development: A conceptual framework (adapted from Villanueva et al., unpublished)

Pilot findings

The GIS-AEDC linked dataset includes observations for 235,655 children living in urban and major regional areas of Australia (roughly 80% of the Australian child population). We found that children living in areas with more quality early childhood and education care services (ECEC) meeting Australian guidelines, had significantly decreased odds of developmental vulnerability compared to those living in areas with less quality ECEC services, holding socioeconomic factors constant. We also found that children living in areas with the highest dwelling densities had significantly decreased odds of developmental vulnerability compared with those living in areas of the lowest dwelling densities. No other built environment measures appeared predictive of developmental vulnerability at this initial pilot testing stage. The results from this pilot testing indicate a need for more refined measures and geographic buffers, and use of complex modelling.

Next steps

Through further testing, this dataset can be used to develop and test a suite of evidence-based measures of the built environment that can be used as tools for supporting optimal child development through engaging communities and policy makers in planning, monitoring progress, benchmarking and decision making.

Part 1 Background

1.1 Why explore the relationship between the built environment and child development?

Major global agencies including the World Health Organization and UNICEF recognise early childhood as one of life's critical development periods.[1] Good early child development (ECD) is important for children's wellbeing[1] and is likely shaped by multiple factors, including children's individual characteristics, family, and the environments (both social and physical) in which they are raised.[2] Children who are exposed to positive, stimulating environments in their first eight years lay optimal foundations for their ongoing physical, social, emotional, and cognitive development.[3] Those who are not exposed to such environments at an early age cannot 'catch-up' because of the timing of neural and brain plasticity developments.[4]

The neighbourhood built environment (e.g. local parks; footpaths and cycling paths; local services, shops, and destinations) is increasingly being recognised as an important exposure for child development.[5] Its potential to be modified by policy and practice means that finding the right leverage points can likely have relatively large, wide ranging, and on-going effects particularly when targeting whole-of-population ECD outcomes.[3, 5]

Yet, most of the existing studies on the factors that promote good child development have focused on family- and school-related factors, while neighbourhoods remain under-explored. This is despite previous research suggesting features of the local environment in which families live has an important influence on parents' capacity to raise their children and therefore promote good developmental outcomes.[6] Given that neighbourhoods are among the most important contexts for children's time spent outside of home and school, it is plausible that the way neighbourhoods are designed and built relates to child development.

1.2 What is the purpose of this data linkage project?

The dataset developed in this pilot project extends earlier child research programs. For example, the Kids in Communities Study (KiCS) was a mixed method (qualitative and quantitative) Australian investigation of community-level factors related to better outcomes for young children.[7] In the Kids in Communities Study, a range of 'Foundational Community Factors' that conceptually laid the foundations of a good community for young children were identified. Parks, public transport, traffic safety, walkability, facilities and services, and housing were found to be critical built environment Foundational Community Factors for ECD.[8] However, these factors were primarily derived from qualitative data obtained from parents, service providers and other community stakeholders. While qualitative data provides important in-depth information about built environment factors, KiCS also initially aimed to create robust community indicators for ECD (specific, measurable and repeatable over time), yet faced limitations with the small quantitative sample available.[9] A key recommendation of the project was to strengthen the development of quantitative indicators. The development of the GIS-AEDC linked dataset is a key step toward achieving this.

The aim of this data linkage project was to develop and pilot test a unique dataset to determine which features of the built environment are associated with child development. The novelty of this dataset comes in the form of large-scale child development survey data with residential addresses linked to geographic information systems (GIS) built environment measures, thereby enabling unique neighbourhood exposures to be established for each participant. Other survey-to-GIS data linkage projects have successfully enabled the testing of associations between the built environment and a range of health outcomes for children through to older adults.[10] GIS is a software used to integrate and analyse spatial location of data, and organises layers of information into visualisations (e.g. maps).[11] As such, it can provide deeper insights into data, such as identifying and monitoring patterns, relationships, and situations[11] and can be effectively used to objectively measure features of the built environment.[12]

A key output of this project is the creation of the first Australian national dataset linking built environment measures to child development outcomes. The geographic coverage of this dataset includes all urban and major regional cities across Australia, containing information for more than 200,000 children aged approximately five years. Through an ongoing research program this dataset will be used to develop and test a suite of evidence-based indicators for optimal child development that can be used by a range of stakeholders across Australia. For international audiences, promising indicators may be tested with available location-specific built environment and child development data.

1.2.1 Why is it better to calculate spatial measures around a child's home address?

To calculate spatial measures for each child's neighbourhood, it is necessary to define their 'neighbourhood' so we can measure the built environment within it. Previous studies have used different spatial boundaries to define the neighbourhood, which may have implications for the strength and direction of findings. Errors in accurately capturing the neighbourhood may contribute to measurement error and attenuate associations; this is referred to as the 'Modifiable Areal Unit Problem' (MAUP) (i.e. bias due to aggregating geographic scales) in neighbourhood research.[13] Examples of pre-defined or administrative spatial boundaries include cities, towns, suburbs/postcodes, census tracts, health districts and school areas. Pre-defined buffers may imprecisely represent children's actual 'neighbourhood' because they may not necessarily correspond to areas that children travel to or use. Therefore, the built environment features which children are exposed to may vary considerably depending on how their 'neighbourhood' is defined.

In the absence of obtaining accurate accounts of where children visit (e.g. global positioning system technology), children's 'neighbourhoods' are typically represented by circular ('as the crow flies') or network buffers (along the street or pedestrian network) ranging from 400m to 1600m (approximately 5-20 minutes walking time) around their home, provided home addresses can be obtained and geocoded. Network buffers are currently best practice. We argue that utilising the smallest geography possible is ideal for this type of research, as it allows for a more accurate representation of an individual's 'neighbourhood'. Compared with using larger geographies, working with the smallest geographic units means that inequities can be more accurately captured and measured *between* as well as *within* areas of interest. Moreover, by working with small geographic units there is also the opportunity to aggregate geographic units (e.g. combine to represent a larger area around the child's home) if needed.

1.2.2 Data linkage stages and processes

This project linked conceptually-derived spatial (GIS) measures of the neighbourhood built environment to child development outcomes from the 2015 Australian Early Development Census (AEDC). The AEDC is a national progress measure of children's development, as assessed by the child's classroom teacher at school entry. The AEDC is administered every three years, funded by the Australian Government Department of Education and Training. The AEDC is an internationally-validated and reliable Australian child population measure of ECD, and provides teacher-reported national data on five key child development domains: physical health and wellbeing, social competence, emotional maturity, language and cognitive skills (e.g. academic learning), and communication skills and general knowledge.[14] These domains are salient and interrelated aspects of healthy ECD, with each child scored on these domains, and subsequently categorised

as: 'developmentally vulnerable', 'developmentally at risk', and 'developmentally on track'.

Developmentally vulnerable on one or more AEDC domains (DV1) is the key outcome variable of interest.

Through our pilot work we have sourced spatial data and created theoretically-informed neighbourhood spatial measures using GIS. The stages of data linkage are illustrated in Figure 2. With funding from the Australian Government Department of Social Services, the Social Research Centre (SRC) on behalf of the Australian Government Department of Education and Training (data custodians), provided geocoded addresses (latitude/longitude coordinates) of 2015 AEDC participants living in urban and major regional Australian cities, to the Australian Institute of Family Studies (AIFS). AIFS, an approved data linkage body, provided a de-identified AEDC participant list that included an additional 5% false addresses to RMIT University, to help ensure anonymity. SRC also provided the 2015 AEDC content data to AIFS.

Spatial measures of the built environment (e.g. distance from home to the closest park) around each geocoded point (i.e. home address) were calculated. The values derived from the built environment measures were attached to this dataset and returned to AIFS, who removed the false addresses and de-identified the final linked dataset by removing the geocodes, and integrated the spatial built environment measures with AEDC content data (e.g. child development outcomes). The final de-identified linked dataset was provided to the research team for analysis.

Approvals from the Royal Children's Hospital (RCH) Human Research Ethics Committee (HREC) (#30016), RMIT University HREC (#0000020749), AEDC data custodians (180130C), and the authorised data linkage agency (AIFS) were obtained for this project. A memorandum of understanding between AIFS and the Australian Government Department of Education and Training was also undertaken.

Figure 2 illustrates the steps taken to link the individualised built environment measures (created using GIS) to child development outcome data (collected as part of the 2015 AEDC). Data linkage was undertaken by AIFS in 2019.

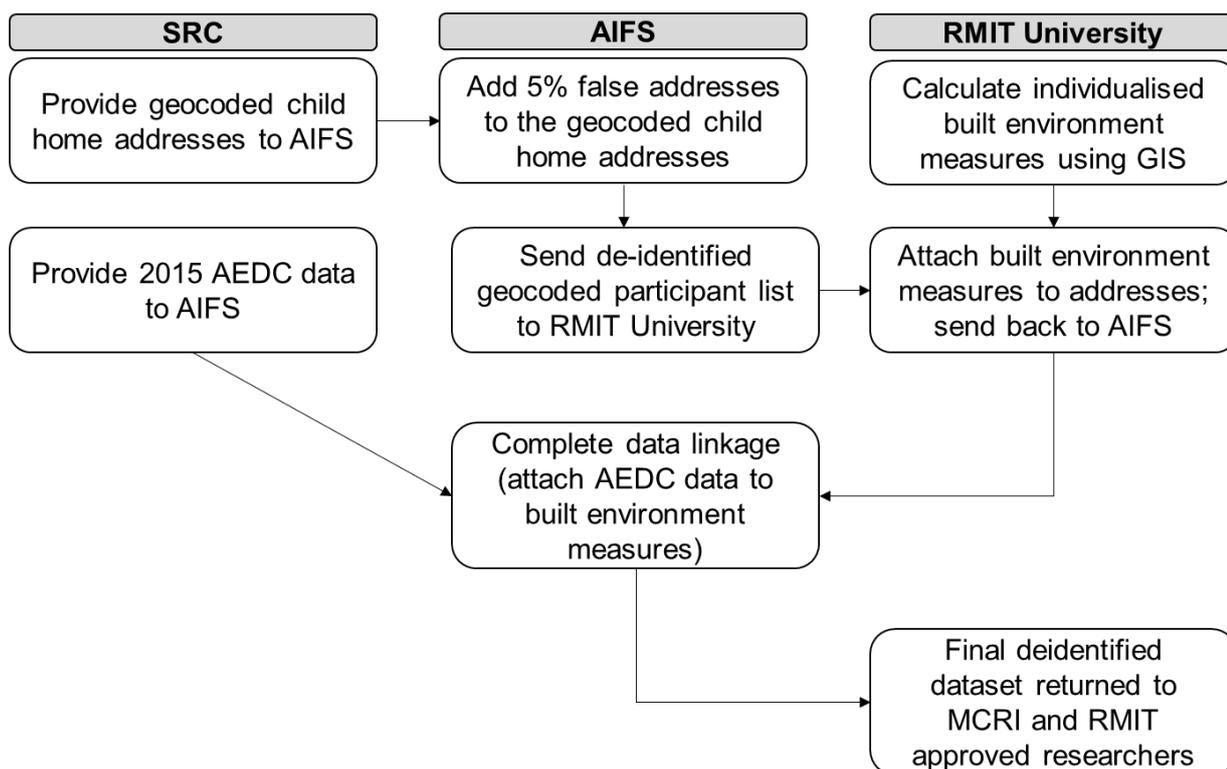


Figure 2. Steps in the data linkage process

AEDC Australian Early Development Census. AIFS Australian Institute of Family Studies. SRC Social Research Centre. MCRI Murdoch Children’s Research Institute

1.3 Aims of pilot testing

The aim of this project was to pilot the use of the linked dataset to analyse associations between the built environment and child development outcomes. We selected six measures of the built environment theorised to be important to child development, based on the best available evidence. For each of these six measures, we sought to answer the following research question:

After accounting for family and neighbourhood socioeconomic circumstances, which neighbourhood built environment features are associated with child development (odds of developmental vulnerability on at least one domain)?

