

Using quality improvement to tackle the triple aim for children and young people with asthma: improving outcomes, experience and costs

Marco Aurelio¹

Rita Araujo²

Janeke Zoetmann³

Julia Moody^{4,5}

Amar Shah^{1,6}

Author details can be found at the end of this article

Correspondence to:

Marco Aurelio;
m.aurelio@nhs.net

Abstract

Background/Aims Asthma in children and young people represents a substantial burden to the healthcare system, with these patients requiring frequent emergency care and having poorer health outcomes, leading to high system costs and poor patient experiences. This study used quality improvement methodology to achieve the triple aim of improved outcomes, better experience and reduced costs for those aged 0–16 years with asthma in north east London.

Methods A multidisciplinary project team used quality improvement methods to implement and assess two interventions: a community high-risk asthma clinic and educational asthma-friendly school groups, both of which were delivered by a specialist asthma nurse. Population-level outcomes included asthma control test scores, accident and emergency department admissions and costs. Intervention-specific outcomes included number of clinic consultations delivered, did-not-attend rates and participant confidence ratings following the school sessions.

Results Accident and emergency admissions for asthma reduced by 52%, with a 50% reduction in average monthly acute care costs. Asthma control test scores improved significantly, from an average of 18.56 to 22.34 out of a maximum score of 25 ($P=0.000$) following the interventions. Participants in the asthma-friendly school groups reported increased confidence in both day-to-day and emergency asthma management at the end of their sessions.

Conclusions Having dedicated specialist asthma nurse input in the community and using school-based interventions can help to improve asthma care for children and young people, reducing the burden of frequent accident and emergency department admissions. Using quality improvement methods in pursuit of triple aim outcomes can help teams to work towards a shared goal.

Key words: Asthma; Children and young people; Community nursing; Respiratory medicine; Quality improvement

Submitted: 29 July 2022; **accepted following double-blind peer review:** 21 April 2023

Distributed under Creative Commons CC BY-NC 4.0

OPEN ACCESS

How to cite this article:

Aurelio M, Araujo R, Zoetmann J et al. Using quality improvement to tackle the triple aim for children and young people with asthma: improving outcomes, experience and costs. *British Journal of Healthcare Management*. 2023. <https://doi.org/10.12968/bjhc.2021.0101>

Introduction

Asthma is a chronic inflammatory condition causing variable, reversible constriction of airways. It is managed through pharmacotherapy, educational and behavioural modifications and environmental changes (Bush and Fleming, 2015). Children and young people with asthma experience a poorer quality of life than their peers (Silva et al, 2015) and make frequent use of healthcare services, at a high cost to the system (Suruki et al, 2017). The UK has one of the highest prevalences of asthma in the world (Lai et al, 2009), which costs the NHS £1.1 billion per year (Mukherjee et al, 2016). Poorly managed asthma in children and young people can reduce quality of life through loss of family earnings (because of care responsibilities for the child), increased absence from school, reduced opportunities for educational attainment and other activities related to wellbeing (Milton et al, 2004, Fleming et al 2019).

Although asthma is highly manageable, deaths can still occur, with the UK having the highest childhood mortality rate from asthma in Europe (Wolfe et al 2013). Factors that can increase the risk of mortality include excessive use of medications for symptom

relief, insufficient prescription of medications for symptom prevention, lack of education and personalised action plans, poor recognition of high-risk factors among patients and healthcare professionals, and environmental factors such as poor housing, pollution and smoking (Dick et al, 2014; Levy, 2015; Lowden and Turner, 2022). Improved continuity of care in the community has been associated with a reduced risk of hospital admission (To et al, 2008; Fleetcroft et al, 2016). Despite this evidence, and the existence of best practice guidelines, children and young people with asthma still often experience poor outcomes (Carroll et al, 2020).

Addressing the issues associated with poor outcomes, high costs and negative patient experiences among children and young people with asthma requires a triple aim approach (Shah et al, 2021). The triple aim is a guiding framework for optimising outcomes across a population by simultaneously focusing on three areas: health outcomes, experience of care and value or cost to the system. Ultimately, this approach aims to provide a better experience of care and improved health outcomes, at a lower system cost (Mery et al, 2017). The triple aim framework was designed to shift away from service improvement, instead focusing on redesigning the system to optimise outcomes across a population (Berwick et al, 2008). It has been used across a variety of settings, including mental health, chronic illness and employee wellbeing (Whittington et al, 2015). Quality improvement methods have also been used in several settings, such as to improve screening for asthma in children and young people in primary care (Sudhanthar et al, 2016) and to improve outcomes for those who frequently present in emergency settings for asthma (Harder et al, 2020).

