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Delayed Disaster Impacts on Academic Performance of Primary School Children

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Social disruption caused by natural disasters often interrupts educational opportunities for children. However, little is known about children's learning in the following years. This study examined change in academic scores for children variably exposed to a major bushfire in Australia. Comparisons were made between children attending high, medium, and low disaster-affected primary schools 2–4 years after the disaster (n = 24,642; 9–12 years). The results showed that in reading and numeracy expected gains from Year 3 to Year 5 scores were reduced in schools with higher levels of bushfire impact. The findings highlight the extended period of academic impact and identify important opportunities for intervention in the education system to enable children to achieve their academic potential.

Natural disasters arise from many different types of hazards and cause widespread destruction, and often death and injury. The size and severity of the event often undermines the capacity of systems and services to respond, resulting in significant loss of infrastructure and facilities. The subsequent ongoing stressors and social disruption add to the trauma of the original event and can reduce mental health and well-being for years afterward (Bonanno, Brewin, Kaniasty, & La Greca, 2010; Bryant et al., 2014; Bryant et al., 2017). In addition to the direct threats of the disaster experienced by adults, children can experience specific challenges associated with different stages of physical, mental, emotional, cognitive, and social stages of development (Anderson, 2005; Bonanno et al., 2010; Peek, 2008).

One of the potential disruptions for children after disasters involves access to schools because school facilities may be destroyed, teachers are not available, or children are relocated (Casserly, 2006;

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Sacerdote, 2008). The likely influence of the individual, family, social, and systemic stressors on child academic achievement have been known for some time (Vogel & Vernberg, 1993), but the evidence base for the nature, extent, and timing of postdisaster impacts on child academic performance is still limited.

The evidence related to trauma exposure in early childhood has shown a range of developmental impacts that may be relevant to academic performance. This includes changes in neurodevelopmental processes such as myelination, synaptogenesis, and pruning. These processes underlie the development of functional neurocircuits and white matter tracts in the brain that in turn facilitate the normal development of cognitive, emotional, social, behavioral, and physical skills (De Bellis & Zisk, 2014; Gabowitz, Zucker, & Cook, 2008; McCrory, DeBrito, & Viding, 2010). Neuropsychological deficits associated with early childhood trauma and posttraumatic stress disorder (PTSD) have been well documented and include difficulties in attention, working memory, speed of processing, memory retrieval, and executive skills such as planning, problem solving, error monitoring, and set shifting, as well as less severe difficulties in language and visual integration skills (Barrera-Valencia, Calderón-Delgado, Trejos-Castillo, & O'Boyle, 2017; Samuelson, Krueger, Burnett, & Wilson, 2010; Spann et al., 2012). Although the majority of research into understanding the neuropsychological impacts of early trauma exposure and PTSD has been done with children exposed to significant maltreatment (Kavanaugh, Dupont-Frechette, Jerskey, & Holler, 2017; Masson, Bussieres, East-Richard, Mercier, & Cellard, 2015), a small number of studies have documented similar cognitive deficits in children exposed to other types of trauma including disasters (Parslow & Jorm, 2007; Turley & Obrzut, 2012). The relationship between specific neuropsychological skills and academic achievement is complex and likely changes as the child develops (Cragg & Gilmore, 2014). Literacy skills in particular are multifactorial and each component (e.g., spelling, reading accuracy, reading fluency, and reading speed) is thought to have different cognitive mechanisms underlying them (Moll et al., 2014; Ozernov-Palchik, Yu, Wang, & Gaab, 2016). Working memory and speed of processing are considered to be core skill requirements (among others) for the development of both numeracy and reading skills in early primary school children (Cragg & Gilmore, 2014; Geary, Hoard, Byrd-Craven, Nugent, & Numtee, 2007; Moll et al., 2014; Wang et al., 2016; Welsh, Nix, Blair, Bierman, & Nelson, 2010). However, as reading progresses, visual verbal integration skills and rapid automatized naming (involving rapid retrieval of the names of sequential visually presented items) along with higher executive functions become important skills that can differentially impact the acquisition of literacy skills (Moll et al., 2014; Ozernov-Palchik et al., 2016). Similarly, continued achievement in mathematics is dependent upon the development of broader executive functions (Cragg & Gilmore, 2014).

The available evidence indicates that early interruptions to the development of these cognitive skills can have adverse impacts on academic performance at primary, secondary, and university levels (Di Pietro, 2015; Pane, McCaffrey, Kalra, & Zhou, 2008; Peek & Richardson, 2010; Pérez-Pereira, Tinajero, Rodríguez, Peralbo, & Sabucedo, 2012; Scott, Lapré, Marsee, & Weems, 2014). In the disaster context such interruptions may arise from the development of a trauma-related mental health disorder, such as PTSD, or be due to ongoing stressors such as having to relocate to another school in another location as a result of the disaster (McFarlane, Policansky, & Irwin, 1987; Pane et al., 2008; Sacerdote, 2008; Scott et al., 2014). Age-based differences emerged in a study with primary and secondary school children 1 year after an oil spill disaster affecting coastal towns in Spain, suggesting stage of development may be a factor in determining subsequent impacts on academic performance (Pérez-Pereira et al., 2012). Conversely, no significant difference was found for completion of secondary school certificates between disaster-affected and nondisaster-affected students 2 years after the Canterbury, New Zealand earthquakes (Beaglehole, Bell, Frampton, & Moor, 2017), or in academic outcomes for primary school children in the Netherlands up to 3 years after a major firework disaster (Smilde-van den Doel, Smit, & Wolleswinkel-van den Bosch, 2006). The authors in the Netherland study speculated these positive outcomes may have been due to various school-based intervention programs for affected children. This is supported by other studies that indicate that positive school environments can, over time, mitigate the disaster-related impacts on academic performance (Barrett, Ausbrooks, & Martinez-Cosio, 2012; Pane et al., 2008; Peek & Richardson, 2010; Reich & Wadsworth, 2008; Sacerdote, 2008). This has not been specifically evaluated in disaster contexts; however, a meta-analysis of the impact of social and emotional learning programs in schools generally, demonstrated improved academic performance across all year levels (Durlak, Weissberg, Dymnicki, Taylor, & Schellinger, 2011).

