Effectiveness of a preschool asthma education programme, compared to usual care, on the frequency of acute asthma events: a community-based cluster randomised trial

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ABSTRACT

AIM: To determine whether an asthma intervention delivered within preschools can improve asthma outcomes in children aged 2–5 years with asthma or a high probability of asthma.

METHODS: Between 2011 and 2013, we undertook a pragmatic, single-blind, cluster randomised trial in Auckland, New Zealand. We randomly assigned (1:1 ratio) preschools, and their children aged 2–5 years with asthma or a high probability of asthma, to receive an asthma intervention (a 12-month respiratory nurse-led asthma assessment using an evidence-based, web-based tool and a class-based asthma education programme for four months), or a control intervention (a class-based science education programme for four months). Both groups received standard asthma management by their primary care physician. The primary outcome was the proportion of children that had at least one unscheduled ("urgent") medical or ED attendance for asthma over 12 months.

RESULTS: We randomised 171 preschools, 85 to the intervention (341 children) and 86 to the control (334 children). We found no difference in the primary outcome (intervention: 216/341, 63% vs control: 181/334, 54%: adjusted Odds Ratio=1.36, 95% Confidence Interval=0.95-1.94, p=0.095). However, compared with the control group, the intervention group had improved and sustained asthma control and fewer asthma symptoms over 12 months.

CONCLUSIONS: Combining asthma education with a nurse-led, evidence-based asthma assessment and education intervention led to sustained improvements in asthma control in this preschool population, but its effect on acute events remains unclear.

In 2001 and 2003, the International Study of Asthma and Allergies in Children (ISAAC) found that young children in New Zealand had some of the world's highest prevalence of asthma symptoms,[1] with reported asthma in 30% of children aged 6–7 years and current wheeze in 22%.[2] More recent data from ISAAC is not available for NZ. The 2020/21 New Zealand Health Survey reported that 6% of children aged 2–4 years had asthma (defined as the child's parents/caregivers had been told by a doctor that the child had asthma, and the child currently used asthma treatments).[3]

A 2002 report noted that asthma was a leading cause of childhood hospital admissions in New Zealand, and the third-ranked cause of years-lost-to-disability.[4] Between 2010–2019 there was a 62% reduction in hospital admissions with an asthma diagnosis for New Zealand children aged under 5-years.[5] However, clear ethnic differences exist, with Māori children under 5 years two to three times more likely to be admitted to hospital for asthma than non-Māori children of the same age.[5]

Most medicines recommended by guidelines for the management of childhood asthma are fully subsidised by the New Zealand Government. Despite this, suboptimal use of these medicines is likely to contribute to asthma-related morbidity. For example, in 2004, inhaled corticosteroids (ICS) were underused, and there was an over-reliance on short-acting beta$_2$-adrenoceptor agonists

(SABA) in children aged 0–4 years.[6] Contributing factors include the difficulty of diagnosing asthma in young children (eg wheeze vs asthma),[7–9] challenges in determining the age to start asthma medication,[10] limited asthma education for children and their families, low adherence to recommended treatment regimens amongst children,[6, 11] low health literacy levels particularly among Māori,[12] and low provision of written asthma action plans to children/guardians/caregivers,[13–14] despite evidence-based asthma guidelines recommending their use.[15]