1.4 Research translation and target audience

Findings from this project will inform further testing and identification of indicators that are associated with an ECD supportive neighbourhood. Indicators are useful tools in engaging communities, policymakers, and urban planners in dialogue about how to support young children and families. Further, indicators can be used by planners and policymakers to benchmark, monitor progress, and guide interventions and investments that support optimal child development. For example, policy-makers can use indicators to identify ‘pockets’ of inequitable distribution of physical access to services or destinations within suburbs and cities.

Part 2 Dataset and measures

2.1 Description of the GIS-AEDC linked dataset

The GIS-AEDC linked dataset includes observations for 235,655 children living in urban and major regional areas of Australia (roughly 80% of the Australian child population). As the GIS-AEDC dataset does not include children living rural or remote areas, the dataset is smaller than the overall 2015 AEDC sample, which includes 302,003 children total representing over 96% of Australian children.[15, 16] The GIS-AEDC linked dataset is cross-sectional, meaning that it offers a 'snapshot' of child development (taken in 2015) and children's neighbourhood built environments across the largest 21 Australian cities and towns in all eight states and territories.[14, 17]

2.1.1 Measures included

This section details the measures included in the GIS-AEDC linked dataset.

a. Built environment measures in the GIS-AEDC dataset

Over 80 spatial measures of the built environment (housing affordability, neighbourhood public open space, early child education and care access/quality) were conceptually derived through an ongoing child liveability research program.[3, 18] These measures were operationalised using GIS software as part of the National Liveability Indicators research program at RMIT University. All distance measures were calculated using the street network.

The measures used data from a variety of sources, including: Australian Census (2016); OpenStreetMap; the Australian Children's Education & Care Quality Authority (ACECQA), the National Health and Services Directory (NHSD). OpenStreetMap is a community contributed global database of geographic information available to use under an open license. It was used as a source for national road data, open space, and for destinations where alternative nationally consistent sources were not available.[19] The National Quality Standard (NQS) assesses Australian early childhood education and care and outside school hours care services against seven quality areas that are important outcomes for children (i.e. educational program and practice, children's health and safety, physical environment, staffing arrangements, relationships with children, collaborative partnerships with families and communities).[20] These services are rated against each of the seven quality areas in the NQS and given an overall rating based on these results (e.g. meeting NQS, exceeding NQS).

b. Built environment measures for pilot testing

Based on the best available international evidence,[21] six measures were initially earmarked as promising measures for pilot testing (**Table 1**). These measures fall across three domains of the neighbourhood built environment: neighbourhood housing, public open space, and social infrastructure.

Table 1. Built environment measures for pilot testing

Measure	Description	Data source(s)
Neighbourhood housing: Dwelling density per hectare	Defined as 'dwelling density per hectare for local 1600m walkable neighbourhoods' where 'walkable neighbourhoods' represent the walkable road network extending 1600m from a child's residence in either direction, including all destinations along this road network.[8, 22]	Australian Census (2016); OpenStreetMap (2018); Healthy Liveable Cities Group Indicators (2018)
Public open space: Distance to closest public open space	Road network distance from child's residence to the closest public open space. This measure was limited to a maximum distance of 3200m (values above 3200m represented less than 1% of participants).	OpenStreetMap (2018)
Public open space: Count of public open space within 800m	Count of public open space within 800m of child's residence in either direction along the road network.	OpenStreetMap (2018)
Social infrastructure: Distance to closest early childhood education and care centre (any)	Road network distance from child's residence to the closest early childhood education and care centre. This measure was limited to a maximum distance of 3200m (values above 3200m represented less than 1% of participants).	Australian Children's Education Quality and Care Authority (2018)
Social infrastructure: Count of early childhood education and care centres (any) within 1600m	Number of early childhood education and care centres (inclusive of any type, e.g. preschools, childcare centres) within 1600m of a child's residence in either direction along the road network.	Australian Children's Education Quality and Care Authority (2018)
Social infrastructure: Count of early childhood education and care centres (any) meeting NQS within 1600m	Number of early childhood education and care centres (inclusive of any type, e.g. preschools, childcare centres) that are either meeting or exceeding NQS within 1600m of a child's residence in either direction along the road network.	Australian Children's Education Quality and Care Authority (2018)

NQS National Quality Standards.

c. Child development

The primary outcome measure examined was a Vulnerability Summary Indicator (DV1) from the AEDC which provides a binary (yes/no) indication of whether a child was developmentally vulnerable on at least one domain of child development. Each child was classified as being either 'vulnerable' or 'not vulnerable (on track)'.

d. Socioeconomic measures

Information on maternal education (highest education level achieved) was collected in relation to each child as part of the 2015 AEDC. Maternal education is a commonly used marker of individual

children's/families' socioeconomic circumstances.[23] The AEDC also utilises information on the socioeconomic context of children's neighbourhoods (i.e. whether a child resides in a disadvantaged neighbourhood). Neighbourhood disadvantage was measured using the 2016 Socioeconomic Index for Areas – Index of Relative Socioeconomic Disadvantage (SEIFA-IRSD), which is a composite variable comprising of 17 items and created by the Australian Bureau of Statistics (ABS) using Australian Census data.[24] This information is available in the dataset at statistical area level 1 (SA1), an average of 400 persons per area.[25]

e. Urban and regional areas

The AEDC records information about the child's area of residence and its remoteness (i.e. urban/major city, inner regional areas). Remoteness is classified into five categories (major city, inner regional, outer regional, remote, or very remote) according to the Australian Statistical Geography Standard Remoteness Structure.[25] This variable was included in the GIS-AEDC linked dataset and used to identify those living in urban/regional areas, as well as examining differences across urban/regional areas. It should be noted that the GIS-AEDC dataset only includes children living in major cities, inner regional (e.g. cities such as Hobart and Bendigo) and outer regional (e.g. towns like Darwin) areas, although a very small number of children classified as living in remote or very remote areas were included (less than 0.1% of participants). As around 80% of child participants in the dataset live in major cities, this measure was created as a binary variable (urban vs. regional) for analysis.

2.2 Cleaning the data

Data cleaning refers to the processes used to ensure the integrity of the dataset. These processes include: checking for missing data, checking that values are within a plausible range, and data reduction (a process of reducing the number of variables). Data cleaning was performed for key variables prior to analysis in August 2019.

Part 3 Analytical strategy

3.1 Analytical approach

Sample characteristics were examined across several demographic variables (**Table 2**). Summary descriptive statistics (e.g. median values, interquartile range) were computed for each built environment measure in the overall sample of children. The median was reported because the built environment data were skewed. For each built environment measure, summary descriptive statistics were computed separately for children identified as being developmentally vulnerable or not (**Table 3**). Key selected neighbourhood built environment features were mapped for Australia's largest 21 cities (see **Appendices**).

Data were analysed using logistic regression, while accounting for the clustering of children's development assessments within the same classroom (i.e. same teacher making the assessment). Accounting for clustering is necessary to produce accurate results, as children who were assessed by the same classroom teacher will have more similar scores compared with children assessed by a different teacher. Assumptions for logistic regression were tested, such as linearity of independent variables and log odds, and collinearity. Built environment measures were quartiled if they violated the assumption of being linearly related to the log odds. Closest distance to public open space (up to 3200m) and count of public open space within 800m remained continuous variables. Logistic regressions (unadjusted results, and results adjusted for socioeconomic factors) are presented in **Table 4**.

3.2 How did we account for socioeconomic factors and differences between urban and regional areas?

First, we explored differences in developmental outcomes across children from varying family socioeconomic circumstances (using maternal education as an indicator), across different levels of neighbourhood disadvantage (SEIFA-IRSD), and by urban/regional location (**Table 2**). We used logistic regression models to analyse the relationships between built environment features and child development while holding the following factors constant: child demographics (age, gender, Aboriginal and Torres Strait Islander, language background other than English), family socioeconomic circumstances (maternal education), neighbourhood disadvantage, state, and remoteness. Results should be interpreted as the associations between the built environment features of a child's neighbourhood and that child's odds (likelihood) of developmental vulnerability, holding these child, family, neighbourhood socioeconomic and urban/regional factors constant.

Part 4 Pilot testing results

4.1 Sample demographics

As shown in Table 2, a total of 235,655 children are included in the dataset. Most (73%) children were aged 5 years old. Overall, 47,416 children – about 1 in 5 children – were assessed by their teachers as being developmentally vulnerable on at least one domain of child development.

Table 2. Sample demographics, by child development outcomes

	Not developmentally vulnerable		Developmentally vulnerable on at least one domain (DV1)		Missing development outcome		Overall sample	
	n	%	n	%	n	%	n	%
Age group[#]								
Under 5 years	651	74.9	173	19.9	45	5.2	869	100
Age 5 years	128,733	74.5	36,866	21.3	7,139	4.1	172,738	100
Age 6+ years or older	46,752	75.3	10,377	16.7	4,919	7.9	62,048	100
Gender								
Female	94,639	82.39	16,410	14.29	3,816	3.32	114,865	48.74
Male	81,467	67.47	31,006	25.67	8,287	6.86	120,790	51.26
Maternal education*								
Year 9 or less	3,448	53.9	2,540	39.7	404	6.3	6,392	100
Year 10	7,584	62.6	3,737	30.9	792	6.5	12,113	100
Year 11	4,556	65.9	1,959	28.4	395	5.7	6,910	100
Year 12 or more	147,598	77.3	34,382	18.0	8,932	4.7	190,912	100
Missing	12,950	67.0	4,798	24.8	1,580	8.2	19,328	100
SEIFA-IRSD of SA1								
Q1 Most disadvantaged	24,128	64.2	10,945	29.1	2,503	6.7	37,576	100
Quintile 2	27,876	70.4	9,402	23.8	2,301	5.8	39,579	100
Quintile 3	33,674	74.9	8,965	19.9	2,300	5.1	44,939	100
Quintile 4	40,964	78.1	9,006	17.2	2,463	4.7	52,433	100
Q5 Least disadvantaged	48,834	81.1	8,907	14.8	2,498	4.1	60,239	100
Missing/not applicable	660	74.2	191	21.5	38	4.3	889	100
Aboriginal and Torres Strait Islander								
No	171,411	75.3	44,701	19.6	11,432	5	227,544	100
Yes	4,725	58.3	2,715	33.5	671	8.3	8,111	100
Language background other than English								
No	134,466	76.2	32,410	18.4	9,517	5.4	176,393	100
Yes	41,670	70.3	15,006	25.3	2,586	4.4	59,262	100
Child has special needs								
No	176,136	78.4	47,416	21.1	1,238	0.6	224,790	100
Yes	-	-	-	-	10,865	100	10,865	100