The trajectory for potential disaster impacts on academic achievement over time is unknown because

the majority of the current evidence base only extends to 3 years postdisaster, although a 20 year follow-up of children affected by a disaster did demonstrate that those who were bushfire affected were less likely than the comparison group to extend their education and careers (McFarlane & Van Hooff, 2009). Further examination of this issue is of paramount importance because of the potential for short-term impacts on academic performance to affect perceptions of capability, aspirations, and long-term educational and employment pathways.

This article reports on a study of academic scores for primary school children in Victoria, Australia up to 4 years after a major bushfire event in February 2009, commonly referred to as the Black Saturday bushfires (another term for "bushfire" is "wildfire"). The aim was to identify whether:

1. students in schools with high and medium bushfire impact showed reduced progression in their academic scores from Year 3 to Year 5 compared to their peers in schools with low or no impact, and;
2. if there were differences in impact for different school subjects.

Black Saturday Bushfires

The 2009 fires in rural Victoria began in January after a decade-long drought. The fire conditions became extreme, beginning in the east of the state and continuing to burn for several weeks. On saturday 7, February temperatures climbed to 47°C (117°F), winds gusted at over 100 km/h (60 mph), and multiple new fires ignited across the rural and regional parts of the state. The fires burned 400,000 hectares of landscape, completely destroyed two townships and significantly damaged others resulting in widespread destruction and the loss of 173 lives including 35 children and young people. Sixteen children and young people were orphaned, and many more were injured and traumatized by their experiences (Victorian Bushfires Royal Commission, 2009). One hundred and nine communities self-identified as being affected by bushfires. Over 2,000 homes were destroyed, three schools and at least three preschools were completely destroyed in the fires with staff and students housed in temporary accommodation for up to 2 years. Over 70 schools and childcare settings in high impact areas were highly affected through building and student exposure, as were other community resources such as sporting facilities and playgrounds, resulting in family, school, and community level disruption for years after the event.

Methods

Participants

This study utilized two major data sets held by the Victorian Department of Education and Training: (a) Enrollment in the first year at a Victorian primary school is accompanied by a parent completed School Entrant Health Questionnaire (SEHQ), which collects health, well-being, development, and demographic information about the student; (b) Standardized National Assessment Program—Literacy and Numeracy (NAPLAN) academic assessments are conducted in Grades 3 and 5 in primary school and Years 7 and 9 in secondary school. The students included in this study were 33,690 students who in 2008 were enrolled in first year at a Victorian government primary school and completed their standardized NAPLAN academic assessments in 2011 (Grade 3) and 2013 (Grade 5). Students were excluded if they changed schools between Grade 3 and Grade 5. Students' NAPLAN results were matched with their SEHQ data. After this matching process the final sample available for the analyses was n = 24,642 students (female = 11,982; male = 12,660).

Measures

Bushfire Affectedness

Schools included in this study were located in areas that receive fire protection from the Country Fire Authority (CFA) rather than the Metropolitan Fire Brigade. This classification was used as a proxy indicator to identify schools located in peri-urban, rural, regional, and remote communities to minimize confounding factors that would arise from comparison with urban schools. The included schools were then classified into three levels of bushfire affectedness (0—low, 1—moderate, 2—high). Classification followed a complicated geospatial procedure using the Victorian Bushfire Reconstruction and Recovery Authority data. There were 78 primary schools (n = 1,285) in localities defined as a "high" bushfire affectedness region based on loss of lives and properties. There were an additional 50 schools (n = 832) that were defined as being in a "moderate" affected region because they were located in a catchment zone adjacent to a high impact locality. The remaining 1,073 schools (n = 22,525) were defined as being in a "low" affected region because very limited

or no damage occurred and there was no loss of lives. They were all classified as "low" rather than "no" impact because even the areas that did not have fire come through were at risk on the day of the fires, their local CFA services were all involved in fire response, and many of the communities were affected by subsequent road closures and service disruptions. This classification procedure was designed by the University of Melbourne Centre for Disaster Management and Public Safety.

National Assessment Program—Literacy and Numeracy

The NAPLAN tests are run annually in Australian primary schools for students in Grade 3 and Grade 5. They are designed to assess four education domains of reading, writing, numeracy, and language conventions. The language conventions are further subdivided into spelling and grammar.

School Entrant Health Questionnaire

Household language. Is the primary household language English? (0—no, 1—yes).

Aboriginal or Torres Strait Islander. Is the student an Aboriginal or Torres Strait Islander (ATSI)? (0—no, 1—yes).

Lives with both parents. Does the student live with both parents? (0—no, 1—yes).

Parents Evaluation of Developmental Status. The Parents Evaluation of Developmental Status pathway is based on parent responses to questions about the child covering eight domains; (a) expressive language and articulation; (b) receptive language; (c) fine motor skills; (d) gross motor skills; (e) behavior; (f) social-emotional; (g) self-help; (h) school. Parents report whether they have concerns in these domains (yes or no). Children are rated for risk, from 1 to 4, with higher scores indicating lower risk, based on the number of items which are scored as "yes."

Mother's education/father's education. The mother's and father's education was a self-report question whereby the parent's highest level of school education was selected as either: "Year 9 or Equivalent or below"; "Year 10 or Equivalent"; "Year 11 or Equivalent"; or, "Year 12 or Equivalent."

Statistical Analyses

When data intrinsically have a hierarchical or clustered structure then multilevel models (MLM) are specifically designed for these types of analyses (Hox, 1998). As is the case in most educational research the data in this study are nested at the individual (Level 1) and within schools (Level 2), which supports the use of MLM analyses. Regardless of whether the primary variables of interest are at the individual or school level, failure to account for the clustering effects can lead to incorrect conclusions due to inaccurate calculations of standard errors and confidence intervals (Maas & Hox, 2004).