Two asthma interventions were independently developed in 2008 in New Zealand to improve asthma education and management. The first intervention was a web-based asthma assessment and education tool called Giving Asthma Support to Patients (GASP), developed by a primary healthcare organisation (Comprehensive Care Ltd.) in Auckland, New Zealand. GASP was designed to link with primary care patient management software, and assist general practitioners (GPs) and GASP-trained nurses with the differential diagnosis of asthma and its management, underpinned by evidence-based asthma treatment guidelines.[16–18] GASP includes an asthma assessment, spirometry (in adults only), provision of a personalised self-management action plan and trigger advice. GASP-trained nurses initiate changes to the action plan over time, after consultation with the patient's GP, who also approves clinically indicated medication changes. Audit data from 2008–2011, from 761 people aged 5–64 years with uncontrolled asthma seen in primary care in the Waitematā region of Auckland, indicated GASP had a positive impact on asthma control, and reduced hospital admissions and emergency department (ED) presentations.[19] The second intervention was developed by the Pharmaceutical Management Agency of New Zealand (PHARMAC) and consisted of an asthma-specific, curriculum-based preschool education programme. In 2017, 64% of New Zealand children under five years attended some form of preschool (up from 54% in 2009).[20] Delivering an asthma intervention within a preschool enables greater reach to the child, their peers, teachers, and guardians/caregivers. In 2009, the intervention was piloted in 20 New Zealand preschools and, although only delivered once, was successful in increasing awareness, knowledge, confidence and asthma self-management in guardians/caregivers of children with asthma.[21] However, the intervention had no impact on ICS, SABA use or asthma-related hospitalisations (most likely due to limitations of the clinical outcome analyses).

In 2011, we designed a pragmatic trial to assess the effectiveness of the GASP tool and the PHARMAC asthma education programme[21] on asthma control in New Zealand children aged 2–5 years. We hypothesised that the combined intervention would significantly reduce the frequency of acute asthma events over 12 months through better asthma control (by increasing ICS use and decreasing SABA use), compared with a control intervention.

Methods

We undertook a single-blind, parallel-group, cluster randomised trial within the Kaipara and Rodney Districts, North Shore City and Waitakere City. The protocol was approved by the Upper South A Regional Ethics Committee and the Auckland and Northern Kindergarten Associations (trial registration number: ACTRN12611001143910).

Participants

Using data from the Ministry of Education register of Early Childhood Services (as of 1 July 2010), we identified preschools located within selected census areas (ie those of low socio-economic status and a high proportion of Māori and Pacific people, regular smokers aged ≥15 years, and household crowding, based on 2006 NZ census data) within the study region. We excluded preschools providing home-based care. We invited the lead teacher in identified preschools to participate and obtained their written consent. The teacher distributed a newsletter to guardians/caregivers of all children enrolled at the preschool. This explained the study, eligibility criteria for the children and how guardians/caregivers could register their interest. Interested guardians/caregivers were contacted by a researcher, the study further explained, inclusion/exclusion criteria assessed, and verbal consent sought (for those who met eligibility criteria) prior to randomisation of the preschool. We obtained written consent from guardians/caregivers at the baseline data collection day, after randomisation of the preschool.

Children were eligible if they were aged between two and four years eight months at enrolment, had received a diagnosis of asthma from a GP or other medical practitioner, and were enrolled at a participating preschool. Eligibility was broadened two months into recruitment (see Appendix for rationale) to include children with a high probability of asthma, defined as currently using an asthma inhaler (any type) and at least one of the following: recurrent wheeze episodes in the last year that responded to treatment with a SABA; and/or a dry

cough in the last year (especially at night and/or on exertion); and/or a personal history or family history of atopy. Children were excluded if they had a medically diagnosed respiratory illness other than asthma, had previously received a GASP assessment, were enrolled at another participating preschool, and/or were currently enrolled in another respiratory-related study.

Randomisation and masking

We digitally randomised preschools to the intervention or control in a 1:1 ratio, using block randomisation stratified by preschool license size (40, 75 children) and centre age group (2–5, 0–5 years). Researchers searching medical records for primary outcome data, and trial clinicians reviewing these data, were masked to treatment allocation. Participants and researchers collecting secondary outcome data were aware of treatment allocation.

Procedures

The study intervention was an asthma intervention comprising asthma education plus GASP, and the control intervention was science education (See Appendix). In brief, intervention preschools received a four-month, asthma-specific, curriculum-linked learning and activity unit (consisting of nine 30-minute lessons), with associated resources for teachers and children, and a staff professional development programme; an asthma accreditation programme; identification bracelets for children with asthma/high probability of asthma; and cessation support for staff who smoked. Resources were delivered by the research team (face-to-face) at baseline and four months, although the lessons could be delivered by teachers at any time. Participating children with asthma/high probability of asthma attending the intervention preschools received standard asthma management by their GP. Additional asthma-specific support was delivered by a GASP-trained nurse (face-to-face) to the children and their guardian/caregiver at baseline, one, four, eight and 12 months. This support included: a GASP assessment (no spirometry); education on asthma medication use and symptom management; a GASP action plan for each child's guardian/caregiver/preschool (a copy of the associated decision support was sent to the child's usual GP. If the GASP assessment identified a required change to the child's asthma medication, the guardian/caregiver was referred to the child's usual GP); strategies to improve medication adherence (eg text reminders, charts), with a focus on the child taking the required medication twice daily; and cessation support for family members that smoked.

