The effectiveness of interventions to improve self-management for adolescents and young adults with allergic conditions: a systematic review

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ABSTRACT

Background: This systematic review aimed to review the literature on interventions for improving self-management and wellbeing in adolescents and young adults (11-25 years) with asthma and allergic conditions.

Methods: A systematic literature search was undertaken across eight databases. References were checked by two reviewers for inclusion. Study data were extracted and their quality was assessed in duplicate. A narrative synthesis was undertaken.

Results: A total of 30 papers reporting data from 27 studies were included. Interventions types were psychological (k=9); E-health (k=8); educational (k=4); peer led (k=5); breathing re-training (k=1). All interventions were for asthma. Psychological interventions resulted in significant improvements in the intervention group compared to the control group for self-esteem, quality of life, self-efficacy, coping strategies, mood and asthma symptoms. E-Health interventions reported significant improvements for inhaler technique, adherence and quality of life. General educational interventions demonstrated significantly improved quality of life, management of asthma symptoms, controller medication use, increased use of a written management plan and reduction in symptoms. The peer led interventions included the Triple A (Adolescent Asthma Action) programme and a peer-led camp based on the Power Breathing Programme. Improvements were found for self-efficacy, school absenteeism and quality of life.

Conclusion: Although significant improvements were seen for all intervention types, many were small feasibility or pilot studies, few studies reported effect sizes and no studies for allergic conditions other than asthma met the inclusion criteria. Research using large longitudinal interventional designs across the range of allergic conditions is required to strengthen the evidence base.

ABBREVIATIONS

PRISMA Preferred Reporting Items for Systematic Reviews and Meta-Analyses

INTRODUCTION

Adolescents and young adults with asthma and allergies are reported to be a group that have poor engagement in their self-care and health condition management, poor adherence with medication regimes and a low perception of risk[1-4]. This may be due to increasing independence from parents, peer pressure and a lack of knowledge regarding their condition[1-3,5,6]. This can result in an increased risk of anaphylaxis or asthma exacerbations[7]. For example, adolescents and young adults have been identified as the age group most at risk for fatal anaphylaxis to foods[8] and have a high incidence of asthma-related death[9-10]. Asthma and food allergy have also been related to increased risk of anxiety and depression in this age group[11]. Other allergic conditions such as allergic rhinitis and atopic dermatitis have been shown to affect quality of life, school performance, self-esteem and identity in this population[12-14].

Adolescence presents a great opportunity for education as this age group are keen to gain independence. While education will have been provided to parents of pre-adolescent patients, we know that young adolescents have a surprisingly poor understanding of their condition and how to self-manage them[15]. Certain types of interventions might be useful to improve adolescent and young adult engagement and address barriers to self-care, such as peer support, educational workshops or use of e-resources. The European Academy of Allergy and Clinical Immunology Task Force on Allergic Diseases in Adolescents and Young Adults has undertaken this systematic review to review the literature on interventions for improving self-management and wellbeing in adolescents and young adults with allergic conditions, including asthma, urticaria/angioedema and atopic dermatitis. This and a related systematic review on the challenges faced by this age group[15] will be used as the basis of a guideline to support the management of adolescents and young adults with allergic conditions.

METHODS

The protocol for this systematic review has been registered in Prospero (CRD42018104868) and the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) checklist has been used to guide reporting.

Search strategy

The search strategy was developed to retrieve articles reporting interventions designed to improve self-management and wellbeing in adolescents and young adults with allergic conditions including asthma, urticaria/angioedema and atopic dermatitis. The search strategy was developed on OVID MEDLINE (see Supplementary files) and then adapted for the other databases. The following databases were searched: Cochrane Database of Systematic Reviews, MEDLINE (OVID), Embase (OVID), Psychinfo, Clinicaltrials.gov, Clinical Trials Register (www.clinicaltrialsregister.eu), Current controlled trials (www.controlled-trials.com) and Australian and New Zealand Clinical Trials Registry (http://www.anzctr.org.au). Databases were searched from inception to March 30, 2018; an updated search was run on February 10, 2019. Additional references were located through searching the references cited by the identified studies and systematic reviews and through discussion with experts in the field.

Inclusion criteria

Studies conducted on adolescents or young adults (aged 11 to 25 years) with allergic conditions (asthma, food allergy, allergic rhinoconjunctivitis, atopic dermatitis, chronic urticaria and/or angioedema, allergic gastrointestinal disease, complex multisystem allergic disease). Included study designs were: controlled trial of an intervention (with two or more groups); randomised controlled trial. Study outcomes included psychological, social and behavioural issues, adherence, skills needed for coping, self-care, deprivation, disease control and symptoms.

Exclusion criteria

The following were excluded: abstracts, reviews, discussion papers, non-research letters, editorials and animal experiments plus studies where children, adolescent and/or adult data were presented together with no subgroup analyses. Studies that did not report an intervention, studies reporting interventions involving a medication or ones only reporting the use of exhaled nitric oxide to manage conditions were also excluded.

Study selection

All references were de-duplicated in Ovid before being uploaded into the systematic review software Rayyan. Study titles and abstracts were independently checked by two reviewers according to the above selection criteria and categorised as: included, not included or unsure. Any discrepancies were resolved through discussion and, if necessary, a third reviewer (RK or GR) was consulted. Full text copies of potentially relevant studies were reviewed by two reviewers for eligibility with discrepancies again resolved through discussion

and, if necessary, a third reviewer (RK or GR). A table of studies excluded with reasons can be found in Supplementary Table S1.

Quality assessment strategy

Quality assessments were independently carried out on each study by two reviewers using the Cochrane Risk of Bias Tool for Randomised Controlled Trials[16]. Any discrepancies were resolved by discussion or a third reviewer (RK or GR).

Data extraction, analysis and synthesis

Data were extracted onto a customized data extraction sheet independently by two reviewers and any discrepancies were resolved by discussion or by a third reviewer (RK or GR). Descriptive summary with summary data tables were produced and a narrative synthesis of the data was undertaken. Meta-analysis could not be undertaken due to the heterogeneity of methods and measurements used.

RESULTS

Description of Studies

A total of 30 papers were included in the final dataset reporting data from 27 studies (Figure 1). A summary of study characteristics can be found in Table 1 and a summary of findings across studies can be found in Table 2. The majority of studies had small sample sizes; the range was 28 to 455 with a mean of 139.39 participants. Interventions were of 4 main types: psychological (k=9); E-health (k=8); educational (k=4); peer led (k=5); there was k=1 intervention which focused on breathing re-training. All interventions were for adolescents and young adults with asthma, there were no interventions meeting the criteria for any other allergic condition. The majority of studies incorporated follow-up which ranged from 2 weeks to 12 months. Studies were conducted in the USA (k=17); Netherlands (k=2); Iran (k=2); Australia (k=2); Jordan (k=1); Canada (k=1); UK (k=1); and Germany (k=1).

Quality Ratings

Papers were rated for risk of bias. Eleven were found to have a low risk, 11 a moderate risk and 8 a high risk (see Table 1). Risk ratings for each component of the risk assessment tool can be found in Supplementary Table S2. Most studies were rated low for selection and reporting bias, but high for performance bias.

Psychological Interventions

Twelve papers reporting on nine studies explored the impact of psychological interventions on adolescents with asthma[17-28]. Eight papers were from the USA, three from Iran and one from Germany. All but two of the studies were randomised controlled trials; Hempel et al[17] employed a non-randomised controlled design and Hemati et al[18-19] conducted alternate allocation to intervention or control group. Participants were recruited from asthma clinics, inpatient clinics or hospital[17,18,19,20,21], schools[22-24] or were identified by review of medical records by clinicians[25-28].

Interventions focused on the management of stress, anxiety and/or depression[17-20,28], improvement of coping or problem-solving skills and self-efficacy[21,23,24]. Interventions also used cognitive behavioural[22,23,25-27] or motivational interviewing methods[21] to improve health outcomes. All interventions included an element of asthma education. Control groups generally received usual care or were on a wait-list, although some received alternatives such as teaching on problem solving[20], family support[25-27] or information on asthma[21,24].

Outcome measures included quality of life[19,21,23,24], self-esteem[18], coping[17], social support[23], self-efficacy[23,24], mood[19,28], asthma knowledge[19,24,25] and maladaptation behaviours[20]. A range of health outcomes such as adherence [21,22,25-27], medication use and number of hospitalisations[23,24,26], sleep[22] and asthma symptoms and lung function [21,24,26,28] were also measured.