We ran our analysis using Mplus version 7.4 (Muthén & Muthén, 2013) with the robust maximum likelihood estimator. Our analysis is a specific type of MLM—random slope analysis. Furthermore, we include the test of whether the random slopes are predicted by the level of bushfire affectedness (i.e., low, moderate or high level of affectedness). Our analysis will control for school clustering effects when defining the slope of change at the individual level, predicting Year 5 NAPLAN domain scores based on corresponding Year 3 NAPLAN domain scores.

In our study, we are primarily focused on whether the level of bushfire affectedness predicts a difference in academic performance at the school level. Therefore, at the higher level of the model we will include bushfire affectedness as a predictor of the slope. If this affectedness level significantly predicts the slope, then the rate of change between Year 3 NAPLAN domain scores and Year 5 NAPLAN domain scores is different between the schools within the three affectedness levels. To account for the influence of demographic factors, we have included "Lives with both parents," "Home language English," "ATSI status," "Mother's level of education," "Father's level of education," "Gender," and "Pediatric Health" as controlling variables for the Year 3 and Year 5 NAPLAN scores. The analysis will account for these demographic influences prior to defining the slope between Year 5 and Year 3 NAPLAN scores.

In simple terms, our analysis will define a slope that represents the relationship between Year 3 NAPLAN scores predicting Year 5 NAPLAN scores. The scores at both year levels are controlled for by relevant demographic variables to minimize noise. As the data are clustered we run this analysis using the recommended MLM approach. Finally, at the school level we investigate the impact of bushfires on the slopes, which were defined at the individual level. This will investigate whether the 2009 Black Saturday bushfires are influencing the natural relationship between Year 3 and Year 5 NAPLAN scores. These analyses have been run five times separately for each of the NAPLAN domains: (a) reading, (b)

writing, (c) spelling, (d) numeracy, and (e) grammar. We ran the multilevel analyses with list wise deletion for missing data enabled, as per the Mplus default settings.

Results

Descriptive Statistics

Demographic details are provided in Table 1. Dependant samples *T*-tests found that both overall and for each affectedness region separately, NAPLAN domain scores in Grade 5 were significantly higher compared with domain scores in Grade 3 (all $p < .001$). Chi-square tests were conducted to compare categorical variables across affectedness regions and found the proportion of students who lived with both parents was significantly lower ($p = .004$) in the high impact region (84.4%) compared with the medium impact (88.9%) and the low impact (87.4%) regions. Additionally, the proportion of mothers who had a minimum level of education being Year 12 or equivalent was significantly lower ($p < .001$) in the high impact (51.8%) and medium impact (56.0%) regions compared with the low impact region (64.4%). Similarly, the proportion of fathers who had a minimum level of education being Year 12 or equivalent was significantly lower ($p < .001$) in the high impact (40.2%) and medium impact (42.4%) regions compared with the low impact region (56.2%). There were no other differences in the demographic variables.

Table 1
Student Participants' Demographics

Measure	*M* (*SD*)/proportion
Age[a]	9.97 (0.42)
Gender (% female)	48.60%
ATSI (% yes)	1.60%
Home language English (% yes)	88.80%
Lives with both parents (% yes)	87.30%
Mother education (mode)	Year 12 + (63.5%)
Father education (mode)	Year 12 + (55.0%)
PEDS	
High risk	6.80%
Moderate risk	16.60%
Low risk	8.20%
None	68.40%
Region impact	
Low (*n*)	22,525 (91.4%)
Medium (*n*)	832 (3.4%)
High (*n*)	1,285 (5.2%)
NAPLAN[b] Grade 3 (2011)	
Reading	435.17 (88.35)
Writing	424.04 (60.86)
Spelling	416.58 (74.96)
Numeracy	417.52 (74.17)
Grammar	436.96 (93.24)
NAPLAN Grade 5 (2013)	
Reading	511.31 (65.47)
Writing	489.59 (60.78)
Spelling	498.02 (68.38)
Numeracy	496.81 (73.25)
Grammar	507.83 (71.21)

Note. ATSI = Aboriginal or Torres Strait Islander; PEDS = Parents Evaluation of Developmental Status; NAPLAN = National Assessment Program—Literacy and Numeracy.
[a]Age at February 1, 2013 (Grade 3). The data were captured in whole years and did not include months. [b]The range of possible scores in each domain for each year level is 0–1,000 (Australian Curriculum Assessment and Reporting Authority, 2013).

Multilevel Results

The full details of the separate multilevel analyses for each of the five NAPLAN domains can be seen in Table 2. In Level 1 we see across all five NAPLAN domains 29 of 35 controlling variables were significant for Year 3 scores, and there were 28 of 35 that were significant for Year 5 scores, although there were some differences in which variables were significant at each year level.

At Level 2 we find the predictive relationship between Year 3 and Year 5 NAPLAN scores is unaffected by level of bushfire impact for the writing, spelling, and grammar domains. Conversely, the predictive relationship between Year 3 and Year 5 NAPLAN scores is affected by level of bushfire impact for the reading and numeracy domains. In both sets of analysis there was a significant negative relationship at Level 2 between the slope and affected level, therefore as affected level increases the slope decreases, or the slope becomes flatter between Year 3 NAPLAN and Year 5 NAPLAN. That is, we find a flattened developmental trajectory between Year 3 and Year 5 NAPLAN scores (reading and numeracy) for those individuals in schools that have been more affected by the bushfires.