	Not developmentally vulnerable		Developmentally vulnerable on at least one domain (DV1)		Missing development outcome		Overall sample	
	n	%	n	%	n	%	n	%
Local community area remoteness category								
Major Cities	157,000	74.9	41,782	19.9	10,766	5.1	209,548	100
Regional (inner or outer)	19,116	73.3	5,631	21.6	1,336	5.1	26,083	100
Remote or very remote	20	83.3	3	12.5	1	4.2	24	100
State/Territory								
Australian Capital Territory	3,989	73.8	1,157	21.4	258	4.8	5,404	100
New South Wales	55,823	76.1	13,783	18.8	3,748	5.1	73,354	100
Northern Territory	1,340	70.3	458	24.0	107	5.6	1,905	100
Queensland	35,612	71.2	11,991	24.0	2,411	4.8	50,014	100
South Australia	10,968	72.4	3,270	21.6	919	6.1	15,157	100
Tasmania	2,955	76.1	769	19.8	157	4.0	3,881	100
Victoria	45,623	76.0	10,995	18.3	3,443	5.7	60,061	100
Western Australia	19,826	76.6	4,993	19.3	1,060	4.1	25,879	100
Total	176,136	74.7	47,416	20.1	12,103	5.1	235,655	100

*Based off the variable 'parent 1 schooling' where parent 1 is the main contact for the child. Previous Australian data shows that this is almost always the child's mother. #Age groups were derived from 15 age categories. The '5 years' age group includes some children slightly less than age 5 years (ages 4 years 10 months and older) and the '6 years and older' group includes children ages 5 years 10 months and older).

4.2 Descriptive statistics

Table 3 shows the distributions of the neighbourhood built environment features in the overall sample and by developmental outcomes. Neighbourhood built environment features were broadly similar across children assessed as being developmentally vulnerable and those who were not developmentally vulnerable. The medians are presented because of the skewed nature of the built environment measures; this allowed a more accurate comparison across built environment measures for children who were/were not developmentally vulnerable.

A selection of map case studies is presented in the **Appendices** to illustrate the variability in built environment measures tested. This includes example maps of a city with the lowest and highest value for dwelling density per hectare (**Appendix 1**), number of ECEC meeting NQS within 1600m of dwellings (**Appendix 2**), distance to closest ECEC (**Appendix 3**), count of public open space within 800m (**Appendix 4**) and distance to closest public open space (**Appendix 5**).

Within every city there is spatial variation (e.g. within local government areas (municipalities), suburbs or communities, and neighbourhoods). However, of the 21 largest Australian cities, the average local neighbourhood in Bendigo (Victoria) had the lowest dwelling density per hectare (8 dwellings/ha) while Sydney (New South Wales) had the highest at 22 dwellings per hectare. For the number of ECEC centres meeting NQS, the average local neighbourhood in eight of the 21

cities had access to 2 childcare centres meeting NQS within 1600m of dwellings while Sydney had the highest at 7. The average distance to the closest ECEC centre varied considerably amongst cities (range 595m-1600m). Five of the 21 cities had local neighbourhoods with access to an average of 3 public open spaces within 800m, with Canberra having the most access (9 public open spaces within 800m). The average local neighbourhood in all 21 cities had access to public open space within 500m.

While there are also different policy targets depending on the Australian state/territory, or city, mapping these features across an area allows patterns to be identified, and urban planners and policymakers to better understand how key infrastructure is being delivered and better target policies to address disparities in infrastructure provision.

Table 3. Neighbourhood built environment characteristics, by child development outcomes

	Median (25th percentile – 75th percentile)			
	Overall 21 cities (183,464 Mesh Blocks, weighted for dwellings)	Overall sample	Developmentally vulnerable on at least one domain (DV1)	Not developmentally vulnerable
Neighbourhood housing				
<i>Dwelling density per hectare</i>	12.9 (10.4 – 17.2)	12.2 (9.9 – 15.2)	12.1 (9.9 – 15.0)	12.2 (9.9 – 15.3)
Public open space				
Distance (m) to closest public open space	227 (131 – 376)	237 (116 – 403)	238 (116 – 409)	236 (116 – 403)
Count of public open space within 800m	4.7 (2.8 – 7.4)	4 (2 – 7)	4 (2 – 7)	4 (2 – 7)
Social infrastructure				
Distance (m) to closest ECEC centre (any type)	617 (392 – 930)	654 (409 – 999)	649 (406 – 987)	655 (410 – 1001)
Count of ECEC centres (any type) within 1600m	5 (2.5 – 8.6)	4 (2 – 8)	4 (2 – 7)	4 (2 – 8)
Count of ECEC centres (any type) meeting NQS within 1600m	3.8 (2 – 6.5)	3 (1 – 6)	3 (2 – 6)	3 (1 – 6)

See Table 1 for complete descriptions of neighbourhood built environment measures. *ECEC* early childhood education and care. *NQS* National Quality Standards.

4.3 Logistic regressions

In **Table 4**, the first model presents unadjusted results, while the second model shows results adjusted for a range of socioeconomic factors. After adjustment of socioeconomic factors, reduced odds of developmental vulnerability were found for children living in areas with the highest dwelling density per hectare (OR 0.92, 95% confidence interval 0.87-0.97). More quality childcare centres within 1600m of children’s homes were associated with less odds of developmental vulnerability in children (OR 0.92, 95% confidence interval 0.88-0.97). That is, children living with the most

childcare centres meeting Australian national quality standards were less likely to be developmentally vulnerable. This association was found before and after adjustment for socioeconomic factors. Public open space measures did not appear to be associated with developmental vulnerability at this stage.

Table 4. Associations between neighbourhood built environment characteristics and child development outcomes

	Developmentally vulnerable on at least one domain [#]	
	Unadjusted OR (95% CI)	Adjusted* OR (95% CI)
Neighbourhood housing		
Dwelling density per hectare (quartiles)		
Q1 (0.09 to 9.85)	Ref.	Ref.
Q2 (9.86 to 12.17)	1.09 (1.05-1.13) ^{***}	1.01 (0.97-1.05)
Q3 (12.18 to 15.23)	1.05 (1.01-1.09)	0.95 (0.91-0.99)
Q4 (15.24 to 81.01)	0.95 (0.91-1.00)	0.92 (0.87-0.97) ^{***}
Public open space		
Distance to closest public open space (per 100m)	1.00 (0.99-1.00)	1.00 (1.00-1.00)
Count of public open space within 800m	1.00 (0.99-1.00)	1.00 (1.00-1.00)
Social infrastructure		
Distance (m) to closest ECEC centre (any type) (quartiles)		
Q1 (0 to 409)	Ref.	Ref.
Q2 (410 to 654)	0.99 (0.96-1.02)	1.00 (0.97-1.04)
Q3 (655 to 999)	0.99 (0.96-1.02)	1.01 (0.98-1.05)
Q4 (1000 to 61642)	0.95 (0.92-0.99)	1.02 (0.98-1.06)
Count of ECEC centres (any type) within 1600m (quartiles)		
Q1 (0 to 2)	Ref.	Ref.
Q2 (3 to 4)	1.05 (1.02-1.09)	0.99 (0.95-1.02)
Q3 (5 to 8)	1.05 (1.01-1.09)	0.98 (0.94-1.02)
Q4 (9 to 45)	0.96 (0.92-1.01)	0.93 (0.88-0.98)
Count of ECEC centres (any type) meeting NQS within 1600m (quartiles)		
Q1 (0 to 1)	Ref.	Ref.
Q2 (2 to 3)	1.06 (1.03-1.10) ^{***}	0.98 (0.95-1.02)
Q3 (4 to 6)	1.07 (1.03-1.11) ^{***}	0.98 (0.94-1.02)
Q4 (7 to 39)	0.92 (0.88-0.96) ^{***}	0.92 (0.88-0.97) ^{***}

CI confidence interval. ECEC early childhood education and care. NQS National Quality Standards. *Adjusted for child characteristics (age, gender, Aboriginal and Torres Strait Islander, language background other than English), maternal education, neighbourhood socioeconomic composition (SEIFA-IRSD quintile), state, and remoteness. ***p<0.001

Part 5 Discussion

In piloting this linked dataset stage, we found that after adjustment of socioeconomic factors (e.g. maternal education, age of child, gender, socioeconomic status), children living in areas with a greater number of quality ECEC services meeting Australian standards[20] had significantly decreased odds of developmental vulnerability compared with those living in areas with fewer quality ECEC services available. We also found that children living in areas with the highest dwelling densities had significantly decreased odds of developmental vulnerability compared with those living in areas of the lowest dwelling densities.

Evidence suggests that attending childcare, preschool, and kindergarten programs are associated with children's outcomes such as learning and socio-emotional development.[26] Our preliminary findings are aligned with previous research indicating that successful child developmental outcomes depend, in part, on availability and quality of ECEC programs.[27] We also found higher dwelling densities were associated with reduced odds of developmental vulnerability. This measure of dwelling density did not refer to 'high-rise' housing developments per se, rather it refers to the number of dwellings in an area (e.g. per hectare). Higher dwelling densities may be a proxy for more walkable and well-connected neighbourhoods, which support a mix of destinations and facilities such as walking and cycling infrastructure, retail and other services.[12, 28] In turn, this may increase opportunities for families to access essential services for children as well as increasing social interaction and neighbourhood cohesion.[3] Recommendations for future research are mentioned in the conclusions and next steps further below.

5.1.1 Strengths

This dataset is the first of its kind to link specific and unique measures of children's neighbourhood built environment to a population census of ECD outcomes (i.e. the AEDC). The dataset includes over 200,000 children living in urban and major regional cities across Australia, and has provided a unique opportunity to initiate exploration into how built environments influence ECD. While the results will be generalisable to the Australian context, international jurisdictions with comparable data can also apply these methods to test the indicators in their contexts.

5.1.2 Limitations

As with any dataset, this pilot testing should be viewed in the light of its limitations, such as its limited family variables and its cross-sectional nature. Hence, causal links between the built environment and ECD cannot be assumed. In addition, while ECD outcomes were based on 2015 AEDC data, built environment data relied on data sources collected in other years (e.g. 2016 Australian Census, 2018 OpenStreetMap data). However, changes in the built environment usually take place over long periods of time, so it seems unlikely that major changes in the built environment would have occurred between 2015 and 2018. Some of the built environment data sources used here were not designed for research purposes, however these sources have been validated against other best-practice built environment datasets. Finally, due to lack of publicly available data on preschools in Tasmania and Western Australia, the ECEC measures in this analysis underestimate the actual local availability of ECEC services for children in these two states.