In 2018, Tower Hamlets Together—an integrated borough-based partnership in Tower Hamlets, east London—decided to use quality improvement methodology in pursuit of the triple aim for children and young people with asthma. Around 4.5% of children and young people in Tower Hamlets have asthma (Tower Hamlets Council, 2016), with the borough having the sixth highest rates of hospital admissions for the condition in London (Parker et al, 2021). Around 19% of the borough are under the age of 16 years, with 77% of the community identifying as non-white (Office for National Statistics, 2023). In a review of asthma care practice, only 4% of cases were judged to reflect good practice, as described by the Scottish Intercollegiate Guidelines Network and British Thoracic Society (2019) guidelines for asthma.

This article describes the authors' experiences of using quality improvement to develop, test, implement and evaluate a programme to improve asthma care for children and young people. In this context, the triple aim outcomes measured were changes in asthma control test scores (outcomes), admissions to the accident and emergency department (experience) and the costs of these admissions (cost).

Methods

Project formulation

This study used the model for improvement framework (Langley et al, 2009). The team followed the process developed by East London NHS Foundation Trust for applying quality improvement in pursuit of the triple aim (Figure 1).

A multidisciplinary project team was formed, consisting of one GP, one asthma nurse, two paediatric consultants, one public health colleague, one commissioner, one colleague from informatics and two representatives from local authority education services. Other

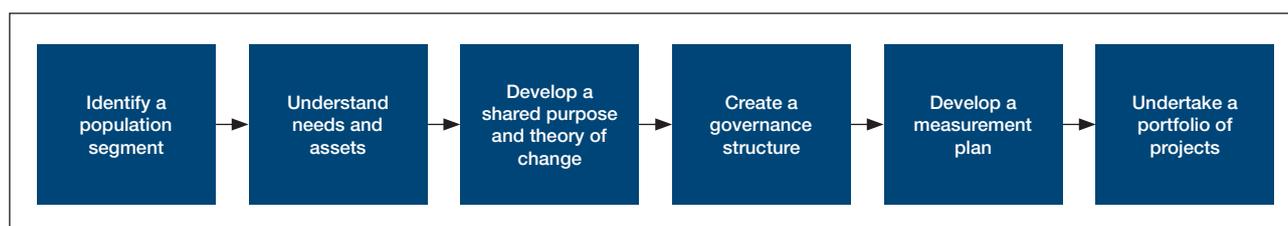


Figure 1. East London NHS Foundation Trust's process for applying quality improvement methodology in pursuit of a triple aim approach.

colleagues were invited into the meetings when their expertise was required. The project team met fortnightly for 1 hour to review progress and plan next steps. The team were supported by an improvement advisor with experience in quality improvement. The target population were defined as people aged 0–16 years living in Tower Hamlet with asthma.

A three-part data review was undertaken to identify existing needs and assets within the healthcare system (Shah et al, 2021), considering the following:

- What do the health and social care data indicate about who is not thriving?
- What do the people who provide care to this population say about challenges and opportunities for improvement?
- What is the perspective of those who are part of this population?

In order to understand some of the challenges and opportunities for improvement in this population, a range of in-person stakeholder events were held with a total of 170 care professionals, including public health practitioners, clinicians and managers from primary and secondary care, pharmacists, health visitors, smoking cessation practitioners, housing providers and teaching colleagues from nurseries, children's centres and primary education. Over 70 children and young people living with asthma, along with their parents, attended in-person events held at local community centres to discuss their experiences of having asthma, how it made them feel and what would make things better. Individuals were invited through a range of promotional material, such as posters and leaflets, with the events being open to all children of school age with asthma. General conversations were facilitated, along with more targeted discussions about what it felt like to have asthma; children and young people in attendance were encouraged to describe these experiences using creative means, such as art. Overall, the result of this engagement highlighted that parental education, peer support and effective management of asthma were all key factors that could help children and young people to manage their condition. A key phrase that came out of these discussions described having an asthma attack to a 'monster day'; therefore, the team's shared purpose statement for the project became 'stopping the monster days'.

The team then used this feedback, along with evidence from the literature, to develop a portfolio of interventions that could help to achieve the aim. This portfolio was displayed as a driver diagram (Figure 2) which was used to select two interventions that the team believed would have the greatest impact on the different parts of the triple aim: developing a high-risk asthma clinic with a specialist nurse and creating asthma-friendly school groups.

Interventions

High-risk asthma clinics

Based on the wider literature, the team hypothesised that a review by a specialist asthma professional in the community would improve asthma control for children and young people and reduce future presentations to the accident and emergency department (Woods et al, 2012). A specialist asthma community nurse was recruited to a fixed-term post to deliver structured reviews in community settings for children and young people considered to have high-risk asthma, defined as:

- Two or more presentations to the accident and emergency department in the last 12 months
- Overuse of a salbutamol inhaler (more than two times in a week, or 10 inhalers per year)
- Repeat preventer prescription uptake of $\leq 80\%$
- Clinical concern, measured using an asthma control test (minimum score=5; maximum score=25). A score of 19 or less was defined as high-risk asthma, as a score of over 19 indicates well-managed asthma (Nathan et al, 2004)
- Parental concern or school attendance issues.