To investigate the differences in the slopes for the reading and numeracy domains across the levels of bushfire affectedness, subpopulation analyses were run in Mplus using the Complex data command to control for clustering effects when calculating standard errors in the model. The differences in the slopes across bushfire affectedness regions can be seen in Figure 1. This figure shows the comparative standardized beta weights for Year 5 NAPLAN domain scores being predicted by Year

Table 2
Multilevel Model Unstandardized Parameter Coefficients (B) *and Significance Tests* (p) *at Level 1 and Level 2 for NAPLAN Domains Reading, Writing, Spelling, Maths, and Grammar*

	Reading (n = 16,240)		Writing (n = 16,182)		Spelling (n = 16,254)		Maths (n = 16,147)		Grammar (n = 16,254)	
	B	*p*	*B*	*p*	*B*	*p*	*B*	*p*	*B*	*p*
Level 1										
Y3 NAPLAN										
Both parent	9.214	.001	3.345	.037	0.594	.603	3.908	.021	2.834	.084
Home lang	6.225	.006	−5.081	< .001	−7.207	< .001	−10.215	< .001	−3.731	.006
ATSI	−19.855	.002	−6.841	.064	−0.528	.847	−4.760	.152	−11.221	.005
Mother education	13.410	< .001	4.289	< .001	1.118	.001	2.569	< .001	4.513	< .001
Father education	13.030	< .001	4.391	< .001	1.956	< .001	3.108	< .001	3.961	< .001
Gender	13.577	< .001	12.639	< .001	3.192	< .001	−7.467	< .001	2.862	< .001
PEDS8	5.911	< .001	1.775	< .001	0.453	.109	0.874	.028	2.743	< .001
Y5 NAPLAN										
Both parent	1.692	.218	5.446	.004	5.822	.010	10.007	< .001	6.760	.017
Home lang	−0.372	.751	−5.410	< .001	−14.159	< .001	2.472	.233	2.040	.396
ATSI	−4.754	.130	−13.396	.002	−8.240	.161	−16.062	.001	−16.779	.031
Mother education	2.400	< .001	7.504	< .001	8.007	< .001	9.559	< .001	13.672	< .001
Father education	2.898	< .001	6.181	< .001	9.958	< .001	10.548	< .001	13.971	< .001
Gender	0.764	.263	19.927	< .001	12.709	< .001	−14.837	< .001	18.932	< .001
PEDS8	1.984	< .001	4.590	< .001	5.059	< .001	4.601	< .001	6.177	< .001
Level 2										
Slope										
AFFLVL	−0.038	< .001	−0.005	.739	−0.016	.101	−0.051	< .001	−0.675	.500
Y5NAPLAN										
AFFLVL	−1.508	.163	−1.659	.170	−1.096	.231	−2.735	.045	−3.014	.028
Y3NAPLAN										
AFFLVL	−4.862	.013	−1.702	.241	−4.853	.002	−3.036	.127	−4.646	.025

Reference category for gender = male. ATSI = Aboriginal or Torres Strait Islander; PEDS = Parents Evaluation of Developmental Status; NAPLAN = National Assessment Program—Literacy and Numeracy.

3 NAPLAN domain scores in each region separately after controlling for demographics. As we can see for the domains of reading and numeracy there is a pattern of reduction in the slope values with the increase in levels of bushfire affectedness. Although the scores for numeracy plateau between the "moderate" and "high" affected regions, they are both sufficiently less than the slope for the "low" region to find a significant result.

Discussion

This study analyzed primary students' academic performance from 2 to 4 years after the Black Saturday bushfires, adjusting for demographic factors collected 1 year before the bushfires. The analyses examined the level of improvement in academic scores from Year 3 to Year 5 across regions of impact (i.e., were the changes in academic scores over time the same for low-, moderate-, and high-affected regions). The results showed that in reading and numeracy the expected gains in academic scores from Year 3 to Year 5 were reduced with higher levels of bushfire impact. There were no significant trends in academic scores for the writing, spelling, and grammar domains of the academic assessment, and no gender differences in any of the scores.

This finding demonstrates the potential impact of disaster exposure on academic performance. The differential impact on subject performance was consistent with another study of student academic performance after a fire at a discotheque party in Sweden in which 63 young people were killed and 213 physically injured (Broberg, Dyregrov, & Lilled, 2005). The authors attributed this to the different levels of concentration required: "The most negative influence on schoolwork was reported for subjects demanding high concentration (e.g., mathematics,

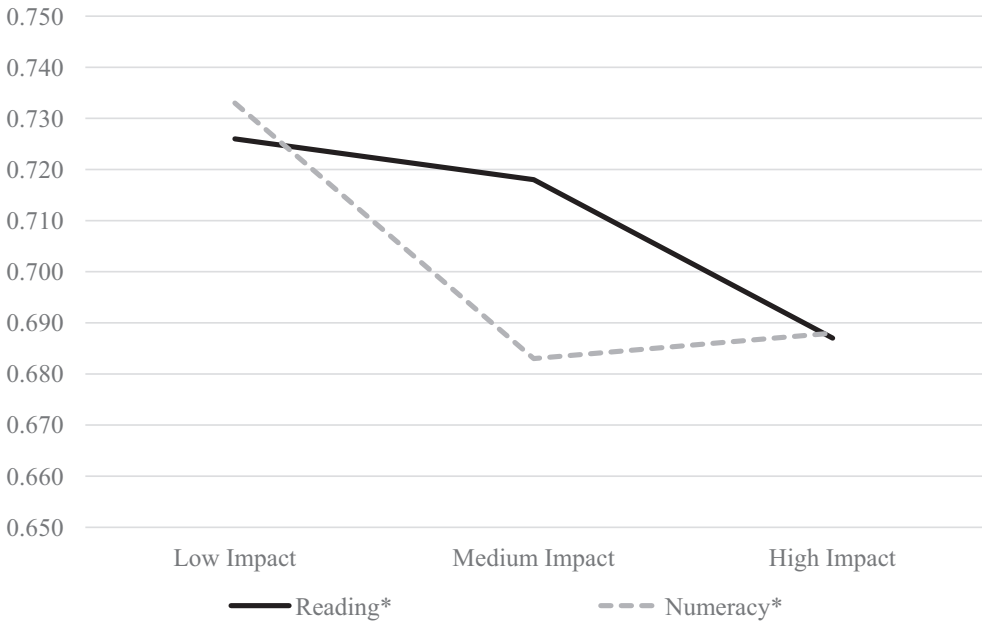

Figure 1. Standardized beta weights for Year 5 National Assessment Program—Literacy and Numeracy (NAPLAN) predicted by Year 3 NAPLAN across regions of bushfire affectedness.

physics, and grammar) whereas subjects like religion, psychology, and arts were reported to have become easier, more interesting or more important" (pp. 1282–1283). This may reflect a shift in student priorities and social and emotional responses to subject content following their loss and trauma experiences. Another explanation is that difficulties with certain subjects are mediated through the disruption of neuro-maturational processes that underlie the development of cognitive, social, and emotional building blocks necessary for academic achievement (De Bellis & Zisk, 2014; Gabowitz et al., 2008; McCrory et al., 2010).