5.1.3 Conclusions and next steps

While only two of the six built environment measures tested in this pilot project yielded significant associations with ECD, we are not concluding there is no association with others (e.g. no relationship with public open space). From this initial pilot work, further work is now needed to refine built environment measures and geographic scales, use stronger analytical techniques to model associations between the built environment and ECD outcomes, and further explore these relationships with markers of socioeconomic status.

Our recommendations for refining built environment measures include generating more appropriate buffer sizes (e.g. 800m), further specificity in measures (e.g. high quality, type of destination or service), and better ways of retaining built environment variables as continuous exposure measures (rather than collapsing into quantiles). While categorising built environment measures is common, others have cautioned against this approach because it contributes to loss of information and power, and reduces comparability between studies since quantile cut-points are based on the sample distribution.[29, 30] Alternative techniques to percentile categorisation should be explored.

More complex modelling (e.g. multilevel modelling) is required to better understand the contribution of the built environment to ECD outcomes. Multilevel modelling is a statistical technique that accounts for 'nested' data, where participants (e.g. children) also belong to groups/clusters within the sample (e.g. classrooms, schools, or neighbourhoods). Further unpacking relationships between socioeconomic status, built environment features, and ECD can provide more insight into inequities in access and distribution. For example, previous research suggests that better quality

early childhood programs is particularly, and strongly associated with children's outcomes in disadvantaged areas.[27] In Australia, there is less availability of ECEC in more socioeconomically disadvantaged areas, and when provided, these programs provide a lower average quality of care than those located in more advantaged neighbourhoods.[31] Exploring modifiable leverage points of ECD-supportive built environments, and better understanding how these attributes are distributed according to neighbourhood disadvantage, diversity, and ECD outcomes, may help address gaps in ECD inequities.

The development and testing of the pilot dataset has enabled the possibility of further refining our linked measures, as well as testing more measures. For example, public transport, traffic safety, walkability, other facilities and services found to be critical built environment Foundational Community Factors for ECD in KiCS, [8] were not examined in this pilot project. However, there is opportunity to explore these. Through additional testing (outside the scope of this pilot project), this dataset will be used to develop a suite of evidence-based built environment indicators of ECD that can be translated into tools to help support urban planning decisions and policies. In this way, these tools can be used to better engage communities and policy makers in decision making, benchmarking, and monitoring progress of optimal built environments for young children that minimise gaps in ECD inequities. Further data visualisation will help in identifying neighbourhood inequities, that can in turn assist where and how to best target areas lacking in resources, policies and infrastructure.

Part 6 References

1. Irwin L. Early child development: A powerful equalizer. Final report for the World Health Organization's Commission on the Social Determinants of Health. 2007.
2. Leventhal T, Brooks-Gunn J. The neighborhoods they live in: the effects of neighborhood residence on child and adolescent outcomes. *Psychological Bulletin*. 2000;126(2):309-37.
3. Villanueva K, Badland H, Kvalsvig A, O'Connor M, Christian H, Woolcock G, et al. Can the neighborhood built environment make a difference in children's development? Building the research agenda to create evidence for place-based children's policy. *Academic Pediatrics*. 2016;16(1). doi: [10.1016/j.acap.2015.09.006](https://doi.org/10.1016/j.acap.2015.09.006)
4. Moore T, Arefadib N, Deery A, West S. *The First Thousand Days: An Evidence Paper*. Parkville, Victoria; 2017.
5. Bronfenbrenner U. *The Ecology of Human Development: Experiments by Nature and Design*. Cambridge, Massachusetts: Harvard University Press; 1979.
6. Waanders C, Mendez J, Downer J. Parent characteristics, economic stress and neighborhood context as predictors of parent involvement in preschool children's education. *Journal of School Psychology*. 2007;45:619-36.
7. Goldfeld S, Villanueva K, Tanton R, Katz I, Brinkman S, Woolcock G, et al. Kids in Communities Study (KICS) study protocol: a cross-sectional mixed-methods approach to measuring community-level factors influencing early child development in Australia. *BMJ Open*. 2017. doi: [10.1136/bmjopen-2016-014047](https://doi.org/10.1136/bmjopen-2016-014047)
8. Goldfeld S, Villanueva K, Lee J, Robinson R, Moriarty A, Peel D, et al. *Foundational Community Factors (FCFs) for early childhood development: A report on the Kids in Communities Study*. Melbourne, Australia; 2018.
9. Goldfeld S, Villanueva K, Tanton R, Katz I, Brinkman S, Giles-Corti B, et al. Creating community indicators for early childhood development: challenges and innovations from the Kids in Communities Study. *Cities & Health*. 2019. doi: [10.1080/23748834.2019.1596525](https://doi.org/10.1080/23748834.2019.1596525)
10. Villanueva K, Perieira G, Kniuman M, Bull F, Wood L, Christian H, et al. The impact of the built environment on health across the life course: design of a cross-sectional data linkage study. *BMJ Open*. 2013. doi: [10.1136/bmjopen-2012-002482](https://doi.org/10.1136/bmjopen-2012-002482)
11. ESRI. What is GIS? [Available from: <https://www.esri.com/en-us/what-is-gis/overview>].
12. Leslie E, Coffee N, Frank L, Owen N, Bauman A, Hugo G. Walkability of local communities: using geographic information systems to objectively assess relevant environmental attributes. *Health & Place*. 2007;13(1):111-22.
13. Jelinski D, Wu J. The modifiable areal unit problem and implications for landscape ecology. *Landscape Ecology*. 1996;11(3):129-40.
14. Brinkman S, Gregory T, Goldfeld S, Lynch J, Hardy M. Data resource profile: the Australian Early Development Index (AEDI). *International Journal of Epidemiology*. 2014;43(4):1089-96.
15. Australian Government Department of Education and Training. Trends from the AEDC. 2019. [Available from: <https://www.aedc.gov.au/resources/detail/trends-from-the-aedc>].
16. Australian Government Department of Education and Training. Research Snapshot: Trends in the number of children starting school with additional health and developmental needs from 2009 to 2015. 2014. [Available from: <https://www.aedc.gov.au/resources/research-snapshots>].
17. Australian Government Department of Infrastructure Transport Cities and Regional Development. National Cities Performance Framework 2017 [Available from: <https://smart-cities.dashboard.gov.au/all-cities/overview>].
18. Christian H, Ball S, Zubrick S, Brinkman S, Turrell G, Boruff B, et al. Relationship between the neighbourhood built environment and early child development. *Health & Place*. 2017. doi: [10.1016/j.healthplace.2017.08.010](https://doi.org/10.1016/j.healthplace.2017.08.010).

19. OpenStreetMap contributors. Planet dump. 2018.
20. Australian Children's Education and Care Quality Authority. National Quality Standard 2018 2018 [Available from: <https://www.acecqa.gov.au/nqf/national-quality-standard>].
21. Alderton A, Villanueva K, O'Connor M, Boulange C, Badland H. Reducing inequities in early childhood mental health: how might the neighborhood built environment help close the gap? A systematic search and critical review. . International Journal of Environmental Research and Public Health. 2019;16(9):1516.
22. Higgs C, Badland H, Simons K, Knibbs L, Giles-Corti B. The Urban Liveability Index: developing a policy-relevant urban liveability composite measure and evaluating associations with transport mode choice. International Journal of Health Geographics. 2019;18(1):14.
23. Desai S, Alva S. Maternal education and child health: is there a strong causal relationship? Demography. 1998;35(1):71-81.
24. Australian Bureau of Statistics. Census of Population and Housing: Socio-Economic Indexes for Areas (SEIFA), Australia, 2016, cat. no. 2033.0.55.001 2016 [Available from: <https://www.abs.gov.au/ausstats/abs@.nsf/mf/2033.0.55.001>].
25. Australian Bureau of Statistics. The Australian Statistical Geography Standard (ASGS) [updated July 2018. Available from: [https://www.abs.gov.au/websitedbs/D3310114.nsf/home/Australian+Statistical+Geography+Standard+\(ASGS\)](https://www.abs.gov.au/websitedbs/D3310114.nsf/home/Australian+Statistical+Geography+Standard+(ASGS))].
26. Barnett W, Ackerman D. Costs, benefits, and long-term effects of early care and education programs: Recommendations and cautions for community developers. Community Development. 2006;37(2):86-100.
27. Elliott A. Early childhood education: Pathways to quality and equity for all children. Camberwell, Victoria: Australian Council for Educational Research; 2006. [Available from: <https://research.acer.edu.au/aer/4/>].
28. Frank L, Sallis J, Saelens B, Leary L, Cain K, Conway T, et al. The development of a walkability index: application to the Neighborhood Quality of Life Study. British Journal of Sports Medicine. 2010. doi: [10.1136/bjism.2009.058701](https://doi.org/10.1136/bjism.2009.058701).
29. Lamb K, White S. Categorisation of built environment characteristics: the trouble with tertiles. International Journal of Behavioral Nutrition and Physical Activity. 2015;12(1):19.
30. Bennette C, A V. Against quantiles: categorization of continuous variables in epidemiologic research, and its discontents. BMC medical research methodology. 2012;12(1):21.
31. Cloney D, Cleveland G, Hattie J, Tayler C. Variations in the availability and quality of early childhood education and care by socioeconomic status of neighborhoods. Early Education and Development. 2016;27(3):384-401.