There are eight GP networks in Tower Hamlets, each with several GP practices. At the start of the project, one practice per network hosted an asthma clinic, making eight asthma clinics across the borough. Clinics were held on different days in different practices. Children and young people with high-risk asthma (as defined above) were invited to their nearest clinic for a 30-minute individual appointment, where the nurse conducted a structured review using a template on the online patient record system EMIS. Clinics were designed considering Scottish Intercollegiate Guidelines Network and British Thoracic Society (2019) and National Institute for Health and Care Excellence (2021) guidelines, and included a

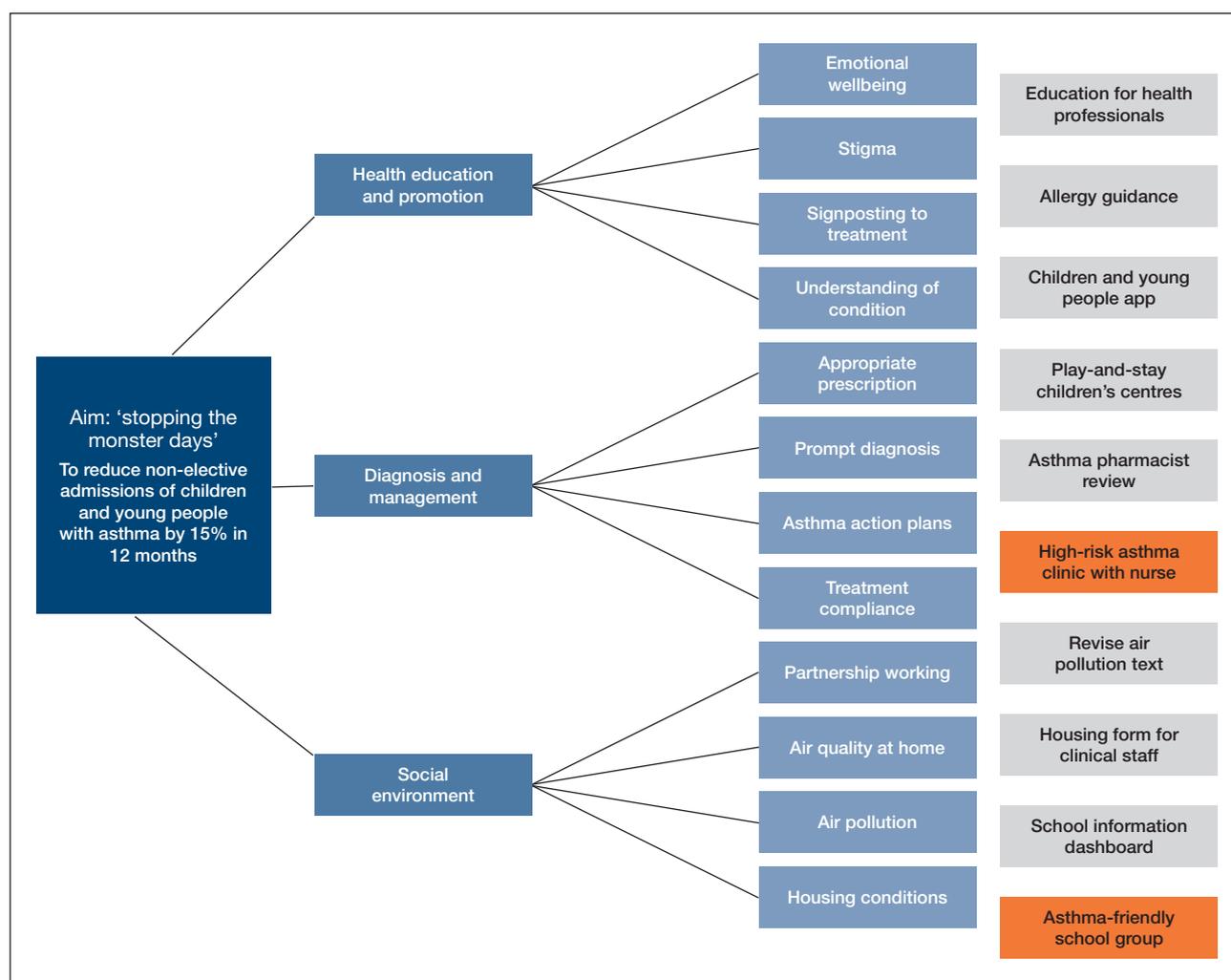


Figure 2. Project driver diagram. Orange=selected intervention.

review of patient history, diagnosis, symptom control (via an asthma control test), inhaler technique and medication, along with the development of a personalised action plan.