Preschools randomised to the control group received a four-month, science-specific, curriculum-linked learning and activity unit (consisting of nine 30-minute lessons), with associated resources for teachers and children, and staff professional development. These resources were delivered to the children by the research team (face-to-face) at baseline and four months, although the lessons could be delivered by teachers at any time. Participating children with asthma/high probability of asthma received standard asthma management by their GP (ie no GASP assessment was undertaken, and no related asthma education was given). After the trial was completed, we offered guardians/caregivers in the control group a free GASP assessment for their child.

Outcomes

Baseline data for the children included age, gender, ethnicity, social class (NZ Deprivation Index 2006,[22] using the preschool's street address as a proxy), age at asthma diagnosis, family history of asthma (immediate blood relatives), asthma triggers, atopic reaction, vaccination history and current asthma medication.

The primary outcome was the proportion of children that had at least one acute asthma event, defined as an unscheduled ("urgent") medical or ED attendance (including hospital admission) for asthma in the last 12 months. Events were self-reported by guardians/caregivers at baseline, and at one, four, eight and 12 months, then verified against medical records via data linkage, using the child's National Health Index number—a unique number allocated to all New Zealanders at birth. A researcher electronically searched GP records (regional) and hospital records (national) for any acute asthma events, and provided the data to a clinician to review and confirm.

Secondary outcomes for children, assessed face-to-face at baseline, one, four, eight (phone interview) and 12 months, included: time to first acute asthma event; frequency of SABA use; asthma symptoms (daytime symptoms, nocturnal awakenings); asthma medication changes; inhaler technique and frequency of preventer inhaler use (defined as good, medium, or poor) for the guardians/caregiver giving the child their inhaler; degree of asthma control[18] as measured by the GASP tool (intervention group only, defined as controlled, partially controlled, or uncontrolled); and absenteeism from preschool/other activities due to asthma.

Additional outcomes assessed face-to-face at baseline and 12 months included: frequency of corticosteroid use for asthma (oral, inhaled); guardians/caregivers absenteeism from work/other activities due to their child's asthma; child's quality of life;[23] second-hand smoke exposure; household crowding; and acceptability of the intervention to guardians/caregivers. See the Appendix for a full description of all secondary outcomes.

Secondary outcomes and characteristics for preschools, assessed in a face-to-face interview with the lead teacher at baseline and 12 months, included: age and gender of children attending; number of staff and their smoking status; number of years the lead teacher had been employed at the preschool; number of asthma-related events at the preschool in the last year; and the "healthy building" status of the preschool. Additional information collected at baseline, one and 12 months included: whether all children with asthma were known to the lead teacher; the current smoke-free and asthma management policies at the preschool and adherence to these policies; knowledge of asthma triggers; confidence in recognising asthma symptoms and how to administer first aid in the event of an asthma attack; and the asthma accreditation status for the preschool. At 12 months we asked the lead teachers about the acceptability of the intervention.