Different types of cognitive deficits related to working memory, speed of processing, visual - verbal integration skills, rapid automatized naming, and higher executive functioning may have greater importance for particular types of learning. However, given that these same cognitive skills are known to be impacted by early trauma experiences and the development of PTSD, it is possible to hypothesize that the deficits in reading and numeracy demonstrated by the children in this study may be cognitively mediated (either directly or indirectly though the development of PTSD), as was reported in the Broberg et al. (2005) study. This is supported by evidence that lower socioeconomic status and proximity to disaster impact zone have been independently associated with higher risk for delayed development of these core neuropsychological skills (Welsh et al., 2010) as well as development of PTSD (Terasaka, Tachibana, Okuyama, & Igarashi, 2015).

Studies of children's postdisaster recovery trajectories have shown different groupings, reflecting individual variation in response to a given experience. Some children show resistance to disaster impacts, others show progressive recovery, and others show ongoing or delayed impacts (Kronenberg et al., 2010; La Greca et al., 2013; Saigh, Mroueh, & Bremner, 1997; Scott et al., 2014; Shannon, Lonigan, Finch, & Taylor, 1994). There are also likely to be different contributing factors to poor academic performance including persistent symptoms of PTSD and aggression (Scott et al., 2014), impacting on school satisfaction (Sims, Boasso, Burch, Naser, & Overstreet, 2015) and test anxiety (Weems et al., 2013) School staff are often acutely aware of the initial impacts of an emergency event on students' academic performance (Dyregrov, Dyregrov, Endsjø, & Idsoe, 2015). However, over time, parents and schools may not recognize that delayed impacts arise from the disaster experience, and therefore children may not be offered appropriate support programs (Gibbs et al., 2015; Grelland Røkholt, Schultz, & Langballe, 2016; Smilde-van den Doel et al., 2006).

The impact on reading results in this study may also have arisen due to reduced supported reading at home. Our previous work has shown that the bushfires and subsequent life stressors markedly

affected the mental health of parents up to 5 years later (Bryant et al., 2017), which could create a family environment that could hinder children's abilities to study and learn. We also note that parents in the high-affected region had lower education levels, and it is possible that this factor may have contributed to the poorer performance of children in these communities. No other studies of children's postdisaster academic performance have identified subject differences in impacts. However, a study of prenatal exposure to disaster has shown a similar association with lower third grade results in reading and maths (Fuller, 2014). It was not possible in this study to assess individual exposure to the disaster from the available data, including psychological or family factors that may moderate academic performance. Instead, attendance at schools in disaster impacted areas was used as a proxy for disaster exposure. At primary school level, the vast majority of students would be attending schools close to their home, as compared to secondary school for which many students travel longer distances.

It is also possible that academic performance was impaired because of substantial damage to infrastructure and social disruption in schools, which directly limited the accessibility of teaching facilities for children. Focusing on school-level impacts is helpful in highlighting the demands on school staff and resources (Alisic, Bus, Dulack, Pennings, & Splinter, 2012; Casserly, 2006), and the importance of a planned comprehensive program of postdisaster support for children. It has been suggested that school-level programs and high standards of academic achievement at students' new schools may mitigate the disruption and academic decline experienced by relocation (Barrett et al., 2012; Pane et al., 2008; Peek & Richardson, 2010). However, this is mostly based on research arising from Hurricane Katrina where the children moved away from schools that have been described as among the most poorly performing schools in the USA to schools with higher academic standards and expectations of students (Casserly, 2006; Peek & Richardson, 2010; Reich & Wadsworth, 2008). A combination of sensitive support from teachers, targeted academic support, and encouragement to engage in extracurricular activities have been indicated but not yet proven as factors likely to enable students to adjust to the school changes and thus to realize their academic potential (Barrett et al., 2012; Grelland Røkholt et al., 2016; Pane et al., 2008; Smilde-van den Doel et al., 2006). This provision of a positive supportive environment has been recognized more broadly as an important element in child and youth resilience (Durlak et al., 2011; Ungar, 2011), and mental health promotion (Weare & Nind, 2011). Further research would be helpful to identify the content and dose of school-level interventions most likely to support positive postdisaster outcomes. Additional examination of regional differences would also provide insights into the influence on student resilience of wider factors such as levels of available resources, local recovery processes, and social connectedness.

In the data sets utilized for this study, it was not possible to track students who moved to different schools during their primary school years. This means that the final sample only included students who attended the same school in Prep, Grade 3, and Grade 5. It is possible that some students temporarily relocated and then returned between the study measures. However, children who permanently relocated were not included in the sample because of the difficulties in linking the data. This is a limitation of the study. Families who relocated following the Black Saturday bushfires were most likely to have been significantly affected in terms of property loss (Gibbs et al., 2016). Other postdisaster studies have also shown that children who relocated to new areas and schools were most at risk initially of poor academic outcomes (Pane et al., 2008; Peek & Richardson, 2010; Sacerdote, 2008). Therefore, the results in this study may represent an underestimation of the disaster impacts on academic achievement. In fact, high mobility in school years is generally considered a risk factor for academic achievement (Obradovic et al., 2009) particularly if it occurs for "negative" reasons, but the effect may be a proxy for a range of other high-risk factors such as low income, marginalized social groups, and non-nuclear families (Pane et al., 2008). As previously noted, in a postdisaster context, it appears that the initial negative consequences of shifting to a new school in a new area may be offset by a positive school culture (Barrett et al., 2012; Peek & Richardson, 2010).