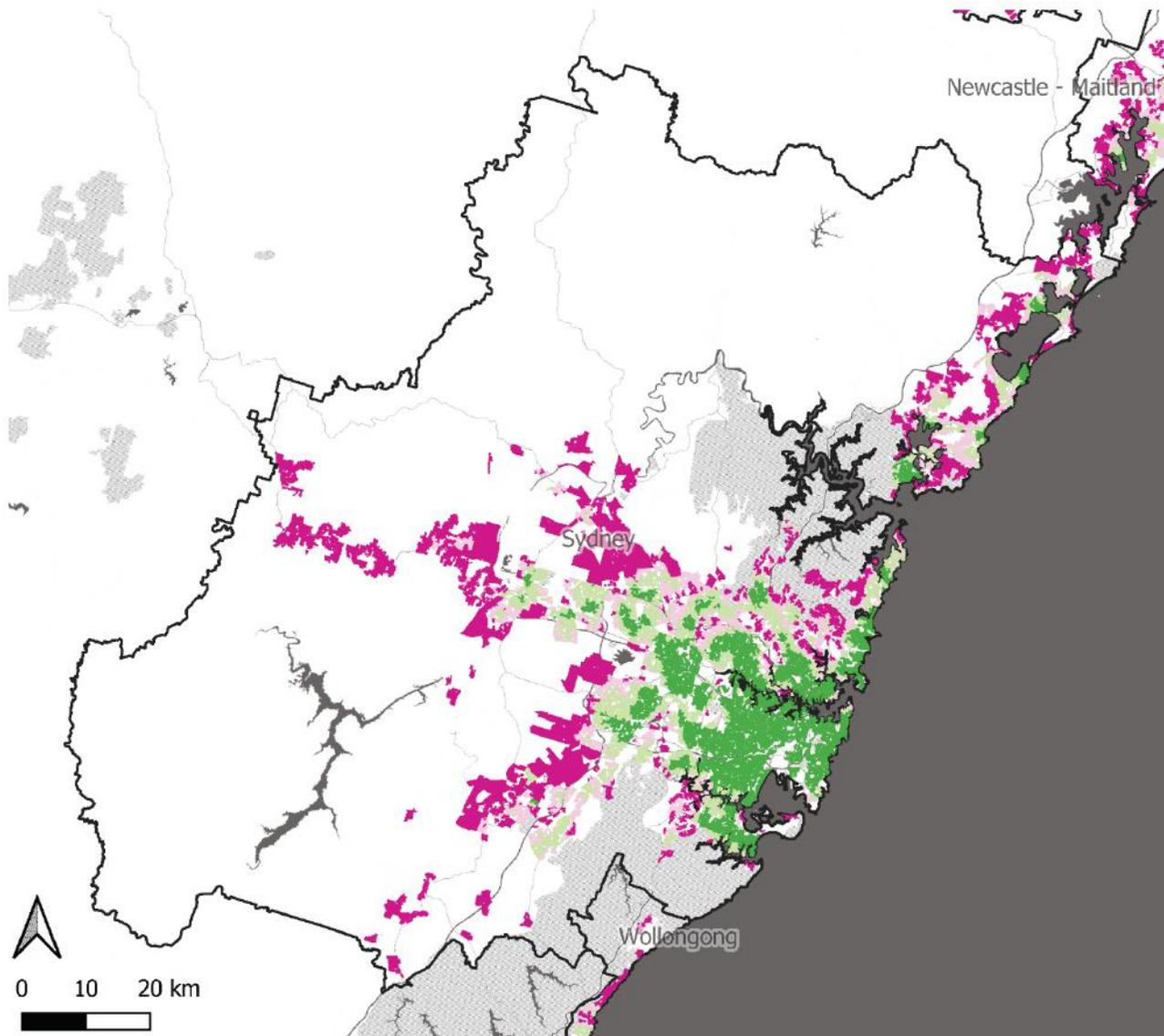
Appendices: Data visualisation (maps)

About these maps

The following appendices (1-5) present data visualisation (maps) for selected case studies (i.e. Australian cities or towns). Four Australian cities were chosen to illustrate geographic patterning within cities (Sydney, NSW and Bendigo, VIC for Appendices 1-3; Canberra, ACT and Launceston, TAS for Appendices 4-5; for a total of 10 maps). Each appendix includes data visualisation for one regional town (Bendigo, Launceston) and one major city (Sydney, Canberra).

Each map displays the built environment feature of interest measured at the SA1 level, mapped across the city. Built environment features were cut into quartiles based on values at the SA1 level for all 21 cities and towns in Australia, providing national comparison. In addition, each map provides an overall summary (i.e. average values) for that particular city.

Appendix 1: Dwelling density per hectare



Sydney

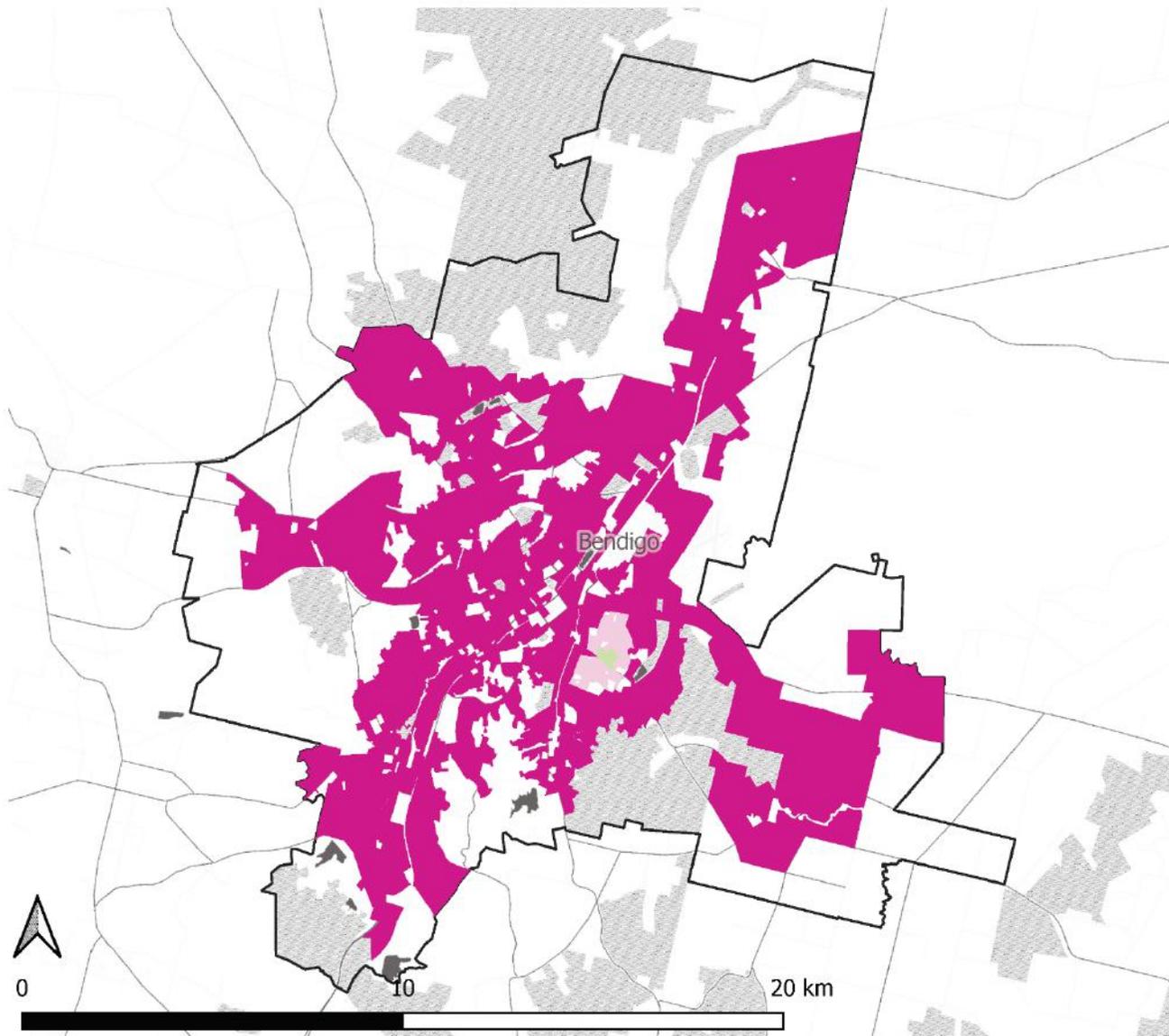
Dwellings per hectare (quartiles)

- 0.6 - 10.3
- 10.3 - 12.6
- 12.6 - 16.1
- 16.1 - 79.9

In Sydney, the average local neighbourhood has a dwelling density of 22 dwellings per hectare.

This map displays quartiles of dwelling density relative to ABS Statistical Area 1 (SA1) regions across 21 of Australia's largest cities.





Bendigo

Dwellings per hectare
(quartiles)

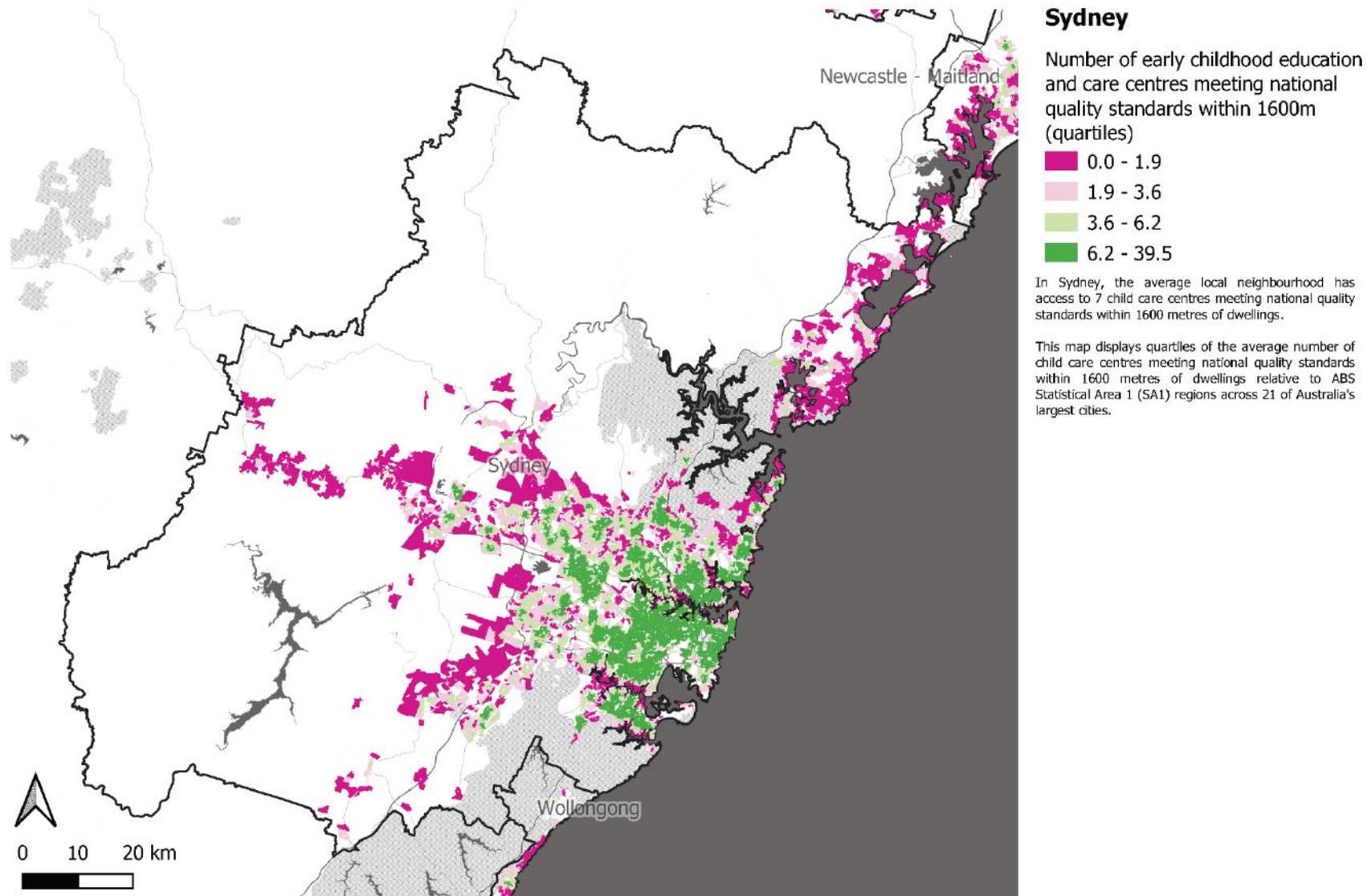
- 0.6 - 10.3
- 10.3 - 12.6
- 12.6 - 16.1
- 16.1 - 79.9

In Bendigo, the average local neighbourhood has a dwelling density of 8 dwellings per hectare.