Sample size

We sought to include 188 preschools (94 preschools per arm, 400 children per arm) to provide at least 90% power (p=0.05) for detecting a 50% reduction in the proportion of children who had at least one acute asthma event in the last 12 months in the intervention group compared with the control group. These figures were based on an expected proportion of acute asthma events of 9% in the intervention group compared with 17% in the control group. In the absence of feasibility data, the control event rate, and likely effect size, was estimated from individual participant data collected previously using the GASP tool (self-report, all ages, those with 12-month follow-up data, n=152). Recruitment aimed for at least 25% of participating children to be Māori, and 15% to be Pacific. A cluster inflation factor was applied assuming a moderate intra-cluster correlation coefficient of 0.02.[24] A cluster size of five was selected. The sample size assumed a 15% loss to follow-up—midway between the loss observed in the few other asthma trials involving children (which ranged from 11.5% to 22%).[25–27]

Statistical analysis

Analyses using SAS v9.3 were guided by a pre-specified plan, and undertaken on an intention-to-treat basis using individual (child) data. All tests of significance were two-tailed. Continuous variables were compared with t-tests or Mann–Whitney tests, and categorical data with Chi-squared tests as appropriate. A generalised Linear Mixed Model with a logit link was used to analyse binary child/guardian outcomes, and a Linear Mixed Model was used to analyse continuous child/guardian outcomes, with a preschool fitted as a random effect. The main analyses were unadjusted and sensitivity analyses were conducted adjusting for potential covariates measured at baseline. Time-to-first acute asthma event between the treatment groups was analysed using Kaplan–Meier curves and the log-rank test.

Funding

PHARMAC funded the trial but had no role in the data collection or analyses.

Results

Participant flow and baseline characteristics

The first preschool randomisation was on 30 September 2011, and the last follow-up was on 10 August 2013. Of 179 preschools assessed, 171 were eligible and randomised, 85 in the intervention group (341 children) and 86 in the control (334 children) (Figure 1).

Loss to follow-up at 12 months was 0.6% for preschools and 10% for children (Figure 1). Significantly fewer children were lost to follow-up at 12 months in the intervention group, compared with the control group (12 vs 29 children, respectively; p=0.008). Baseline characteristics were balanced, except for asthma diagnosis, inhaler technique, wheeze and atopy (Table 1), and preschool cleaning and asthma triggers (see Appendix). These variables were subsequently adjusted for in the primary analyses.

Primary outcome

Based on medical record data, a total of 216 (63%) children in the intervention group were found to have had 577 acute asthma events over 12 months, compared with 181 (54%) children, and 466 events in the control group. Unadjusted analyses indicated a significantly higher proportion of acute asthma events in the intervention group compared with the control group (Odds

Figure 1: Recruitment and retention of participants throughout the trial.