Two papers reported findings from an 8-week interventional study based on Orem's Self-Care Model[18,19] focusing on self-care needs and reduction of stress and anxiety, which produced a significant improvement in self-esteem and quality of life in the intervention group compared to the control group. The same research group also reported on a similar intervention using the Roy Adaptation Model which focuses on identifying and changing maladaptive behaviours in managing health[20]. Their intervention was delivered over 6 weeks with a 2-month follow-up and resulted in a significant reduction in maladaptation behaviours in the intervention group compared to the control group. The clinical relevance of these impacts is not clear as effect sizes and minimal clinical important differences are not reported.

Three papers reported findings from a prospective randomised controlled trial using Multisystemic Therapy for African American adolescents with moderately to severe poorly controlled asthma[25-27]. This therapy incorporates cognitive behavioural therapy to promote behavioural changes and coping skills, delivered at home over six months. Adherence, asthma knowledge, asthma symptoms and hospitalisations were found to significantly improve in the intervention compared to the control group[25-27], with a per protocol analysis showing a medium effect on adherence[27]. Asthma knowledge and device skill knowledge was still improved six months later[25]. Again, the clinical significance is not clear.

Five studies focused on coping skills, problem-solving training or management of asthma using either cognitive behavioural strategies[17,22,23,24] or motivational interviewing[21]. Two of the studies found quality of life to significantly improve in the intervention group compared to the control group although this did not reach the minimal clinical important difference at the group level[21,23]. Self-efficacy improved[23], asthma symptoms significantly reduced[21] and sleep and a sense of responsibility for carrying medication improved[22]. Hampel et al.[17] found significant improvements in emotion and problem-focused coping strategies from pre- to post-treatment in the intervention groups. In comparison Velsor-Friedrich et al.[24] found no differences in the intervention or control group for quality of life, self-efficacy, coping or asthma health outcomes with both improving over time. One study focused on reduction of negative affect using emotional disclosure[28] and found significant improvements in the intervention group compared to the control group.

In summary, a number of studies have examined the impact of a range of psychological interventions in adolescents with asthma. Compared to a controlled group, they have been found to improve a range of health outcomes. There is a lack of replication and it is unclear whether the magnitude of any of the health impacts are clinically significant.

E-Health Interventions

Eight studies used e-health interventions[29-36]; seven studies from the United States and one from the Netherlands. All studies were randomized controlled trials, although three were just pilot studies[29-31]. Participants were recruited from rural and suburban paediatric clinics or outpatients[29-34], emergency departments[35] or high schools[36].

Interventions consisted of the use of computer web-based applications[31,33,35,36], telecommunication compressed videos[32,34] or the use of mobile applications[29,30]. Bynum et al.[32] designed an experimental study with random assignment of participants to a telepharmacy counselling group or control group. The intervention consisted of a compressed video telecommunication with a pharmacist to review and instruct on metered dose inhaler technique. Similar to this, Sleath et al.[34] designed a pragmatic trial in which adolescents watched a video on an iPad and then completed an asthma question prompt list. Two other randomized controlled trials evaluated internet-based self-management[33] and the Puff-city-web-based computer-tailored intervention[35,36]. One of the pilot studies was a block-randomized controlled study to assess the impact of a personal health application-web based system called MyMediHealth which sent medication reminders via text[29]. Perry et al[30] piloted a novel smartphone-based personalized asthma action plan; Rhee et al[31] piloted a computer assisted decision making programme with tailored counselling.

Across studies, control groups either received usual care[29,33,34], written instructions[30,32] or education sessions (e.g. sessions link to asthma website or a sham CD ROM)[31,35,36]. Outcome measures for studies included: asthma control[29,30,33]; self-efficacy[29,30]; quality of life[29,33]; user satisfaction[30,32] and clinical symptoms[35,36]. Most outcome follow-ups were assessed at 6 months[30,31,35,36] or 1 year[33,35,36]. However, for three studies the evaluation post-intervention was shorter (1st day - 4 weeks)[29,32,34].

E-health interventions were significantly related to improved study outcomes for the intervention group compared to the control group in most studies, especially among those meeting criteria for moderate-severe asthma[36], and adolescents with uncontrolled asthma[30,33]. Significant improvements were seen in inhaler technique[32], in asking questions about asthma medication, triggers and environmental control[34], adherence[29], quality of life[29,33], asthma control[33] and reduced clinical symptoms at 12-month follow-up[36]. However, asthma self-efficacy scores significantly improved in just one study[29] as did user satisfaction[30]. Asthma control did not improve in four studies[29,30,35,36] although Perry et al.[30] found a significant improvement in a sub-group who did not have well-controlled asthma. Again, there were no clear clinically significant improvements in health outcomes.

General educational Interventions

Four studies assessed educational interventions[37-40]; one from the UK, one from the Netherlands, one from Canada and one from the USA. All were randomized controlled trials and included group sessions focusing on asthma prevention and management[37-39], individual coaching sessions[37] and nurse-led asthma clinics[39,40]. Participant identification and intervention delivery was school-based[37,40], community-based[38], and in an outpatient setting[39]. One study recruited urban ethnic minority teens[37]. Control groups were randomized either to normal care[37,39,40], or a less active form of intervention including basic spirometry and revision of inhaler technique[38].

All of the general education interventions focused on outcomes relating to asthma knowledge, symptom identification, symptom prevention and asthma management. They demonstrated significantly improved knowledge of asthma and inhaler technique[37,40], reduction in night-time symptoms and school absences[37] amongst the intervention group compared to the control group. Longevity of this positive impact varied. One study focused in particular on attitudes and self-efficacy with regards to asthma, demonstrating only improved self-reported adherence amongst the intervention group after 2 years[39], however Cowie et al.[38] reported no differences between intervention and control group six months post intervention.

Three studies assessed the impact educational interventions had on quality of life[37,38,40]. Results were mixed, with one study demonstrating a statistically (but not clinically) significant improvement in quality of life amongst the intervention group 12 months post-intervention[37], one showed a non-significant trend in overall quality of life and significant improvements for symptom related and emotional quality of life[38] and one found no effects on quality of life[40]. Three of the interventions focused on healthcare use and two demonstrated a reduction in acute medical visits amongst the intervention group [37,38], whilst the third study focused on asthma review clinic attendance, demonstrating an increased attendance amongst the intervention group[40].

Peer-Led Interventions

Five studies assessed peer-lead interventions for asthma[41-45]; two studies from Australia, one from Jordan and two from the USA. Two used a cluster-randomized design[41,42]; and three used a randomized controlled

294 design[43-45]. Participants were recruited from high schools in Jordan[41], rural high schools in Australia[42,43], or an
295 asthma day camp in the USA[44,45].
296
297 The intervention utilised in three of the five papers was the Triple A (Adolescent Asthma Action) programme[41-
298 43] and was compared to standard practice. In two studies[44,45] a peer-led camp based on the Power Breathing
299 Programme was compared to an adult led camp. In two studies the effect of the intervention was measured
300 after 3 months[41,42], and in two studies outcomes were measured at 3, 6 and 9 months[44,45]. In one study
301 measurements were performed 1-2 months prior and after the intervention with no long-term follow-up[43].
302
303 Four of the five studies measured quality of life using asthma-specific quality of life scales; three found that
304 quality of life significantly improved in the intervention group compared to the control group[41,42,44], while one
305 study showed no change in quality of life[43]. For two studies, the magnitude of the group change in quality of
306 life was greater than the minimal clinical important difference[41,44]. Rhee et al.[44] found the intervention to be
307 more beneficial to adolescents of male gender, low family income and non-white participants while Shah et
308 al.[42] showed the effect of the intervention was greatest in females.
309
310 Shah et al.[42] measured school absenteeism and found it decreased in the intervention group whilst asthma
311 attacks in school increased in control group. An 80-82% reduction in acute office visits in the peer-led group
312 was found in the study by Rhee et al.[45] and this group were 4-5 times more likely to use school clinics due to
313 asthma. Al-Sheyab et al.[41] measured self-efficacy to resist smoking and knowledge of asthma self-
314 management and found this improved compared to the control group. Gibson et al.[43] also showed an
315 improvement in asthma knowledge in students with asthma and peers at the intervention schools. The impact
316 on asthma control was only assessed by Rhee et al.,[44] who found no difference in FEV1 between intervention
317 and control group.
318
319 **Relaxation and breathing re-training**
320 One study assessed the effectiveness of relaxation and breathing re-training[46]. The intervention consisted of
321 practice in diaphragmatic breathing, asthma-specific guided imagery and progressive muscle relaxation over
322 two sessions of 30 minutes, a month apart, plus a compact disk to use at home. Control participants had two

sessions of educational material on asthma only. Both groups improved over time and there was no significant difference between intervention and control group for quality of life, asthma control or anxiety.