This map displays quartiles of dwelling density relative to ABS Statistical Area 1 (SA1) regions across 21 of Australia's largest cities.

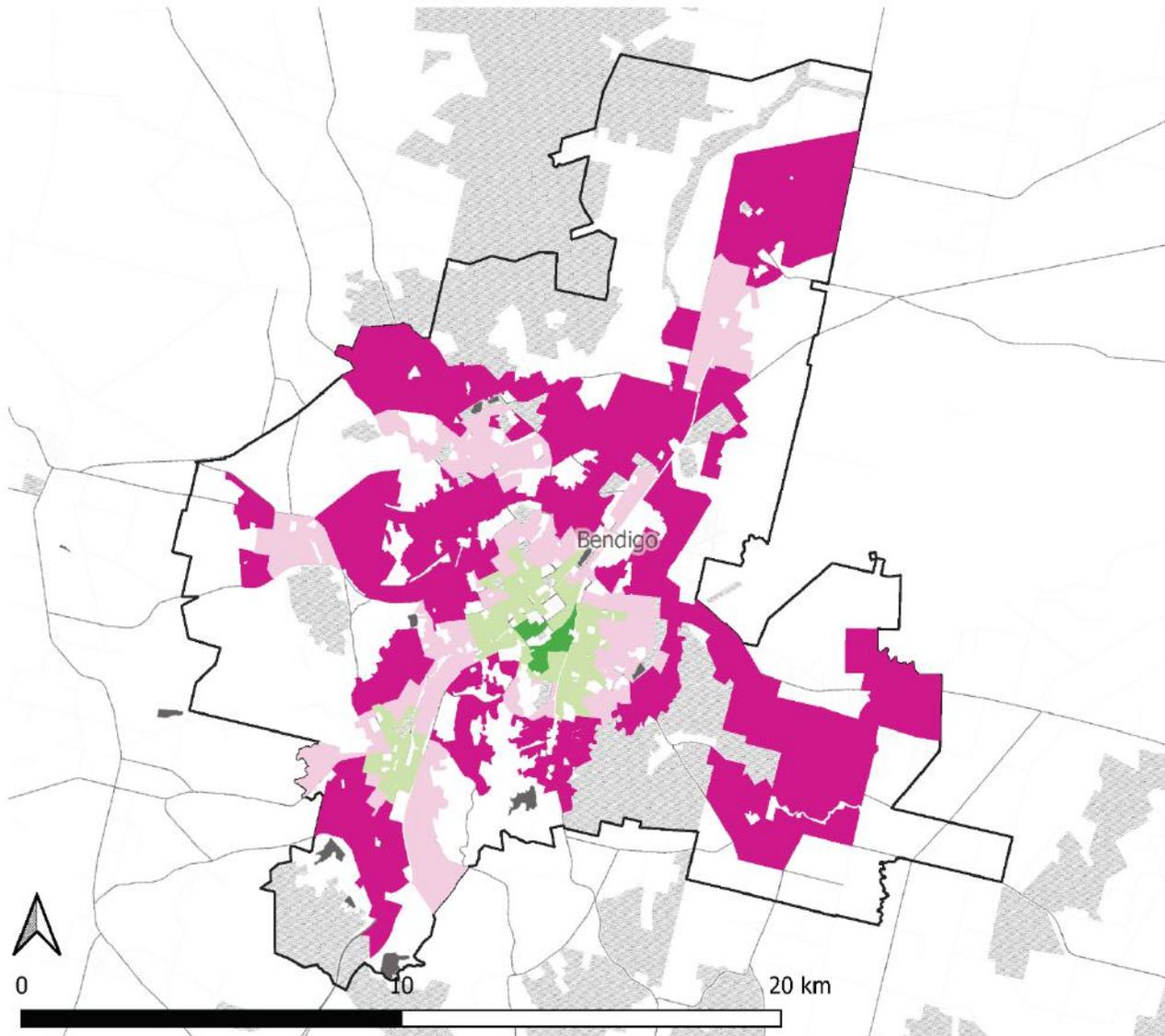


Appendix 2: Count of ECEC services meeting NQS within 1600m



Healthy Liveable Cities group, RMIT University 2019 CC BY-NC-ND 4.0 | Boundary and dwelling data: Australian Bureau of Statistics (ABS), 2016 under CC by 3.0 | Routable network data: OpenStreetMap, 2018 under ODbL | Childcare data: Australian Children's Education and Care Quality Authority (ACECQA), 2018 | Map tiles: Stamen Design, under CC BY 3.0, featuring data by OpenStreetMap, under ODbL.





Bendigo

Number of early childhood education and care centres meeting national quality standards within 1600m (quartiles)

- 0.0 - 1.9
- 1.9 - 3.6
- 3.6 - 6.2
- 6.2 - 39.5

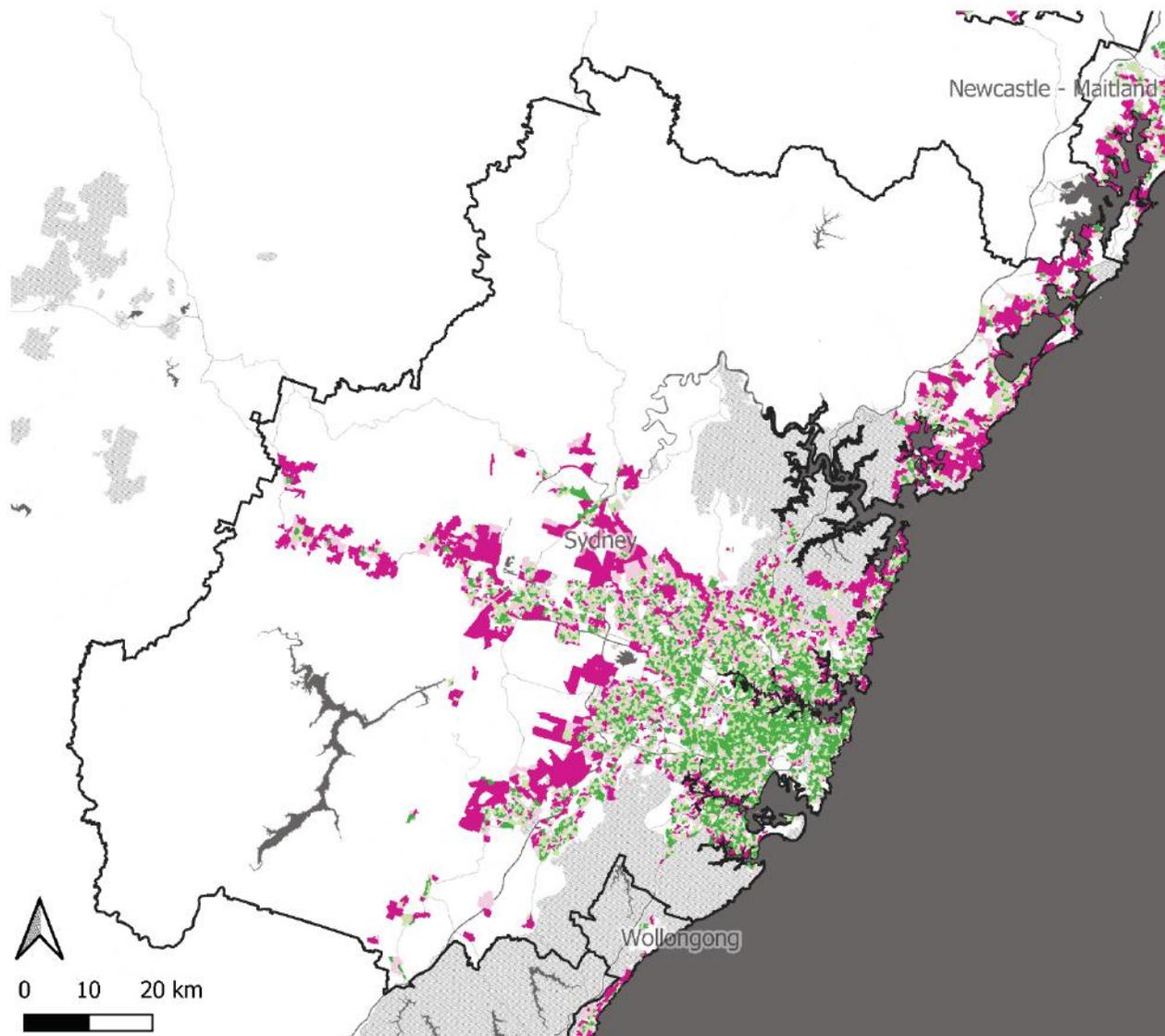
In Bendigo, the average local neighbourhood has access to 2 child care centres meeting national quality standards within 1600 metres of dwellings.

This map displays quartiles of the average number of child care centres meeting national quality standards within 1600 metres of dwellings relative to ABS Statistical Area 1 (SA1) regions across 21 of Australia's largest cities.

Healthy Liveable Cities group, RMIT University 2019 CC BY-NC-ND 4.0 | Boundary and dwelling data: Australian Bureau of Statistics (ABS), 2016 under CC by 3.0 | Routable network data: OpenStreetMap, 2018 under ODbL | Childcare data: Australian Children's Education and Care Quality Authority (ACECQA), 2018 | Map tiles: Stamen Design, under CC BY 3.0, featuring data by OpenStreetMap, under ODbL.