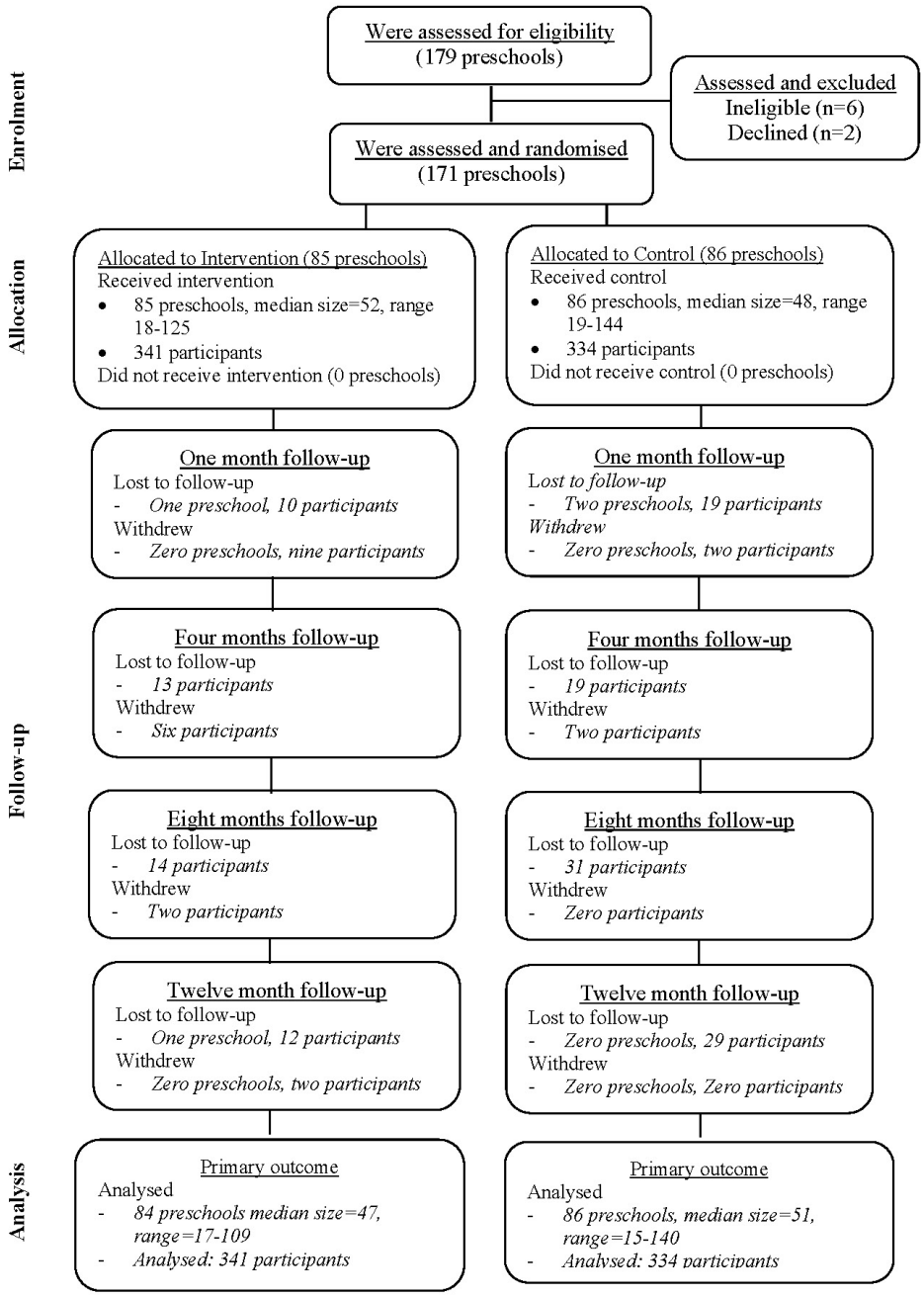

Table 1: Baseline characteristics.

Preschool characteristics	**Intervention N=85 (n, %)**	**Control N=86 (n, %)**
Number of children preschool licenced for:		
40	48 (57)	47 (55)
75	37 (43)	39 (45)
Age group preschool licenced for:		
0–5 years	43 (51)	44 (51)
2–5 years	42 (49)	42 (49)
Number of children aged 2-5 years		
Total	4,599	4,855
Mean per preschool (SD)	54 (21)	57 (26)
Number of asthma related events at the preschool in the last year Mean (SD)	6.4 (11.9)	5.5 (11.2)
All asthmatic children were known to lead teacher	55 (65)	63 (73)
Preschool had asthma-specific guidelines	11 (13)	9 (11)
Characteristics of children	**Intervention N=341 (n, %)**	**Control N=334 (n, %)**
Female	133 (39)	142 (43)
Age (years)		
Mean (SD)	3.2 (0.8)	3.1 (0.8)
Ethnicity		
Māori	87 (26)	66 (20)
Pacific	56 (16)	48 (14)
Other (non-Māori, non-Pacific)	198 (58)	220 (66)
Deprivation index[a]		
By census area unit (Mean, SD)	5.9 (2.5)	5.8 (2.2)
Diagnosed with asthma	**203 (60)**	**163 (49)**
Māori	55 (63)	33 (50)
Pacific	36 (64)	26 (54)
Other (non-Māori, non-Pacific)	112 (57)	104 (47)

Table 1 (continued): Baseline characteristics.

Preschool characteristics	Intervention N=85 (n, %)	Control N=86 (n, %)
High probability of asthma*	**138 (40)**	**171 (51)**
Used an asthma inhaler AND	123 (36)	157 (47)
Had a recurrent wheeze	126 (37)	126 (38)
Had a dry cough	117 (34)	153 (46)
Had a history of atopy		
Age diagnosed with asthma (years)		
Mean (SD)	1.8 (0.8)	1.8 (0.8)
Family history of asthma	292 (86)	282 (84)

SD: Standard deviation.
[a] For preschool location, where 1 is least deprived and 10 is most deprived area of New Zealand by NZDep2006.[22]
* None of these children went on to get a medical diagnosis of asthma during the study.