DISCUSSION

This systematic review aimed to review the literature on interventions for improving self-management and wellbeing in adolescents and young adults with asthma and allergic conditions. Thirty papers reporting data from 27 studies met the inclusion criteria, all for adolescents and young adults with asthma, with no interventions meeting the criteria for any other allergic condition. Interventions were varied and included those incorporating psychological elements such as cognitive behavioural therapy or motivational interviewing; peer-led interventions in schools or asthma camps; e-health interventions using smart phones or computers; and general educational interventions led by health care professionals. A large range of outcome variables were measured including quality of life, self-esteem and self-efficacy, coping skills, mood, asthma adherence, asthma knowledge, symptoms and hospital visits. Across interventions, improvements were generally seen for intervention groups compared to control groups in a number of outcome measures, however the quality of the studies varied greatly.

Overall effectiveness across interventions

All but four of the interventions reported significantly better outcomes for the intervention group compared to the control group for at least one outcome measure. Psychological outcomes such as quality of life, self-esteem, self-efficacy, use of social support, coping and mood all improved. Clinical outcomes such as asthma symptoms, hospital visits, adherence, device technique and asthma knowledge were also shown to improve. Velsor-Friedrich et al.'s[24] coping-skills training intervention, Bignall et al.'s[46] breathing re-training intervention, Joseph et al.'s[35] computer tailored intervention and an educational intervention by van Es et al[39] reported no differences, with both intervention and control groups improving over time. This may be due to the participants and setting for Velsor-Friedrich et al.[24] (low income urban adolescents in a community setting) and to the low participant numbers for the other studies. Overall therefore, it appears that taking part in an intervention as an adolescent or young adult with asthma may provide some benefits in terms of psychological and/or clinical outcomes.

Psychological outcomes

Quality of life was measured by studies in each category of intervention and reported in 15 out of the 30 papers in this review but only ten papers reported improved quality of life in the intervention groups compared to the control groups. In only two studies, employing peer-led interventions, was this a clinically important group increase[41,44]. Adolescents receiving psychological interventions generally reported better quality of life than controls with the notable exception of the intervention reported by Velsor-Friedrich et al.[24]. For E-Health interventions two of the three papers measuring quality of life reported improvements and similarly for educational interventions, two of the three papers reported improvements. For peer-led interventions, out of four papers measuring quality of life, just Gibson et al.[43] reported no significant improvements in the intervention group. Not all studies reporting non-significant findings were small feasibility or pilot studies but many of these studies included participants who were from low income backgrounds, ethnic minority groups or had severe asthma where you may expect to see improvements in the control groups due to being recruited into a study.

Self-efficacy was measured by seven studies and found to significantly improve in the intervention group in four of these. Those not reporting improvements were small pilot studies and thus may not have been fully powered to detect differences. The only other psychological outcome reported by more than one study was mood, which was found to improve in the intervention group in two studies but not in the breathing re-training study by Bignall et al.[46].

Although it is difficult to make comparisons across intervention types and measures, the general trend across studies is an improvement in psychological outcomes for adolescents and young adults with asthma. Further work is needed with fully powered trials for asthma and other allergic conditions that focus on assessing for clinically important improvements in self-efficacy and other endpoints.

Clinical outcomes

Most studies in this review measured clinical outcomes. The majority of studies that measured device technique, sleep and adherence reported significant improvements in the intervention groups compared to

control groups. The majority of studies measuring asthma knowledge and symptom improvement also reported significant improvements in the intervention groups. It is not clear whether these improvements are clinically relevant as we do not know the size of effects reported. Findings for hospitalisation, self-reported asthma control and FEV_1 were more equivocal. So, while there are encouraging results, there is currently limited evidence for efficacy for key contemporary, patient-centred endpoints of asthma control and exacerbations.

Limitations of studies in this review

There are limitations of the studies in this review, which could in part explain the varied results. Quality ratings showed that the majority of studies had either a moderate or high risk of bias. This was for a number of reasons including small sample sizes, lack of information on randomisation, no blinding of participants to intervention group, incomplete outcome data, use of unvalidated outcome measures and a lack of information about control groups. There was also a lack of information on the content of the intervention for many papers and publication of an intervention protocol would be useful. It was difficult to ascertain whether findings had clinical importance due to the use of poorly validated endpoints with no information about minimal clinically important differences or effect sizes. It was also not possible to run a meta-analysis due to variability in the outcome measures used for any intervention type. The diagnosis of asthma varied from questionnaire-based criteria to clinical criteria including spirometry. Lastly, there are other factors that need to be taken into consideration such as how the intervention fits in with the structure of the health system, the training provided to health workers delivering the interventions, whether more than one intervention is required, the best age to initiate such interventions (perhaps in the pre-adolescent years) and how much more motivated trial participants are likely to be compared to routine clinic patients.

Policy implications and recommendations

Policy reports across Europe have an emphasis on integrated care and one of the key components of this is self- management[47,48]. This systematic review is timely to help commissioners and policy makers understand the context for this important and often overlooked age group of adolescents and young adults. Population health approaches are also being supported in policy and these aim to promote improvements in both the physical and mental outcomes whilst addressing health inequities across a population[49]. The King's fund report 'A vision for population health: towards a healthier future' considers four pillars of population health: 'wider

determinants of health, health behaviours and lifestyles, places and communities that people live in, and an integrated care system'[49].

It is clear that although the results of the systematic review so far are promising we should be investing in further research to support self- management and patient-centred care in order for integrated care to be truly realised. The aim of this is it achieve better quality care, improved patient experience and lower costs, thus supporting a more sustainable health system. This will also involve an understanding of relevant behavioural and cultural approaches and an investment in education for both health care staff and patients. However, we do need to be mindful that many interventions are complex, time-consuming and expensive and so cost-effective interventions that are feasible to implement are needed.

Conclusions

Although significant improvements were seen across all intervention types, many studies in this review were small feasibility or pilot studies and none for allergic conditions other than asthma met the inclusion criteria. Large, longitudinal, interventional studies carried out across the range of allergic conditions, particularly for food allergy and atopic dermatitis, are required to strengthen the evidence base. These need to focus on interventions where there is preliminary evidence, for example the peer-led interventions. Studies need to utilise well validated outcomes and outcome measures that are patient-centred, disease specific where possible, and provide information about the clinical importance of results.

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REFERENCES

1. de Benedictis D, Bush A. The challenge of asthma in adolescence. Pediatr Pulmonology 2007;42:683-92.

2. de Benedictis D, Bush A. Asthma in adolescence: Is there any news? Pediatr Pulmonology 2017;52:129-38.

3. Marrs T, Lack G. Why do few food-allergic adolescents treat anaphylaxis with adrenaline? reviewing a pressing issue. Pediatr Allergy Immunol 2013;24:222-9.

4. DunnGalvin A, Gaffney A, Hourihane JOB. Developmental pathways in food allergy: a new theoretical framework. Allergy 2009;64:560-8.

5. Holley S, Walker D, Knibb R, Latter S, Liossi C, Mitchell F, et al. Barriers and facilitators to self-management of asthma in adolescents: An interview study to inform development of a novel intervention. Clin Exp Allergy 2018;48:944-56.

6. Holley S, Morris R, Knibb R, Latter S, Liossi C, Mitchell F, Roberts G. Barriers and facilitators to asthma self-management in adolescents: A systematic review of qualitative and quantitative studies. Pediatr Pulmonology 2017;52:430-42.