Appendix 3: Distance to closest ECEC service



Sydney

Distance to nearest early childhood education and care centre (metres; quartiles)

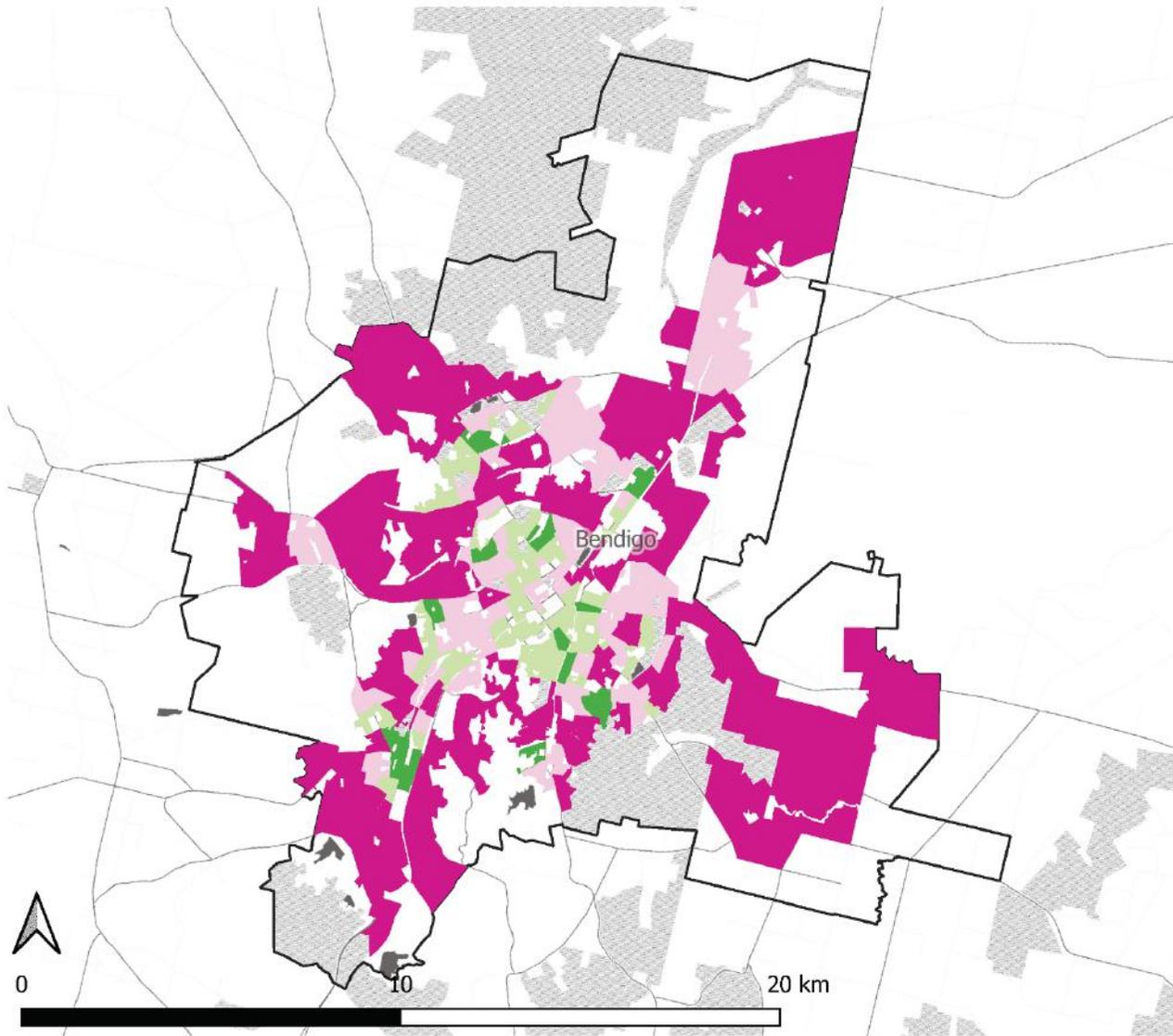
- 1 - 419
- 419 - 624
- 624 - 925
- 925 - 27924

In Sydney, the average local neighbourhood has access to a child care centre within 595 metres of dwellings.

This map displays quartiles of the average distance to the closest child care centre for dwellings relative to ABS Statistical Area 1 (SA1) regions across 21 of Australia's largest cities.

Healthy Liveable Cities group, RMIT University 2019 CC BY-NC-ND 4.0 | Boundary and dwelling data: Australian Bureau of Statistics (ABS), 2016 under CC by 3.0 | Routable network data: OpenStreetMap, 2018 under ODbL | Childcare data: Australian Children's Education and Care Quality Authority (ACECQA), 2018 | Map tiles: Stamen Design, under CC BY 3.0, featuring data by OpenStreetMap, under ODbL.





Bendigo

Distance to nearest early childhood education and care centre (metres; quartiles)

- 1 - 419
- 419 - 624
- 624 - 925
- 925 - 27924

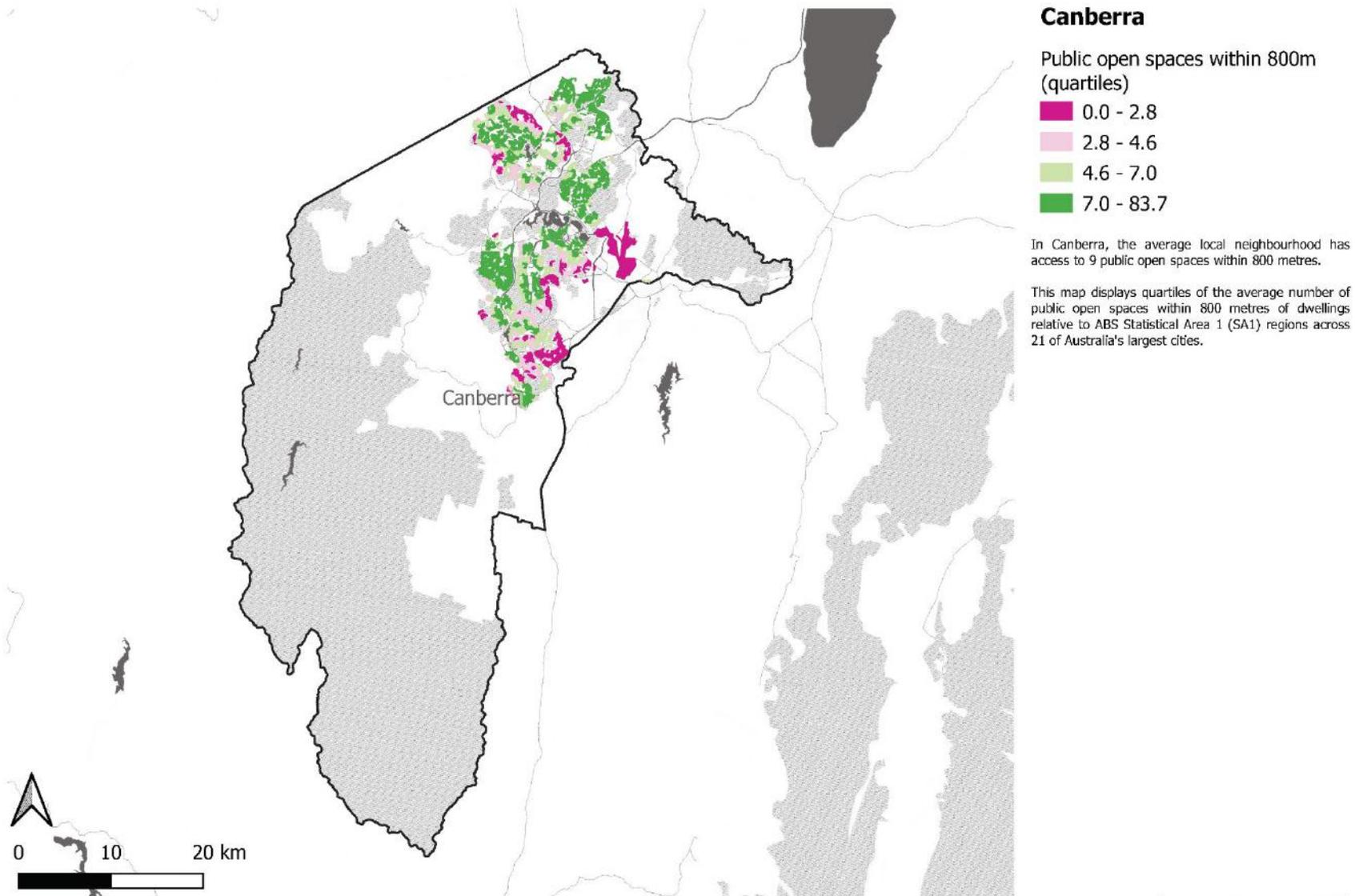
In Bendigo, the average local neighbourhood has access to a child care centre within 1,049 metres of dwellings.

This map displays quartiles of the average distance to the closest child care centre for dwellings relative to ABS Statistical Area 1 (SA1) regions across 21 of Australia's largest cities.

Healthy Liveable Cities group, RMIT University 2019 CC BY-NC-ND 4.0 | Boundary and dwelling data: Australian Bureau of Statistics (ABS), 2016 under CC by 3.0 | Routable network data: OpenStreetMap, 2018 under ODbL | Childcare data: Australian Children's Education and Care Quality Authority (ACECQA), 2018 | Map tiles: Stamen Design, under CC BY 3.0, featuring data by OpenStreetMap, under ODbL.

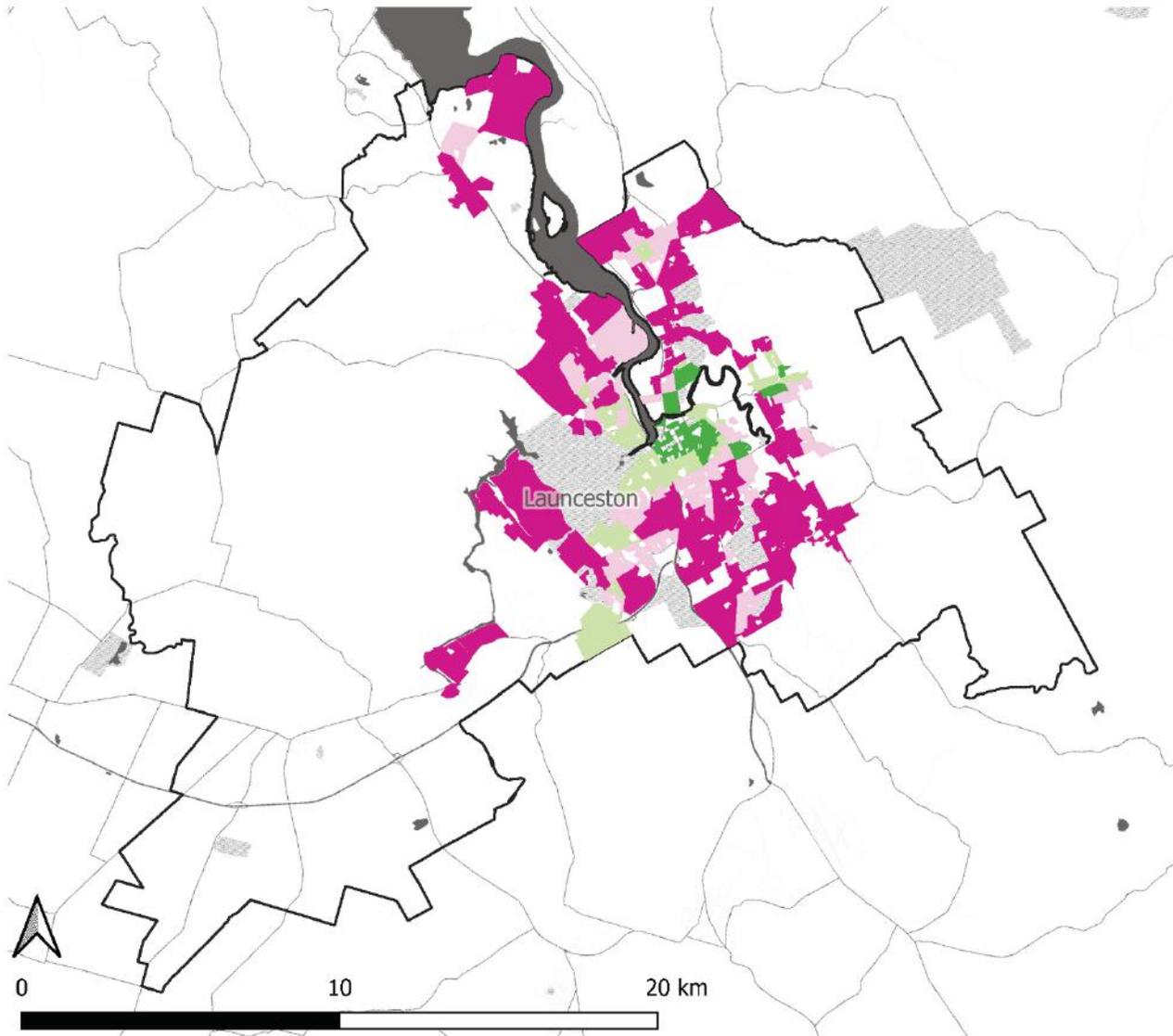


Appendix 4: Count of public open space within 800m



Healthy Liveable Cities group, RMIT University 2019 CC BY-NC-ND 4.0 | Boundary and dwelling data: Australian Bureau of Statistics (ABS), 2016 under CC by 3.0 | Routable network and public open space data: OpenStreetMap, 2018 under ODbL | Map tiles: Stamen Design, under CC BY 3.0, featuring data by OpenStreetMap, under ODbL.