Conclusion

This study contributes new findings about delayed impacts on academic achievements for children living in postdisaster communities. It extends the existing evidence base by examining the period up to 4 years after the event and identifies a subject-specific depression in academic achievements over time for reading and numeracy that clearly differentiates between different levels of bushfire affectedness at the school

level. Given the apparent delayed impact, previous findings in the literature of no impact within a 3-year period of the disaster event should be reviewed. Although it is positive to find no difference in those early years after the event, the risk is that subsequent impacts on academic performance are overlooked and, without targeted interventions, children's future academic trajectories, and life opportunities may be compromised. There is emerging evidence that the early neurodevelopmental impacts of trauma may only be observed at later stages of development when key abilities are due to emerge, for example, the development of executive skills through adolescence. Without early intervention, these adverse developmental trajectories have the potential to impact educational and functional outcomes many years down the track. It is promising that the wider evidence base indicates there are opportunities to mitigate negative impacts on child academic achievements through positive multilevel school strategies. This provides direction for research, policy, and school-level planning and response to disaster events. This study may also be used to guide future research studies into the developmental factors likely to be underlying the delayed impacts on academic achievement specifically relating to reading and numeracy.

References

Alisic, E., Bus, M., Dulack, W., Pennings, L., & Splinter, J. (2012). Teachers' experiences supporting children after traumatic exposure. *Journal of Traumatic Stress*, *25*, 98–101. https://doi.org/10.1002/jts.20709

Anderson, W. A. (2005). Bringing children into focus on the social science disaster research agenda. *International Journal of Mass Emergencies and Disasters*, *23*, 159–175. http://ijmed.org/articles/376/download/

Australian Curriculum Assessment and Reporting Authority. (2013). *NAPLAN achievement in reading, persuasive writing, language conventions and numeracy: National report for 2013*. Sydney, NSW: Author.

Barrera-Valencia, M., Calderón-Delgado, L., Trejos-Castillo, E., & O'Boyle, M. (2017). Cognitive profiles of posttraumatic stress disorder and depression in children and adolescents. *International Journal of Clinical and Health Psychology*, *17*, 242–250. https://doi.org/10.1016/j.ijchp.2017.05.001

Barrett, E. J., Ausbrooks, C. Y. B., & Martinez-Cosio, M. (2012). The tempering effect of schools on students experiencing a life-changing event teenagers and the Hurricane Katrina evacuation. *Urban Education*, *47*, 7–31. https://doi.org/10.1177/0042085911416011

Beaglehole, B., Bell, C., Frampton, C., & Moor, S. (2017). The impact of the Canterbury earthquakes on successful school leaving for adolescents. *Australian and New Zealand Journal of Public Health*, *41*, 70–73. https://doi.org/10.1111/1753-6405.12625

Bonanno, G. A., Brewin, C. R., Kaniasty, K., & La Greca, A. M. (2010). Weighing the costs of disaster: Consequences, risks, and resilience in individuals, families, and communities. *Psychological Science in the Public Interest*, *11*, 1–49. https://doi.org/10.1177/1529100610387086

Broberg, A. O., Dyregrov, A., & Lilled, L. (2005). The Goteborg discotheque fire: Posttraumatic stress, and school adjustment as reported by the primary victims 18 months later. *Journal of Child Psychology and Psychiatry*, *46*, 1279–1286. https://doi.org/10.1111/j.1469-7610.2005.01439.x

Bryant, R. A., Gibbs, L., Gallagher, H. C., Pattison, P., Lusher, D., MacDougall, C., . . . Forbes, D. (2017). Longitudinal study of changing psychological outcomes following the Victorian Black Saturday bushfires. *Australian and New Zealand Journal of Psychiatry*, *52*, 542–551. https://doi.org/10.1177/0004867417714337

Bryant, R., Waters, E., Gibbs, L., Gallagher, H. C., Pattison, P., Lusher, D., . . . Forbes, D. (2014). Psychological outcomes following the Victorian Black Saturday bushfires. *Australian and New Zealand Journal of Psychiatry*, *48*, 634–643. https://doi.org/10.1177/0004867414534476

Casserly, M. (2006). Double jeopardy: Public education in New Orleans before and after the storm. In C. Hartman & G. D. Squires (Eds.), *There is no such thing as a natural disaster; race, class and Hurricane Katrina* (pp. 197–214). New York, NY: Routledge.

Cragg, L., & Gilmore, C. (2014). Skills underlying mathematics: The role of executive function in the development of mathematics proficiency. *Trends in Neuroscience and Education*, *3*, 63–68. https://doi.org/10.1016/j.tine.2013.12.001

De Bellis, M. D., & Zisk, A. (2014). The biological effects of childhood trauma. *Child Adolescent Psychiatric Clinics of North America*, *23*, 185–222. https://doi.org/10.1016/j.chc.2014.01.002

Di Pietro, G. (2015). *The academic impact of natural disasters: Evidence from L'Aquila earthquake*. IZA Discussion Papers, No. 8867. Retrieved from http://ftp.iza.org/dp8867.pdf

Durlak, J. A., Weissberg, R. P., Dymnicki, A. B., Taylor, R. D., & Schellinger, K. B. (2011). The impact of enhancing students' social and emotional learning: A meta-analysis of school-based universal interventions. *Child Development*, *82*, 405–432. https://doi.org/10.1111/j.1467-8624.2010.01564.x

Dyregrov, A., Dyregrov, K., Endsjø, M., & Idsoe, T. (2015). Teachers' perception of bereaved children's academic performance. *Advances in School Mental Health Promotion*, *8*, 187–198. https://doi.org/10.1080/1754730X.2015.1051888

Fuller, S. C. (2014). The effect of prenatal natural disaster exposure on school outcomes. *Demography*, *51*, 1501–1525. https://doi.org/10.1007/s13524-014-0310-0