7. Vazquez-Ortiz M, Giner MT, Piquer M, Dominguez O, Alvaro M, Lozano J, et al. Life-threatening reactions to oral immunotherapy (OIT) in egg and cow's milk (CM) allergic teenagers. Allergy: European J Allergy Clin Immunol 2014:33rd Congress of the European Academy of Allergy and Clinical Immunology. Copenhagen Denmark. Conference Publication: 69, Suppl. 99; 278.

8. Turner PJ, Gowland MH, Sharma V, Lerodiakonou D, Harper N, Garcez T, et al. Increase in anaphylaxis-related hospitalizations but no increase in fatalities: an analysis of United Kingdom national anaphylaxis data, 1992-2012. J Allergy Clin Immunol 2015;135:956-63.

9. van Asperen P. Deaths from childhood asthma, 2004–2013: what lessons can we learn? Med J Australia 2015;202:125-6.

10. Wolfe I, Thompson M, Gill P, Tamburlini G, Blair M, van den Bruel A, et al. Health services for children in western Europe. The Lancet 2013;381:1224-34.

11. Ferro MA, Van Lieshout RJ, Scott JG, Alati R, Mamun AA, Dingle K. Condition-specific associations of symptoms of depression and anxiety in adolescents and young adults with asthma and food allergy. J Asthma 2016;53:282-8.

12. Walker S, Khan-Wasti S, Fletcher M, Cullinan P, Harris J, Sheikh A. Seasonal allergic rhinitis is associated with a detrimental effect on examination performance in United Kingdom teenagers: case-control study. J Allergy Clin Immunol 2007;120:381-7.

13. Nguyen CM, Koo J, Cordoro KM. Psychodermatologic effects of atopic dermatitis and acne: a review on self-esteem and identity. Pediatr Dermatology 2016;33:129-35.

14. Mortz C, Andersen K, Dellgren C, Barington T, Bindslev-Jensen C. Atopic dermatitis from adolescence to adulthood in the TOACS cohort: prevalence, persistence and comorbidities. Allergy 2015;70:836-45.

15. Vazquez-Ortiz M, Angier E, Blumchen K, Comberiati P, Duca B, DunnGalvin A, et al. Understanding the challenges faced by adolescents and young adults with allergic conditions: a systematic review. Allergy, under review.

16. Higgins JPT, Altman DG, Gotzsche P, Juni P, Moher D, Oxman AD, et al. The Cochrane Collaboration's tool for assessing risk of bias in randomised trials. Brit Med J 2011;343:d5928.

17. Hampel P, Rudolph H, Stachow R, Petermann F. Multimodal patient education program with stress management for childhood and adolescent asthma. Patient Education Counselling 2003;49:59-66.

18. Hemati Z, Sadat Mosaviasl F, Abasi S, Ghazavi Z, Kiani D. Effect of Orem's Self-Care Model on self-esteem of adolescents with asthma referred to an asthma and allergy clinic in Isfahan. Tanaffos 2015;14:232-237.

19. Hemati Z, Shakerian B, Shirani F, Sadat Mosaviasl F, Kiani D. Effect of Orem Self-care Model on quality of life in adolescents with asthma. J Compr Ped 2017;8:e59343.

20. Alimohammadi N, Maleki B, Abbasi S, Shakerian B, Hemati Z. The effect of adaptation training on controlling maladaptation behaviors in adolescents with asthma Based on Roy Adaptation Model. Tanaffos 2018;17:103-109.

21. Seid M, D'Amico EJ, Varni JW, Munafo JK, Britto MT, Kercsmar CM, et al. The *In Vivo* adherence intervention for at risk adolescents with asthma: report of a randomized pilot trial. J Pediatr Psychol 2012;37:390-403.

22. Bruzzese J-M, Unikel L, Gallagher R, Evans D, Colland V. Feasibility and impact of a school-based intervention for families of urban adolescents with asthma: result from a randomized pilot trial. Fam Proc 2008;47:95-113.

23. Srof BJ, Velsor-Friedrich B, Penckofer S. The effects of coping skills training among teens with asthma. Western J Nursing Res 2012;34:1043-1061.

24. Velsor-Friedrich B, Militello LK, Richards MH, Harrison PR, Gross IM, Romero E, et al. Effects of coping-skills training in low-income urban African-American adolescents with asthma. J Asthma 2012;49:372-379.

25. Ellis DA, King P, Naar-King S. Mediators of treatment effects in a randomized clinical trial of Multisystemic Therapy-Health Care in adolescents with poorly controlled asthma: Disease knowledge and device use skills. J Pediatr Psychol 2016;41:522-530.

26. Naar S, Ellis D, Cunningham P, Pennar AL, Lam P, Brownstein NC, Bruzzese J-M. Comprehensive community-based intervention and asthma outcomes in African American adolescents. Pediatrics 2018;142:e20173737.

27. Naar-King S, Ellis D, King PS, Lam P, Cunningham P, Secord E, Burzzese J-M. Multisystemic therapy for high-risk African American adolescents with asthma: a randomised clinical trial. J Consulting Clin Psychol 2014:82:536-545.

28. Warner LJ, Lumley MA, Casey RJ, Pierantoni W, Salazar R, Zoratti EM, et al. Health effects of written emotional disclosure in adolescents with asthma: a randomised controlled trial. J Pediatr Psychol 2006;31:557-568.

29. Johnson KB, Patterson BL, Ho YX, Chen Q, Nian H, Davison CL, et al. The feasibility of text reminders to improve medication adherence in adolescents with asthma. J Am Med Inform Assoc. 2016;23:449-55.

30. Perry TT, Marshall A, Berlinski A, Rettiganti M, Brown RH, Randle SM, et al. Smartphone-based vs paper-based asthma action plans for adolescents. Ann Allergy Asthma Immunol 2017;118:298-303.

31. Rhee H, Hollen PJ, Belyea MJ, Sutherland MA. Decision-making program for rural adolescents with asthma: a pilot study. J Pediatr Nurs 2008;23:439-50.

32. Bynum A, Hopkins D, Thomas A, Copeland N, Irwin C. The effect of telepharmacy counselling on metered-dose inhaler technique among adolescents with asthma in rural Arkansas. Telemed J E Health. 2001;7:207-17.

33. Rikkers-Mutsaerts ERVM, Winters AE, Bakker MJ, van Stel HF, van der Meer V, de Jongste JC, et al. Internet-based self-management compared with usual care in adolescents with asthma: a randomized controlled trial. Pediatr Pulmonol. 2012;47:1170-9.

34. Sleath B, Carpenter DM, Davis SA, Watson CH, Lee C, Loughlin CE, et al. Improving youth question-asking and provider education during pediatric asthma visits. Patient Educ Couns 2018;101:1051-1057.

35. Joseph CLM, Mahajan P, Stokes-Buzzelli S, Johnson DA, Duffy E, Williams R, et al. Pilot study of a randomized trial to evaluate a web-based intervention targeting adolescents presenting to the emergency department with acute asthma. Pilot and Feasibility Studies 2018;4:5.

36. Joseph CLM, Ownby DR, Havstad SL, Saltzgaber J, Considine S, Johnson D, et al. Evaluation of a web-based asthma management intervention program for urban teenagers: reaching the hard to reach. J Adolesc Health 2013;52:419-26.

37. Bruzzese J-M, Sheares BJ, Vincent DJ, Du Y, Sadeghi H, Levison MJ, Mellins RB, et al. Effects of a school-based intervention for urban adolescents with asthma. A controlled trial. Am J Respir Crit Care Med; 2011;183:998-1006.

38. Cowie RL, Underwood MF, Little CB, Mitchell I, Spier S, Ford GT. Asthma in adolescents: a randomized, controlled trial of an asthma program for adolescents and young adults with severe asthma. Can Respir J 2002;9:253-259.

39. Van Es SM, Nagelkerke AF, Colland VT, Scholten RJPM, Bouter LM. An intervention programme using the ASE model aimed at enhancing adherence in adolescents with asthma. Patient Educ Couns 2001;44:193-203.

40. Salisbury C, Francis C, Rogers C, Parry K, Thomas H, Chadwick S, et al. A randomised controlled trial of clinics in secondary schools for adolescents with asthma. Brit J Gen Prac 2002;52:988-996.

41. Al-sheyab N, Gallagher R, Crisp J, Shah, S. Peer-led education for adolescents with asthma in Jordan: a cluster-randomized controlled trial. Pediatrics 2011;129:e106-112.