Table 2: Acute asthma events in children over the last 12 months.

	Intervention N=341 (n, %)	Control N=334 (n, %)	Adjusted Odds Ratio (95% CI)	P-value
Number of children with at least one event in the last 12 months	216 (63)	181 (54)	1.35 (0.95–1.92)[a] 1.22 (0.85–1.74)[b] 1.36 (0.95–1.94)[c] 1.27 (0.77–2.10)[d]	0.095 0.286 0.095 0.352
Subgroup analyses				
- Asthma diagnosis	133 (66)	97 (60)	1.29 (0.84–1.99)	0.247
- High probability of asthma	83 (60)	84 (49)	1.49 (0.90–2.47)	0.117
Hospitalisations in the last 12 months	6 children* (8 events, 1.4% of all 577 events)	2 children (2 events, 0.4% of all 466 events)	–	–

[a] Adjusted for stratification factors (preschool licence size, preschool age group) and asthma inclusion criteria (asthma diagnosis, high probability of asthma).
[b] Adjusted for same factors as in [a], but also asthma inhaler technique (good, medium, poor) and deprivation index.[22]
[c] Adjusted for same factors as in [b], but also ethnicity (Māori, Pacific, Other).
[d] Adjusted for same factors as in [c], but also age group (<3 years, ≥3 years), medication use (defined as "using an inhaled corticosteroid twice a day every day") and symptoms (defined as "waking ≥3 times per week or every night").
*One child died.
CI=Confidence Interval.

Ratio=1.43; 95% Confidence interval [CI]=1.10-2.01; p=0.042). After adjusting for asthma diagnosis, inhaler technique, stratification factors, social class, ethnicity, age group, medication use and night time waking, no significant difference in the primary outcome was observed between the groups (Table 2).

Post-hoc subgroup analysis found no difference in the proportion of acute asthma events between those children with a medical diagnosis of asthma compared to those with a high probability of asthma (Table 2). When considering only those children hospitalised with asthma (as an indicator of severity), more children in the intervention group were hospitalised than those in the control group, but this difference was not significant (p=0.286) (Table 2).

Comparison of self-reported data on acute asthma events with medical records revealed under-reporting of these events over the 12-month study period by guardians/caregivers, particularly in the intervention group. Hospitalisations were over-reported in both groups, whilst GP and ED visits were under-reported (See Appendix). We investigated whether the children who had under-reported events were any different to those that did not, but found no difference according to asthma severity, age, and Deprivation Index.

Secondary outcomes

Based on medical record data, the median time to first acute asthma event was significantly shorter in the intervention group compared to the control group

Table 3: Frequency of asthma medication use by children over time.

	Intervention N=341 (n, %)		**Control N=334 (n, %)**	
SABA use	**Baseline**	**12 months**	**Baseline**	**12 months**
Never	120 (35)	184 (60)	134 (40)	135 (45)
≤2 times per week	137 (40)	103 (33)	105 (31)	35 (12)
≥3 times per week	49 (14)	12 (4)	60 (18)	16 (5)
Less than 6 puffs daily	29 (9)	9 (3)	24 (7)	62 (21)
More than 6 puffs per day	6 (2)	1 (0.3)	11 (3)	46 (15)
OCS use (Number of courses in last 12 months)				
0	132 (43)	224 (73)	132 (44)	187 (62)
1–5	158 (52)	81 (27)	158 (53)	107 (36)
≥6	15 (5)	0 (0)	10 (3)	6 (2)
ICS use				
One puff, once a day	10 (3)	3 (1)	30 (9)	22 (7)
Two puffs, once a day	5 (2)	4 (1)	42 (13)	32 (11)
One puff, twice a day	71 (21)	97 (31)	8 (2)	46 (16)
Two puffs, twice a day	68 (20)	128 (41)	36 (11)	49 (16)
One puff, three times a day	0	3 (1)	21 (6)	0
Two puffs, three times a day	0	0	13 (4)	2 (1)
Not using	162 (48)	73 (24)	173 (52)	131 (44)
Missing data	25 (7)	1	11 (3)	18 (6)

SABA: short-acting beta$_2$-adrenoceptor agonists.
OCS: oral corticosteroids.
ICS: inhaled corticosteroids.