Gabowitz, D., Zucker, M., & Cook, A. (2008). Neuropsychological assessment in clinical evaluation of children and adolescents with complex trauma. *Journal of Child*

and Adolescent Trauma, *1*, 163–178. https://doi.org/10.1080/19361520802003822

Geary, D. C., Hoard, M. K., Byrd-Craven, J., Nugent, L., & Numtee, C. (2007). Cognitive mechanisims underlying achievement deficits in children with mathematical learning disability. *Child Development*, *78*, 1343–1359. https://doi.org/10.1111/j.1467-8624.2007.01069.x

Gibbs, L., Block, K., Harms, L., MacDougall, C., Snowdon, E., Ireton, G., . . . Waters, E. (2015). Children and young people's wellbeing post-disaster: Safety and stability are critical. *International Journal of Disaster Risk Reduction*, *14*, 195–201. https://doi.org/10.1016/j.ijdrr.2015.06.006

Gibbs, L., Gallagher, H. C., Block, K., Snowdon, E., Bryant, R., Harms, L., . . . Waters, E. (2016). Post-bushfire relocation decision-making and personal wellbeing: A case study from Victoria, Australia. In A. Awotona (Ed.), *Planning for community-based disaster resilience worldwide: Learning from case studies in six continents* (pp. 333–356). London, UK and New York, NY: Routledge.

Grelland Røkholt, E., Schultz, J. H., & Langballe, Å. (2016). Negotiating a new day: Parents' contributions to supporting students' school functioning after exposure to trauma. *Psychology Research and Behavior Management*, *9*, 81–93. https://doi.org/10.2147/PRBM

Hox, J. (1998). Multilevel modeling: When and why. In I. Balderjahn, R. Mathar, & M. Schader (Eds.), *Classification, data analysis, and data highways* (pp. 147–154). New York, NY: Springer Verlag. https://doi.org/10.1007/978-3-642-72087-1

Kavanaugh, B. C., Dupont-Frechette, J. A., Jerskey, B. A., & Holler, K. A. (2017). Neurocognitive deficits in children and adolescents following maltreatment: Neurodevelopmental consequences and neuropsychological implications of traumatic stress. *Applied Neuropsychology: Child*, *6*, 64–78. https://doi.org/10.1080/21622965.2015.1079712

Kronenberg, M. E., Hansel, T. C., Brennan, A. M., Osofsky, H. J., Osofsky, J. D., & Lawrason, B. (2010). Children of Katrina: Lessons learned about postdisaster symptoms and recovery patterns. *Child Development*, *81*, 1241–1259. https://doi.org/10.1111/(ISSN)1467-8624

La Greca, A. M., Lai, B. S., Llabre, M. M., Silverman, W. K., Vernberg, E. M., & Prinstein, M. J. (2013). Children's postdisaster trajectories of PTS symptoms: Predicting chronic distress. *Child & Youth Care Forum*, *42*, 351–369. https://doi.org/10.1007/s10566-013-9206-1

Maas, C. J. M., & Hox, J. (2004). Robustness issues in multilevel regression analysis. *Statistica Neerlandica*, *58*, 127–137. https://doi.org/10.1046/j.0039-0402.2003.00252.x

Masson, M., Bussieres, E.-L., East-Richard, C., Mercier, A. R., & Cellard, C. (2015). Neuropsychological profile of children, adolescents and adults experiencing maltreatment: A meta-analysis. *Clinical Neurosychologist*, *29*, 573–594. https://doi.org/10.1080/13854046.2015.1061057

McCrory, E., DeBrito, S. A., & Viding, E. (2010). Research review: The neurobiology and genetics of maltreatment and adversity. *Journal of Child Psychology and Psychiatry*, *51*, 1079–1095. https://doi.org/10.1111/j.1469-7610.2010.02271.x

McFarlane, A. C., Policansky, S. K., & Irwin, C. (1987). A longitudinal study of the psychological morbidity in children due to a natural disaster. *Psychological Medicine*, *17*, 727–738. https://doi.org/10.1017/S0033291700025964

McFarlane, A. C., & Van Hooff, M. (2009). Impact of childhood exposure to a natural disaster on adult mental health: 20-year longitudinal follow-up study. *British Journal of Psychiatry*, *195*, 142–148. https://doi.org/10.1192/bjp.bp.108.054270

Moll, K., Ramus, F., Bartling, J., Bruder, J., Kunze, S., Neuhoff, N., . . . Landerl, K. (2014). Cognitive mechanisims underlying reading and spelling development in five European orthographies. *Learning and Instruction*, *29*, 65–77. https://doi.org/10.1016/j.learninstruc.2013.09.003

Muthén, L. K., & Muthén, B. O. (2013). *Mplus (Version 7)*. Los Angeles, CA: Author.

Obradovic, J., Long, J. D., Cutuli, J. J., Chan, C.-K., Hinz, E., Heistad, D., & Masten, A. S. (2009). Academic achievement of homeless and highly mobile children in an urban school district: Longitudinal evidence on risk, growth, and resilience. *Development and Psychopathology*, *21*, 493–518. https://doi.org/10.1017/S0954579409000273

Ozernov-Palchik, O., Yu, X., Wang, Y., & Gaab, N. (2016). Lessons to be learned: How a comprehensive neurobiological framework of atypical reading development can inform educational practice. *Current Opinion in Behavioural Sciences*, *10*, 45–58. https://doi.org/10.1016/j.cobeha.2016.05.006

Pane, J. F., McCaffrey, D. F., Kalra, N., & Zhou, A. J. (2008). Effects of student displacement in Louisiana during the first academic year after the hurricanes of 2005. *Journal of Education for Students Placed at Risk*, *13*, 168–211. https://doi.org/10.1080/10824660802350169

Parslow, R. A., & Jorm, A. F. (2007). Pretrauma and posttrauma neurocognitive functioning and PTSD symptoms in a community sample of young adults. *American Journal of Psychiatry*, *164*, 509–515. https://doi.org/10.1176/ajp.2007.164.3.509