42. Shah S, Peat JK, Mazurski EJ, Wang H, Sindhusake D, Bruce C, et al. Effect of peer led programme for asthma education in adolescents: cluster randomised controlled trial. Brit Med J 2001;322:583-5.

43. Gibson PG, Shah S, Mamoon HA. Peer-led asthma education for adolescents: impact evaluation. J Adol Health 1998;22:66-72.

44. Rhee H, Belyea MJ, Hunt JF, Brasch J. Effects of a peer-led asthma self-management program for adolescents. Archives Pediatr Adol Med 2011;165:513-9.

45. Rhee H, Pesis-Katz I, Xing J. Cost benefits of a peer-led asthma self-management program for adolescents. J Asthma 2012;49:606-13.

46. Bignal WJR, Luberto CM, Cornette AF, Haj-Hamed M, Cotton S. Breathing retraining for African-American adolescents with asthma: a pilot study of a school-based randomized controlled trial. J Asthma. 2015;52:889-896.

47. Agache I, Annesi-Maesano I, Bonertz A, Branca F, Cant A, Fras Z, Ingenrieth F, Namazova-Baranova L, Odemyr M, Spanevello A, Vieths S. Prioritizing research challenges and funding for allergy and asthma and the need for translational research—The European Strategic Forum on Allergic Diseases. Allergy. 2019 May 9.

48. World Health Organization. Health 2020. A European policy framework and strategy for the 21st century (2013). (http://www.euro.who.int/en/publications/abstracts/health-2020.-a-european-policy-framework-and-strategy-for-the-21st-century-2013, accessed 28th December 2019)

608 49. A vision for population health: Towards a healthier future. Kings fund 2018.
609 (https://www.kingsfund.org.uk/publications/vision-population-health, accessed 28th December 2019)
610

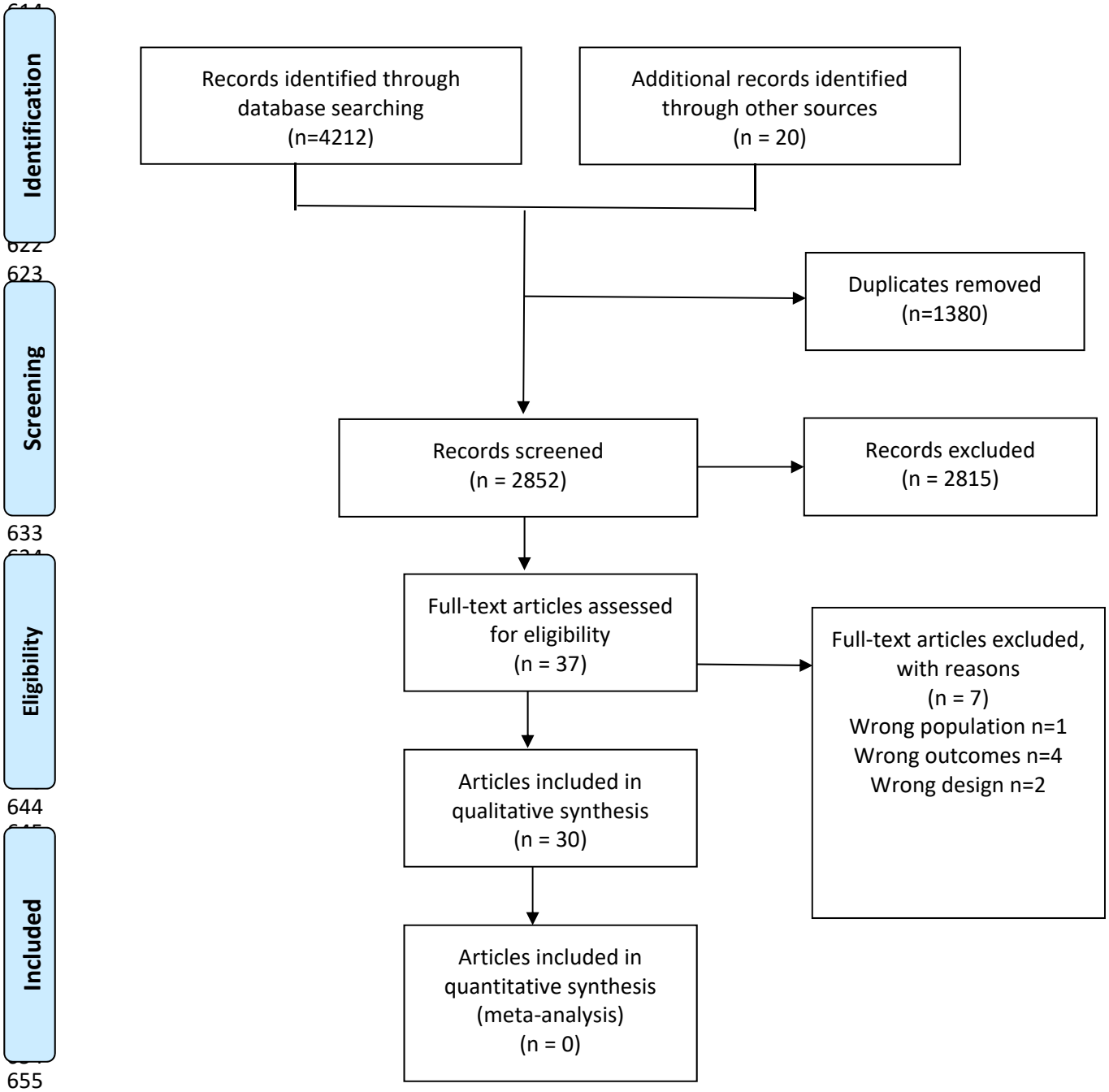

Figure 1. **PRISMA figure demonstrating literature excluded and examined in systematic review**

663 Table 1. Study characteristics ordered by type of intervention and risk of bias ratings

Author, year, country	Population, number, and setting	Measures	Intervention	Analysis	Authors' results / conclusions	Risk of bias
Psychological Interventions						
1.Alimo-hammadi et al., 2018, Iran	N=64 from asthma and allergy clinic with moderate to severe asthma; randomly allocated to intervention and control group; 11-21 years old; mean age 15.8 experimental; 14.8 control group	Questionnaire based on Roy's adaptation model. Before intervention and after 2 months.	Six weeks with six two-hour sessions; 2 months follow up. Sessions run by physicians, nurse and psychologists on causes of asthma, asthma knowledge, ways to prevent symptoms, managing anxiety and depression, dietary advice. Were called once a week for 2 months. Control group receiving teaching and problem solving by physician in regular visits.	Paired t test Independent t test Mann-Whitney ANOVA Chi-square	Mean score of maladaption behaviours significantly reduced in intervention group after training ($p<0.001$); no difference in control group. Significant differences between intervention and control groups across all domains of maladaptive behaviours after intervention.	Moderate
2.Bruzzese et al., 2008, USA	N=24 families; 1 child with asthma and 1 parent from each family; mean age children 12.9 years 13 male, 11 female. Setting: city public school. N=12 randomised to intervention group; N=12 to control group.	Asthma symptoms. Symptom prevention and asthma attack management completed by students; caregivers reported on children's behaviour; Asthma Responsibility Questionnaire. Parent-Adolescent Relationship Questionnaire.	It's a Family Affair Intervention; behavioural intervention based on CBT. Students: 6 group sessions on prevention and management on asthma. Caregivers: 5 group sessions teaching child-rearing skills to support the youth's autonomy and asthma self-management. Control group received no treatment.	One-tailed ANCOVA controlling for baseline comparing intervention and control group at 2 month follow-up.	Improvement in caregivers solving problems with children $p<0.05$; rated children more responsible for remembering to carry medication $p<0.05$; children reported more steps to prevent asthma symptoms $p<0.05$, reduction in nights awakened $p<0.01$. No difference in daytime symptoms.	Moderate
3.Ellis et al., 2016[1], USA	N=167 12-16 year olds. Intervention N=84; comparison N=86 African-American, moderate-severe asthma; home based delivery	Asthma knowledge (Family Asthma Management System Scale, Asthma Knowledge scale and Medication Adherence subscale)	Multisystemic Therapy-Health Care (MST-HC therapy adapted for youths with poor asthma self-management); weekly sessions over 6 months versus in home family support. Control: weekly supportive family counselling for 6 months	Differences in asthma knowledge and device use skills assessed immediately after and then 6 months post completion of intervention using	Asthma knowledge improved over time in intervention group ($p<0.05$), unchanged in control group. Device skills knowledge improved over time in intervention group, declined in control group ($p<0.1$). Asthma knowledge	Low