(159 vs 255 days, respectively; Hazard ratio=1.33; 95% CI 1.09–1.62; log-rank test p=0.005). Note that the log-rank test does not enable adjustment for cluster.

No differences in asthma medication use were noted by treatment group at baseline, or by ethnicity. Almost two thirds of children (421/675) were using a SABA at baseline. SABA use in the intervention group significantly decreased over 12 months, compared to the control group (p<0.0001) (Table 3). At baseline, OCS use varied between 0–13 courses in the last 12 months, with just over 50% of children having had between 1–5 courses. A greater mean change from baseline to 12 months in OCS use was observed in the intervention group (0.97, Standard error [SE]=0.07), compared to the control group (0.44; SE=0·07; mean change 0.53, 95%; CI 0.34–0.72; p<0.0001). At baseline, 50% (335/675) of children did not use an ICS. A greater reduction in the proportion not using an ICS from baseline to 12 months was observed in the intervention group (from 48% to 24%), compared to the control group (from 52% to 44%; p<0.0001) (Table 3).

Children in the intervention group were significantly more likely to have medication changes, a better inhaler technique, more frequent use of their preventer inhaler, have fewer daytime asthma symptoms, less night time waking, and improved quality of life (in some domains) over 12 months, than children in the control group (see Appendix). Asthma control, although only measured in the intervention group children using the GASP tool, also improved over time (see Appendix). Despite these findings, no significant differences in absenteeism rates due to asthma (preschool, the child's usual activities, and the guardians/caregivers work and usual activities) were found between the two groups after 12 months (see Appendix).

Over 12 months, 84% of preschools in the intervention group had more than one asthma-specific lesson plan delivered (number of lessons delivered in addition to the introductory lesson: mean=3.4; SD=2.1; median=3) (see Appendix). Teachers in the intervention group were significantly more likely to feel confident in their asthma understanding after 12 months than control group teachers (see Appendix). Both the teachers and the guardians/caregivers of the children involved found the study helpful and were satisfied with its conduct, with those in the intervention group reporting more positive views than those in the control group for all outcomes, except the effectiveness of the curriculum material (see Appendix).

Discussion

We found significant underuse of ICS and over-reliance on SABA in the trial population at baseline, justifying the need for an intervention. The trial intervention had no significant impact on acute asthma events, even after adjusting for baseline differences or when comparing children diagnosed with asthma to those with a high probability of asthma. However, time to first acute asthma event was significantly shorter in the intervention group, possibly due to increased awareness of early symptoms because of the asthma-specific education delivered to this group. Compared to the control group, the trial intervention resulted in less frequent use of SABA and OCS by the children, and increased use of ICS, resulting in improved and sustained control of asthma and fewer asthma symptoms.

This trial is one of the first to investigate the effectiveness of an asthma education programme in a preschool environment. Our study had several strengths. First, rather than merely educating immediate family members about how to manage asthma (including acute events), our more holistic approach included reaching out to all the child's caregivers (ie the child and their peers, teachers and guardians). It is often assumed that asthma education can only be delivered by health professionals, but understanding asthma triggers and early recognition and management of an acute asthma event is relevant to all who interact with children. Second, the pragmatic study design helped ensure greater generalisability to the population of interest. Third, the trial was rigorous, with blinded assessment of the primary outcome, a large sample size, high participant retention, intention-to-treat analysis, and randomisation to ensure a balance in baseline characteristics (the few observed differences were likely due to chance and subsequently adjusted for in analyses). Given the above strengths, the observed impact of the intervention on non-acute asthma outcomes, and the fact that medication management via the GASP tool was appropriate for this age group (and based on current evidence-based best practice guidelines at that time),[16–18] it is unclear why the intervention had no impact on the primary outcome.