Peek, L. (2008). Children and disasters: Understanding vulnerability, developing capacities, and promoting resilience—An introduction. *Children, Youth and Environments*, *18*, 1–29. https://www.jstor.org/stable/10.7721/chilyoutenvi.18.1.0001

Peek, L., & Richardson, K. (2010). Their own words: Displaced children's educational recovery needs after Hurricane Katrina. *Disaster Medicine and Public Health Preparedness*, *4*, S63–S70. https://doi.org/10.1001/dmp.2010.10060910

Pérez-Pereira, M., Tinajero, C., Rodríguez, M. S., Peralbo, M., & Sabucedo, J. M. (2012). Academic effects of the prestige oil spill disaster. *Spanish Journal of Psychology*, *15*, 1055–1068. https://doi.org/10.5209/rev_SJOP.2012.v15.n3.39396

Reich, J. A., & Wadsworth, M. (2008). Out of the floodwaters, but not yet on dry ground: Experiences of displacement and adjustment in adolescents and their parents following Hurricane Katrina. *Children, Youth*

and Environments, *18*, 354–370. https://www.jstor.org/stable/10.7721/chilyoutenvi.18.1.0354

Sacerdote, B. (2008). *When the saints come marching in: Effects of Hurricanes Katrina and Rita on student evacuees*. NBER Working Paper No. 14385. Retrieved from http://papers.nber.org/papers/w14385

Saigh, P. A., Mroueh, M., & Bremner, J. D. (1997). Scholastic impairments among traumatized adolescents. *Behaviour Research and Therapy*, *35*, 429–436. https://doi.org/10.1016/S0005-7967(96)00111-8

Samuelson, K. W., Krueger, C. E., Burnett, C., & Wilson, C. K. (2010). Neuropsychological functioning in children with posttraumatic stress disorder. *Child Neuropsychology*, *16*, 119–133. https://doi.org/10.1080/09297040903190782

Scott, B. G., Lapré, G. E., Marsee, M. A., & Weems, C. F. (2014). Aggressive behavior and its associations with posttraumatic stress and academic achievement following a natural disaster. *Journal of Clinical Child & Adolescent Psychology*, *43*, 43–50. https://doi.org/10.1080/15374416.2013.807733

Shannon, M. P., Lonigan, C. J., Finch, A. J., & Taylor, C. M. (1994). Children exposed to disaster: I. Epidemiology of post-traumatic symptoms and symptom profiles. *Journal of the American Academy of Child and Aolescent Psychiatry*, *33*, 80–93. https://doi.org/10.1097/00004583-199401000-00012

Sims, A. J., Boasso, A. M., Burch, B., Naser, S., & Overstreet, S. (2015). School dissatisfaction in a post-disaster environment: The mediating role of posttraumatic stress symptoms. *Child & Youth Care Forum*, *44*, 583–595. https://doi.org/10.1007/s10566-015-9316-z

Smilde-van den Doel, D. A., Smit, C., & Wolleswinkel-van den Bosch, J. H. (2006). School performance and social-emotional behavior of primary school children before and after a disaster. *Pediatrics*, *118*, e1311–e1320. https://doi.org/10.1542/peds.2005-2781

Spann, M. N., Mayes, L. C., Kalmar, J. H., Guiney, J., Womer, F. Y., Pittman, B., . . . Blumberg, H. P. (2012). Childhood abuse and neglect and cognitive flexibility in adolescents. *Child Neuropsychology*, *18*, 182–189. https://doi.org/10.1080/09297049.2011.595400

Terasaka, A., Tachibana, Y., Okuyama, M., & Igarashi, T. (2015). Postraumatic stress disorder in children following natural disasters: Assytematic review of the long-term follow-up studies. *International Journal of Child, Youth and Family Studies*, *6*, 111–133. https://doi.org/10.18357/ijcyfs.61201513481

Turley, M. R., & Obrzut, J. E. (2012). Neuropsychological effects of postraumatic stress disorder in children and adolescents. *Canadian Journal of School Psychology*, *27*, 166–182. https://doi.org/10.1177/0829573512440420

Ungar, M. (2011). The social ecology of resilience: Addressing contextual and cultural ambiguity of a nascent construct. *American Journal of Orthopsychiatry*, *81*, 1–17. https://doi.org/10.1111/j.1939-0025.2010.01067.x

Victorian Bushfires Royal Commission. (2009). *The 2009 Victorian Bushfires Royal Commission final report summary*. Retrieved from http://www.royalcommission.vic.gov.au/Commission-Reports/Final-Report

Vogel, J. M., & Vernberg, E. M. (1993). Part 1: Children's psychological responses to disasters. *Journal of Clinical Child Psychology*, *22*, 464–484. https://doi.org/10.1207/s15374424jccp2204_7

Wang, Y., Mauer, M. V., Raney, T., Peysakhovich, B., Becker, B. L. C., Silva, D. D., & Gaab, N. (2016). Development of tract specific white matter pathways during early reading development in at-risk children and typical controls. *Cerebral Cortex*, *27*, 2469–2485.

Weare, K., & Nind, M. (2011). Mental health promotion and problem prevention in schools: What does the evidence say? *Health Promotion International*, *26*, i29–i69. https://doi.org/10.1093/heapro/dar1075

Weems, C. F., Scott, B. G., Taylor, L. K., Cannon, M. F., Romano, D. M., & Perry, A. M. (2013). A theoretical model of continuity in anxiety and links to academic achievement in disaster-exposed school children. *Development and Psychopathology*, *25*, 729–737. https://doi.org/10.1017/S0954579413000138

Welsh, J. A., Nix, R. L., Blair, C., Bierman, K. L., & Nelson, K. E. (2010). The development of cognitive skills and gains in academic school readiness for children from low-income families. *Journal of Educational Psychology*, *102*, 43–53. https://doi.org/10.1037/a0016738