Author, year, country	Population, number, and setting	Measures	Intervention	Analysis	Authors' results / conclusions	Risk of bias
		Device use skills (Equipment skills check-list		linear mixed models and t-test.	and device use skills better in intervention group 6 months post treatment (p<0.5).	
4.Hampel et al., 2003 Germany	N=68 participants aged 8-16years from inpatient asthma clinics; analysis split by age group: 8-10, 11-13, 14-16 years	General satisfaction with health; German Coping Questionnaires. Measures taken before, immediately after and 6 months after the intervention.	Cognitive stress management training versus educational programme without stress management.	Factorial ANOVA to compare treatment and control group across different age groups. Friedman Rank, Wilcoxon and Mann-Whitney U-tests to assess long-term effects at follow-up.	Improvement in emotion and problem focused-coping strategies from pre- to post-treatment in treatment group in 14-16 year olds (p<0.05)	High
5.Hemati et al., 2015[2] Iran	N=64 adolescents with asthma recruited from hospital; N=32 to control and N=32 to intervention. Mean age 14.15 years in intervention; 15.21 years in control group	Coopersmith Self-Esteem Inventories. Measures taken before and 2 months after intervention.	Semi-experimental study; 8 two-hour sessions based on Orem's self-care model and self-care needs delivered by the researcher. Focused on self-care and reduction of stress and anxiety	Independent and paired samples t-tests.	Difference in mean score of self-esteem between intervention and control group after training (p<0.05); Increase in self-esteem in intervention group post training (p<0.05) but not in control group.	High
6. Hemati et al., 2017[2] Iran		Questionnaire based on Orem's Self-Care Model; QoL scale developed by Marks et al to measure QoL in adults with asthma.		Paired t test, Independent t test, Chi-square, Mann-Whitney.	Mean score of QoL in all domains and overall significantly reduced in intervention group after training (ps<0.05); no difference in control group (p>0.05).	High
7. Naar et al., 2018[1] USA	N=167 African American adolescents; 12-16 years with moderate to severe	Lung function (FEV1)-primary outcome. Secondary outcome:	Multisystemic Therapy-Health Care (MST-HC therapy adapted for youths with poor asthma self-management);	T test, Chi-square, Linear mixed-effects models.	Adolescents in the treatment group had greater improvement in FEV_1 (p=0.01) adherence to controller	Low

Author, year, country	Population, number, and setting	Measures	Intervention	Analysis	Authors' results / conclusions	Risk of bias
	persistent asthma and >- 1 inpatient hospitalization or >-2 ED visits in the last 12 months. Randomized to MST-HC (N=84) or in-home family support (N=83).	medication adherence, symptom severity, health care use; hospitalizations and ED visits. Data taken from medical records; FAMSS and DPD completed Evaluation at baseline and after 7 and 12 months.	weekly sessions over 6 months versus in home family support.	Multiple imputation methods within the trajectory analysis. Multiple binomial regression.	medication (p=.004) and frequency of asthma symptoms (p=.03) compared to controls. Treatment group had a greater reduction in hospitalizations but no difference in ED visits.	
8.Naar-King et al., 2014[1] USA		Asthma Family Management System Scale (a clinical interview); medication adherence daily phone diary; lung function. Measures taken at baseline and 7 months post treatment		T-tests and chi-squares; mixed models controlling for gender, age, family income, N of treatment sessions, single-parent household. Intent to treat and per protocol analysis	ITT analysis – intervention group more likely to improve medication adherence and FEV1. PP analysis – intervention had medium effect on adherence and small to medium effect on FEV1 and child response to asthma symptoms and exacerbations	Low
9.Seid et al., 2012, USA	N=28 12-18 year olds with moderate-severe asthma (N=14 in control group, N=14 in intervention group). Outpatient setting.	Participant motivation, adherence barriers, asthma symptoms and HRQOL: PedsQL	Education, in-person motivational interviewing and problem-solving skills training (2 sessions 1 week apart); phone with tailored text messages. Control: asthma education and phone without tailored text messages. Intervention lasted 1month, with follow-up then and one month later.	Comparison between time points using Wilcoxon rank-sum and repeated measures analysis of variance.	At 1 and 3 months, asthma symptoms (Cohen's d's=0.40, 0.96) and HRQOL (Cohen's d's=0.23, 1.25) had clinically meaningful medium to large effect size improvement in the intervention group.	Moderate
10.Srof et al., 2012, USA	N=39 14 to 18 year olds with asthma from 3 midwestern high schools	Asthma Belief Survey for self-efficacy; Revised Personal Resource Questionnaire for social support; PAQLQ asthma QoL; peak exp flow rate;	Coping skills training based on cognitive behaviour strategy. One session per week for five weeks. Control group – usual care.	ANCOVA to compare treatment and control group and to compare pre- and post-scores for	Treatment group scored sig higher on self-efficacy (p<0.001), activity related QoL (p=0.05), social support (p<0.001) than control group. Pre- to post-treatment	Moderate

Author, year, country	Population, number, and setting	Measures	Intervention	Analysis	Authors' results / conclusions	Risk of bias
		diary for symptoms; medication use Post-test measures 6 weeks after end of intervention.		treatment group, controlling for baseline scores	improvement in treatment group for self-efficacy ($p<0.001$) and QoL ($p=.02$)	
11.Velsor-Friedrich et al., 2012 USA	N=137 African American adolescents with asthma from 5 high schools	Parent asthma self-care questionnaires; Asthma self-care; Asthma QoL; Knowledge About Asthma; Asthma self-efficacy; Coping frequency/efficacy; FEV_1, FVC, PEFR, number of symptom days; ED visits; hospitalisation. Measures taken at baseline, 2 months (immediately after intervention), 6 and 12 months	Randomised controlled trial of a coping skills intervention compared with standard asthma education	Multiple regression; ANOVA	Both groups improved over time. No significant differences in groups in relation to QoL, knowledge, self-efficacy, symptoms days and school absences.	Moderate
12.Warner et al., 2006 USA	N=50 adolescents aged 12-17yrs with asthma and parents, randomised to each group.	Mood ratings; essay ratings; Asthma Sum Scale (for asthma symptoms); PANAS for children; Child Behaviour Check List; Functional Disability Inventory; lung function. Measures taken at baseline, 1 and 2 months after the intervention.	Written emotional disclosure: write for 3 days about stressful events or control topics – how you manage your time	Factorial ANOVA and ANCOVA; regression analyses	Improvement in positive affect and internalizing problems in intervention versus control group ($p<0.01$). Decreased asthma symptoms and functional disability in intervention group in those with baseline elevations. No differences in FEV_1	Moderate
E-Health interventions						
1.Bynum et al., 2001, USA	N=49 rural adolescents aged 12-19 years with asthma; intervention N=24, control N=25.	MDI technique and patient satisfaction. MDI technique checklist completed before,	Compressed video telecommunication (telepharmacy) with a pharmacist to review and instruct on MDI technique.	ANOVA, chi-square, *t*-test	From pre-test to follow-up the telepharmacy counselling group showed more	High