Several limitations should be noted. First, the study was under-powered; the estimate used to calculate the sample size was based on a small GASP dataset and the recruitment target of 94 preschools (and 400 children) per arm was not met. Second, inconsistencies between self-reported

and medical record data of the primary outcome indicate that recall and/or social desirability bias may have been at play. Third, the multiple statistical comparisons increased the chances of a type I error. Fourth, guardians/caregivers may have changed their behaviour due to being part of a trial (Hawthorne effect). Fifth, researchers collecting secondary outcome data were not blinded to group allocation. Sixth, it is possible that teachers and guardians/caregivers attending preschools nearby, but randomised to different arms, may have shared intervention information. Seventh, differential loss to follow-up was observed; however, the availability of primary outcome data for all randomised children via electronic health records minimised this bias. Eighth, international evidence suggests both an under- and over-diagnosis of asthma in primary care,[28] so it is possible we may have missed some children with asthma and included some children without asthma. However, the final eligibility criteria for the trial were broad, including both children with a medical diagnosis of asthma or a high probability of asthma, and was in line with current New Zealand treatment guidelines for this age group at the time the trial started recruitment.[29] Ninth, we were unable to follow-up patients for as long as we would have liked, due to funding constraints. Tenth, asthma definitions change over time[30] and there are overlaps of asthma phenotypes.[31] Finally, while the trial was designed in conjunction with asthma specialists, based on the asthma treatment guidelines in 2011,[16–18] new asthma treatment guidelines post-trial completion may impact how the trial findings are interpreted, and how preschool children with asthma-related symptoms are managed.[7,29]

Our findings contrast with those of three Cochrane reviews examining the impact of self-management asthma programmes for children and adolescents.[32–34] These reviews reported that asthma education reduced absenteeism from school and usual activities, improved self-efficacy and physiological measures of lung function,[32] and reduced asthma-related ED visits and hospitalisations.[32–34] One review highlighted the need to investigate the effectiveness of the individual components of asthma education programmes.[32] Our trial had many different components and, although it is not possible to say which of these had the greatest impact, evidence indicates them to be individually effective.[35,36] Furthermore, the 2008–2011 GASP audit suggested its use resulted in a reduction in acute asthma events.[19] Our findings for preschool staff are consistent with those reported by a Cochrane review (five trials, 111 primary/secondary schools) reporting asthma education provided to staff working within school environments can increase both asthma knowledge and confidence.[37]

The trial has signalled that significant and sustained changes in the personalised management of asthma symptoms in young children is possible through regular reviews of asthma medication, clear explanations about medication use, recognising and addressing key triggers, and use of asthma action plans by children with asthma (or a high probability of asthma) and their guardians/caregivers/teachers. Screening programmes for early identification of 1) wheeze and other asthma-related symptoms in children, and 2) children at higher risk of asthma, have been effective in other countries (eg the Head Start Program in the USA),[38] and it seems prudent to establish them in New Zealand. This screening could involve incorporation of a GASP-trained nurse within general practices, after-hours medical centres, and hospital emergency rooms (supported by Government funding). Delivery of the programme to schools of all levels could also be worth exploring, prioritising to areas of greatest need and incorporating interactive computerised asthma patient education programmes.[39] Evaluations of the intervention within these environments, over a long period, would be important to determine sustainability. Finally, the trial has highlighted the limitations of using self-reported data related to acute asthma events. Future research focusing on such outcomes should use medically verified data wherever possible.

Appendix:
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COMPETING INTERESTS
Janet Mackay, Scott Metcalfe and Marama Parore are, or were, employees of PHARMAC, which funded the study. The Ministry of Done is the name of a company specialising in project deployment and development of educational resources and is not a government agency. We declare no competing interests.

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All requests for de-identified individual participant data or programme documents will be considered where the proposed use aligns with public good purposes, does not conflict with other requests, or by planned use of the Trial Steering Committee, and the requestor is willing to sign a data access agreement. Contact regarding data sharing should be via the corresponding author.

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