Launceston

Public open spaces within 800m
(quartiles)

- 0.0 - 2.8
- 2.8 - 4.6
- 4.6 - 7.0
- 7.0 - 83.7

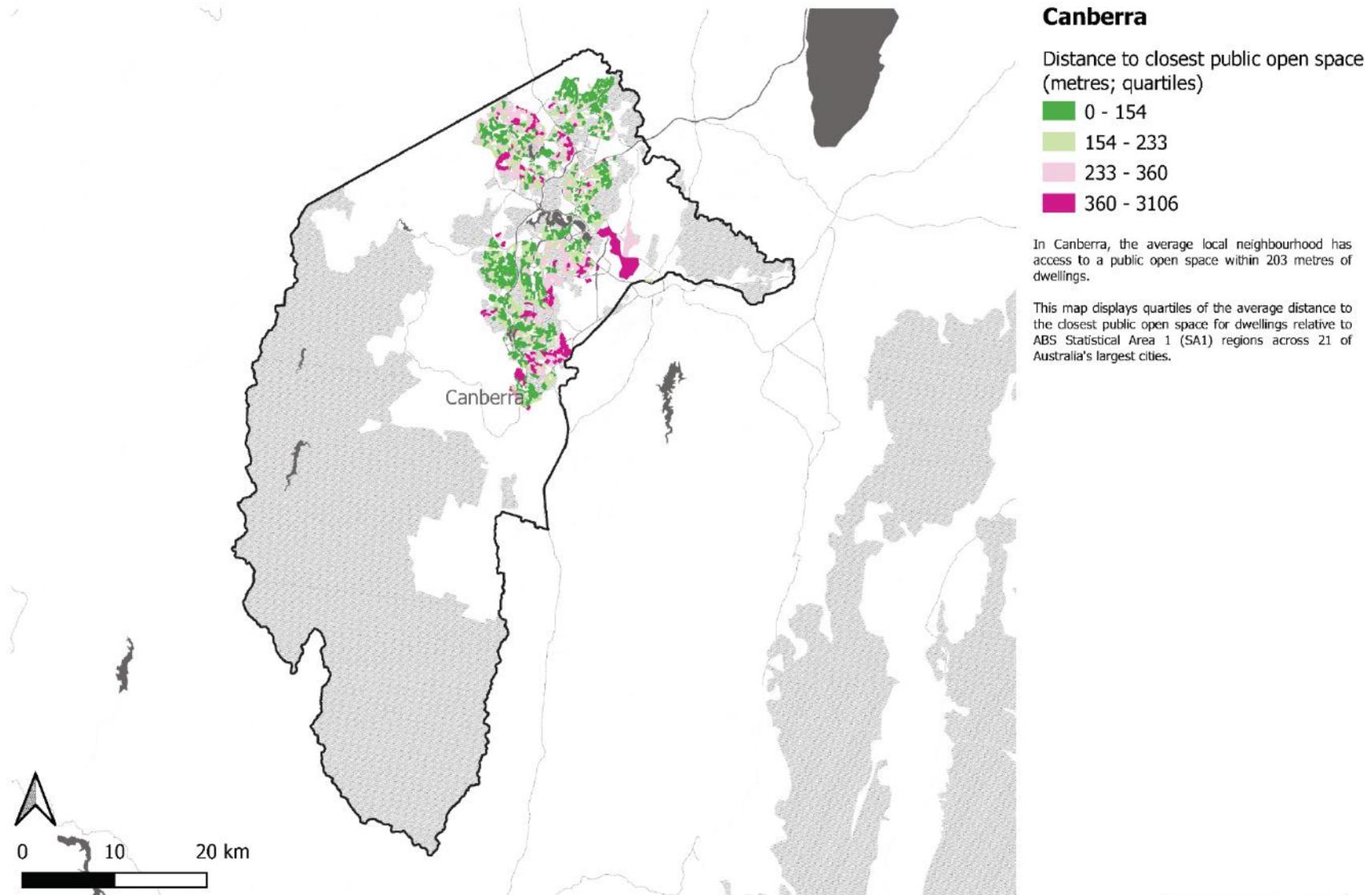
In Launceston, the average local neighbourhood has access to 3 public open spaces within 800 metres.

This map displays quartiles of the average number of public open spaces within 800 metres of dwellings relative to ABS Statistical Area 1 (SA1) regions across 21 of Australia's largest cities.

Healthy Liveable Cities group, RMIT University 2019 CC BY-NC-ND 4.0 | Boundary and dwelling data: Australian Bureau of Statistics (ABS), 2016 under CC by 3.0 | Routable network and public open space data: OpenStreetMap, 2018 under ODbL | Map tiles: Stamen Design, under CC BY 3.0, featuring data by OpenStreetMap, under ODbL.



Appendix 5: Distance to closest public open space



Canberra

Distance to closest public open space (metres; quartiles)

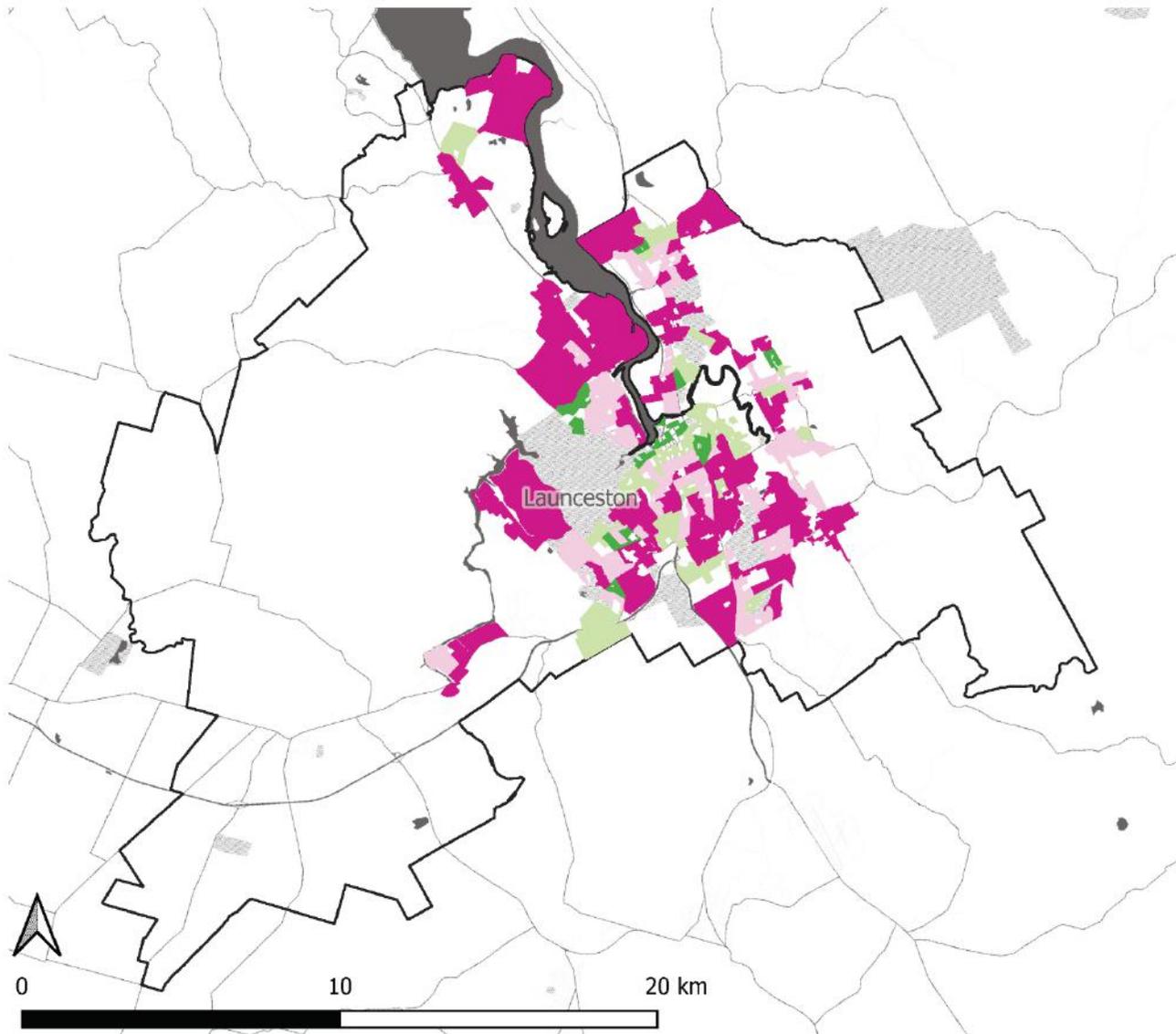
- 0 - 154
- 154 - 233
- 233 - 360
- 360 - 3106

In Canberra, the average local neighbourhood has access to a public open space within 203 metres of dwellings.

This map displays quartiles of the average distance to the closest public open space for dwellings relative to ABS Statistical Area 1 (SA1) regions across 21 of Australia's largest cities.

Healthy Liveable Cities group, RMIT University 2019 CC BY-NC-ND 4.0 | Boundary and dwelling data: Australian Bureau of Statistics (ABS), 2016 under CC by 3.0 | Routable network and public open space data: OpenStreetMap, 2018 under ODbL | Map tiles: Stamen Design, under CC BY 3.0, featuring data by OpenStreetMap, under ODbL.





Launceston

Distance to closest public open space (metres; quartiles)

- 0 - 154
- 154 - 233
- 233 - 360
- 360 - 3106

In Launceston, the average local neighbourhood has access to a public open space within 432 metres of dwellings.

This map displays quartiles of the average distance to the closest public open space for dwellings relative to ABS Statistical Area 1 (SA1) regions across 21 of Australia's largest cities.

Healthy Liveable Cities group, RMIT University 2019 CC BY-NC-ND 4.0 | Boundary and dwelling data: Australian Bureau of Statistics (ABS), 2016 under CC by 3.0 | Routable network and public open space data: OpenStreetMap, 2018 under ODbL | Map tiles: Stamen Design, under CC BY 3.0, featuring data by OpenStreetMap, under ODbL.