Author, year, country	Population, number, and setting	Measures	Intervention	Analysis	Authors' results / conclusions	Risk of bias
	69% female. Local health clinic setting	immediately after and 2-4 weeks post intervention. Evaluation form to assess participant satisfaction completed 2-4 weeks later.	Control: written instructions on MDI technique.		improvement in MDI technique than control group (p=0.001). No significant difference between telepharmacy group and control group in satisfaction scores.	
2.Johnson et al., 2016, USA	N=89 12-17 year olds; N=46 in intervention group, N=43 in control group with current asthma diagnosis. Outpatient setting	Medication adherence, Asthma Control Test, Perceptions of Asthma medication survey, Self-efficacy scale, Illness management scale.	MyMediHealth personal health application- web based system that sends medication reminders via text. Used for 3 weeks. Control: Online educational materials about asthma medication management	Wilcoxon and Pearson tests used to assess change in adherence, self-efficacy, ACT and QoL ITT analysis	Intervention improved adherence in past 7 days (p=0.01), improved self-efficacy (p=0.016), and QoL (p=0.037) compared to control group. No effect on ACT.	Low
3.Joseph et al., 2013, USA	N=422 Urban, African-American 9^{th}-12^{th} grade students, with any asthma severity. N=204 in intervention group; N=218 in control group. School based	Symptom free days, restricted activity, missed school; ED visits and hospitalization	Puff-city- web-based, computer-tailored intervention. Initial survey and 4 online sessions within 180 days. Novel intervention. Control: 4 asthma education sessions.	Outcome comparison at 12 month follow-up analysed by binomial regression or Chi-squared/ Wilcoxons	Intervention group reported reduced symptom days at 12 month follow-up (aRR 0.8, 95% CI 0.6-1.0, p= 0.019). No difference in ED visits/ hospitalization. For moderate-severe asthmatics- greater effects seen on symptom reduction (aRR 0.6, 95% CI 0.5-0.9, p = 0.013.	High
4.Joseph et al., 2018 USA	N=121 13-19 year olds attending ED with acute asthma. N=65 in treatment group, 86% African American. ED initiated setting	Primary outcome: ED visits at 12 months. Secondary: asthma control as measured by the ACT, functional status, quality of life, behaviour change	Puff-city- web-based, computer-tailored intervention. 4 education sessions plus a booster. Control group: standard care + access to existing asthma informational websites	Wilcoxon test and adjusted OR.	33.8% of treatment teens had made an ED visit, versus 46.4% of control teens, OR = 0.53 (0.24–1.15), p = 0.15. No secondary endpoints were statistically significant.	Low

Author, year, country	Population, number, and setting	Measures	Intervention	Analysis	Authors' results / conclusions	Risk of bias
5.Perry et al., 2017 USA	N=34 12-17 year olds with asthma (using a controller device). N=17 in intervention, N=17 in control group Outpatient based	ACT, self-efficacy scores after 6 months	Novel smartphone based personalized asthma action plan, including symptoms diary, medication reminders. Not validated Control: paper Action-plan and paper symptom diary	Wilcoxon rank-sum test	Improvement in ACT seen in in intervention group when stratified for "uncontrolled" asthma (p= 0.04). No improvement seen in control group or well-controlled asthmatics. No improvement in self-efficacy scores.	High
6 Rikkers-Mutsaerts et al., 2012, Netherlands	N=90 12-18 year olds with poorly controlled asthma; N=46 intervention, N=44 in control group. Outpatient setting	Primary end-point: PAQLQ, secondary outcome asthma control questionnaire, FEV_1, daily ICS dose, exacerbation and symptom-free days Outcomes assessed at baseline, 3 months, 1 year.	Internet based self-management education (web-based and face to face), weekly ACQ and FEV_1 reporting, followed by tailored electronic action plan + usual care for 1 year Control: Usual care.	Linear mixed effects modelling used for difference in PAQLQ and ACQ over time.	At 3 months, PAQLQ improved in intervention compared to control group (p=0.02). No difference at 12 months. At 3 months ACQ improved more in intervention than control group (p<0.01). No difference at 12 months.	Low
7.Rhee et al., 2008 USA	N=41 adolescents age 14-20. Intervention N=20; control N=21 with current asthma diagnosis. Rural outpatient setting	Participant reported decision making quality scale; Risk Motivation Questionnaire, assessment of drug use	Computer assisted decision making programme- tailored counselling and two modules delivered on computer-lasting 1 hour. Boosters sent at 2 and 4 months Control: Watched a sham CD ROM on study skills.	Mixed general linear model at 6 months post-intervention.	No significant group differences over time for decision making scores. Decreased smoking and drug use motivation scores seen in intervention group at 6 months (p<0.02).	High
8.Sleath et al., 2018 USA	N=359 English or Spanish speaking adolescents aged 11-17 years with asthma; N=185 intervention; N=174 controls. Paediatric clinic setting	Demographic variables; N of questions asked	Pragmatic randomised controlled trial; asthma question prompt list with video intervention vs usual care	Chi-square; t-tests	Intervention group more likely to ask 1 or more questions about medication, triggers and environmental control than control group	Low

Author, year, country	Population, number, and setting	Measures	Intervention	Analysis	Authors' results / conclusions	Risk of bias
Educational interventions						
1.Bruzzese et al., 2011 USA	N=345 Urban teens (average age 15) with moderate-severe asthma; N=175 intervention, N=170 control; 68% female. School setting	Symptom frequency (over last 2 weeks), QOL (using PAQLQ) and asthma self-management indices; secondary outcomes- activity restriction (past 2 weeks), school absence, asthma medical management and health care use. 6 and 12 month follow-up	ASMA (Asthma Self-management for Adolescents) developed by authors. Three group sessions + individual coaching sessions held weekly over 8 weeks for participants. Their medical providers received academic detailing. Controls: normal care	Regression analysis of asthma self-management indices, activity restriction, QoL and health-care use	Intervention group reported better self-management than controls at 6 and 12 months ($p<0.0001$), better self-efficacy, improved use of controller medication ($p= 0.006$) and increase use of a written treatment plan, reduced asthma symptoms ($p= 0.003$), reduced night waking/school absence, reduction in acute medical visits ($p = 0.0002$).	Low
2.Cowie et al., 2002, Canada	N=93 15-20 yr olds who had attended ED with asthma. At 6 month follow up N=29 in intervention group, N=33 in control. Community setting.	Primary: ED attendance in 6 months following intervention. Secondary: asthma quality of life and severity	Young Adult Action programme- 2 visits. Completed questionnaires (asthma severity and QoL), spirometry, received asthma education and medical review. Control: Attended an appointment to complete questionnaire and spirometry + revision of inhaler technique	Chi Square Fisher's exact test, t-test, Kruskal-Wallis	Both groups showed improvement in asthma impact and ED attendance. Symptom and emotional QoL improved in intervention group compared to control group ($p<0.05$).	High
3.Salisbury et al., 2002, UK	N=455 Secondary school children with asthma; N=157 in school clinic arm, N=151 practice care arm; N=142 control school. School/ primary care setting.	Primary outcome: PAQLQ (QoL scale), level of symptoms and proportion of patients with a review consultation in 6 months	Nurse led asthma clinic in school, 1 and 6 month follow-up. Control: GP review of asthma (practice care group)- normal care. Control school group- similar school with no asthma clinic running.	Logistic regression, ordinal regression and analysis of co-variance.	More pupils in intervention group attended an asthma review compared to controls ($p<0.001$), no difference in symptoms or QoL scores. Intervention group had higher inhaler technique scores ($p<0.001$).	Low

Author, year, country	Population, number, and setting	Measures	Intervention	Analysis	Authors' results / conclusions	Risk of bias
4.Van Es et al., 2001. Netherlands	N=112 11-18 yr olds with asthma; N=58 intervention; N=54 control. Outpatient setting	Attitude- social influence-self efficacy model (ASE) variables including adherence, self efficacy, positive and negative attitudes, social influence	Usual paediatrician led care (4 monthly) with added discussion of asthma management zone system, PEF results discussion plus visits to asthma nurse for further education with written information; 3x 90 minutes group sessions to discuss coping with asthma. Control group: paediatrician led care (4 monthly visit) no asthma nurse input.	Comparisons of ASE variables responses using t-tests.	After one year of intervention, no difference was seen for any variables between the groups, at 2 years self-reported adherence was higher in the intervention group (p=0.05).	Moderate
Peer-led interventions						
1.Al-Sheyab et al., 2011 Jordan	4 high schools in Jordan. N=24 peer leaders in year 11; N=92 year 10s; N=148 years 8 and 9. N=132 in intervention group; N=129 in control group	ISAAC questionnaire for asthma symptoms and severity; PAQLQ; self-efficacy sub-scale of the Self-Administered Nicotine Dependence Scale; Asthma Knowledge Consumer Questionnaire. Measures taken at baseline and 3 months after the intervention.	Cluster randomised controlled trial. Peer-led education programme: Triple A Adolescent Asthma Action Programme. Year 11s delivered education to year 10s who presented brief skits to years 8 and 9	Mixed models to assess intervention effect; adjusted for baseline covariates: gender, English proficiency, N of recent wheezing episodes	Intervention group reported better total QoL and QoL sub-domains; self-efficacy to resist smoking; knowledge of asthma self-management compared to control group, all $p<0.05$	Low
2.Gibson et al., 1998 Australia	N=62 in intervention schools and N=30 in comparison school; Girls' high schools in areas of low SES and large non-English speaking community	Asthma Knowledge Questionnaire; Asthma Attitude Questionnaire; Asthma Symptoms Questionnaire; Asthma QoL Questionnaire (AQLQ) Pre-test measures 1-2 months prior; post-test	Asthma education Triple A programme; Year 11s instructed Year 10s who developed asthma health messages and performed them to the student body.	T-tests used to look at knowledge between intervention and control schools at survey 2. Bonferroni adjusted p-values used.	Improvement in asthma knowledge in students with asthma and peers ($p<0.0001$); no change in the comparison school.	Moderate

Author, year, country	Population, number, and setting	Measures	Intervention	Analysis	Authors' results / conclusions	Risk of bias
		measures 1-2 months after the intervention.				
3.Rhee et al., 2011, USA	N=112 13-17 year olds with asthma; N=59 in intervention, N=53 in control group. Asthma day camp setting	Child attitude toward health scale PAQLQ scale FEV_1 and FEV_1/FVC. Participant completed questionnaire at baseline, immediately post camp and then 3,6,9 months after camp. Spirometry at baseline and 9 months.	Use of peer leaders - trained 16-20 year olds with asthma (novel scheme, training adapted from Power Breathing programme). One day camp (3 sessions within day) with monthly phone contact for 8 months. Control: use of healthcare professionals instead of peer leaders to run a similar camp (comparable content and structure)	Linear mixed model repeated measures analysis of variance.	Improvement in overall attitudes in both groups and in quality of life over time(p=.002); intervention group higher quality of life at 9 months (p=.008). No improvement in % predicted FEV_1 or FEV_1/FVC in either group.	Moderate
4.Rhee et al., 2012 USA	N=91 adolescents with asthma aged 13-17years in a peer led (N=46) or adult led (N=45) asthma self-management	Asthma associated health-care services utilisation: hospitalisations; visits at ED; asthma specialist; primary care; scheduled; school. Measures taken at baseline, immediately after, 3, 6, 9 months after intervention.	A camp-based asthma programme based on the Power Breathing programme led by peer leaders with asthma vs adults	Binomial regression models controlling for SES.	Acute office visits reduced by 80-82% in peer led group at 3 and 9 month follow-ups. Peer-led group 4-5x more likely to use school clinics.	Moderate
5.Shah et al., 2001 Australia	N=272 students with asthma from two school years in 6 rural Australia High Schools Mean age 12.5; 15.5yrs	Quality of life (PAQLQ); school absenteeism, asthma attacks, lung function. Measures taken at baseline and 3 months after end of the intervention.	Cluster randomised controlled trial. Triple A Programme: educational programme for peers.	N needed to treat analysis. 2 way ANOVAs; Chi-sq analyses, McNemar's test, Wicoxon Signed Rank	QoL increased in intervention versus control group, adjusted for year and sex (p=.01). Number NTT was 8. Improvements in activities and emotions QoL. School absenteeism decreased in intervention group only; asthma attacks in school sig increased for year 10 only.	Low

Author, year, country	Population, number, and setting	Measures	Intervention	Analysis	Authors' results / conclusions	Risk of bias
Breathing re-training intervention						
1.Bignall et al., 2015 USA	N=33 12-17 yr olds with asthma. N=15 intervention, N=18 control. 66% female, all African-American. School-based.	ACT; PedsQL for quality of life; STAI for state and trait anxiety; Peak-flow and FEV_1	(1) diaphragmatic breathing, (2) asthma-specific guided imagery and (3) progressive muscle relaxation. Developed by authors- novel, non-validated 2 sessions of 30 minutes a month apart, plus CD to use at home. Control- 2 sessions a month apart- educational material on asthma only.	ANOVA- four per variable (effect of group, time, pre-post intervention and group by time). Qualitative analysis of acceptability of intervention	Both groups significantly improved in ACT (p=0.001); quality of life (p=0.0030); anxiety (p=0.01). No effect on FEV_1 or peak flow. No significant effect of group on any outcome but trend towards significant improvement in ACT with intervention.	Moderate

ACT: Asthma Control Test; ACQ: Asthma Control Questionnaire; ED: Emergency Department; FEV_1: forced expiratory volume in 1 second; FVC: Forced vital capacity; ICS: Inhaled corticosteroids; ITT: Intention to treat; PAQLQ: Pediatric Asthma Quality of Life Questionnaire; PEFR: Peak flow reading; PP: Per protocol; MDI: Metered dose inhaler; NTT: Needed to treat; QoL: Quality of life

669 Table 2. A comparison of study outcomes across intervention types

Author, year, intervention	HRQoL	Mood	Coping	Self-esteem	Self-efficacy	Maladaptation behaviour	Device technique	Asthma knowledge	Sleep problems	Symptoms	Adherence	ACT	FEV_1	Hospitalisation	Asking question /decision making
Psychological Interventions															
1.Alimohammadi et al., 2018, psycho-education						↓***									
2.Bruzzese et al., 2008, CBT (It's a Family Affair Intervention)									↓**		↑*				
3.Ellis et al., 2016, Multisystemic Therapy-Health Care							↑**	↑*							
4.Hampel et al., 2003, cognitive stress management training			↑*[1]												
5,6.Hemati et al., 2015, Hemati et al., 2017, Orem's self-care model	↑**[+]	↑*[+]		↑**				↑**[2]							
7,8. Naar et al., 2018; Naar-King et al., 2014, Multisystemic Therapy-Health Care										↓*	↑*		↑*	↓*	
9.Seid et al., 2012, motivational interviewing	↑*									↓*					
10.Srof et al., 2012, CBT	↑*				↑*										
11.Velsor-Friedrich et al., 2012, CBT	↔				↔			↔		↔					
12.Warner et al., 2006, written emotional disclosure		↑*								↓*			↔		
E-Health interventions															
1.Bynum et al., 2001, telepharmacy							↑***								
2.Johnson et al., 2016, MyMediHealth	↑*				↑*						↑*	↔			
3.Joseph et al., 2013, Puff-city-web-intervention										↓***		↔		↔	
4.Joseph et al., 2018, Puff-city-web-intervention	↔											↔		↔	
5.Perry et al., 2017, smart phone action plan					↔							↔[3]			
6 Rikkers-Mutsaerts et al., 2012, web-based education	↑*[1]									↔		↑*[4]	↔		
7.Rhee et al., 2008, computer assisted action plan															↔
8.Sleath et al., 2018, asthma question prompt list															↑*
Educational interventions															

Author, year, intervention	HRQoL	Mood	Coping	Self-esteem	Self-efficacy	Maladaptation behaviour	Device technique	Asthma knowledge	Sleep problems	Symptoms	Adherence	ACT	FEV_1	Hospitalisation	Asking question /decision making
1.Bruzzese et al., 2011, Asthma Self-management for Adolescents	↑**				↑**		↑*		↓*	↓*				↓*	
2.Cowie et al., 2002, Young Adult Action programme	↔													↔	
3.Salisbury et al., 2002, nurse led school asthma clinic	↔						↑***	↑*		↔					
4.Van Es et al., 2001, paediatrician education					↔						↔				
Peer-led interventions															
1.Al-Sheyab et al., 2011, Triple A programme	**↑***				↑*			↑*							
2.Gibson et al., 1998, Triple A programme	↔							↑*							
3.Rhee et al., 2011, adapted from Power Breathing programme	**↑***												↔		
4.Rhee et al., 2012, Power Breathing programme														↓**[5]	
5.Shah et al., 2001, Triple A programme	↑*														
Breathing re-training intervention															
1.Bignall et al., 2015, diaphragmatic breathing, relaxation	↔	↔											↔		

↓: reduction; *:p<0.05; **p<0.01; ***p<0.005; bold **↑**: change larger than minimally clinical significant difference; ↔: no difference; HRQoL: health related quality of life. ACT: Asthma control test. CBT: cognitive behavioural therapy. FEV_1: forced expiratory flow in 1 second. [1]: short term only; [2]: within group comparison only; [3]: ACT improved in those uncontrolled at baseline; [4]: only at 3 months, no difference at 12 months; [5] acute office visits