Because most children and young people with asthma are under primary care, the authors asked colleagues in this setting to promote the clinic. Each GP practice was asked to identify local children and young people with high-risk asthma and refer them to the clinic. However, primary care clinicians reported that they often felt uncomfortable referring patients based on a data search if they had not had any recent contact with the family. Therefore, children and young people were identified through secondary care settings, which the team hoped would allow those in the most urgent need of support to be reached. Weekly manual searches of accident and emergency department attendances at the local hospital were carried out to identify children and young people with a discharge diagnosis of asthma who were considered high risk according to the study criteria. However, when parents were contacted a few days after their child's admission, it was often difficult to convince them of the need for their child to attend the new clinic, because they were now feeling better.

To address this, the team focused on increasing awareness among secondary care staff and parents of children and young people with high-risk asthma. To increase staff awareness, an 'asthma bundle' was developed, including information on the community asthma clinic, referral criteria, asthma guidelines, wheeze discharge checklists and smoking cessation services for parents. A poster with referral information for the new community clinic was displayed in the emergency department and ward. An information leaflet to explain the purpose of the clinic was also created for families. Letters to hand out or send to patients following discharge from hospital were included in the secondary care staff's asthma bundle. Some families found the appointment confirmation letters confusing, as

the clinics could be in a different location to their usual GP practice. Therefore, the letters were clarified to explain this.

Asthma-friendly school groups

Ongoing feedback from children and young people, along with data gathered from the three-part data review, highlighted the importance of schools in the management of asthma. A series of interviews with key stakeholders from health and education were conducted to explore their perceptions of asthma care in the borough. These individuals reported feeling anxious about caring for children and young people with asthma because of the limited links with healthcare services—an issue that has been identified in previous research (Caruana et al 2021). They also felt that neither the young person nor their parents had sufficient information to safely look after themselves. Overall, there was an underlying belief in the education sector that asthma care responsibilities lie with healthcare services and the young person.

Based on this, a group intervention was designed for families, children and young people and school staff who had responsibility for asthma care in their schools. The intervention was led by the specialist community asthma nurse and carried out in 12 primary schools in Tower Hamlets, with all children in the school registered as having a salbutamol inhaler being invited to attend. Sessions were held after school and attended by an average of 20 people including children, parents/carers and members of staff. The aims of the sessions were to educate the child, their family and teachers about asthma, identify those at high risk by conducting an asthma control test, and improve participants' confidence in managing asthma. The use of asthma inhalers and spacers were reviewed in a school setting, and checks were carried out to ensure that all pupils on the asthma register had an up-to-date asthma action plan. Triggers for asthma, including damp, overcrowding and smoking, were discussed with parents and carers. Smoking cessation advice was offered to parents who attended the sessions. Pupils who were identified as high risk during the sessions were invited to the high-risk asthma clinic for a follow up and more thorough review with a nurse.

Evaluating the interventions

In triple aim work, measurement is hierarchical and requires focus across all three arms of the triple aim (outcomes, experience and cost) and at the individual intervention level (Shah et al, 2021). The following measures were used to capture impact across the three arms of the triple aim:

- Outcome: an asthma control test was administered to high-risk children and young people with asthma before and after the intervention, with statistical analysis performed to assess any changes in scores
- Experience: data were collected regarding the number of admissions of patients aged 0–16 years to the Royal London Hospital accident and emergency department for asthma each month. These data ran from July 2018 to November 2019, with a baseline period (pre-intervention) from July 2018 to January 2019
- Value/cost: the cost of admissions for patients aged 0–16 years to the Royal London Hospital accident and emergency department for asthma each month. These data ran from July 2018 to November 2019, with a baseline period (pre-intervention) from July 2018 to January 2019.

The intervention-specific measurements for the high-risk asthma clinics were:

- Total number of consultations (including phone consultations, first in-person and follow-up consultations with the nurse) each month
- Percentage of total consultations that were not attended each month.

For both intervention-specific measures for the high-risk asthma clinics, the data ran from January 2019 to March 2020. There was no baseline period for this, as the data were not collected before the intervention

For the asthma-friendly school groups, the intervention-specific measurements were:

- Number of children/young people, parents and staff participating in the groups
- Participants' self-rated confidence levels in managing asthma in day-to-day and emergency situations. Participants were asked 'are you confident in managing asthma day to day?' and 'are you confident in managing asthma in an emergency?' at the start and end of the session. Available responses were 'yes', 'sometimes' and 'no'.

Data were collected using automated clinical systems from the local hospital and clinical commissioning group, as well as through manual real-time records kept by the staff administering the interventions .

Data analysis

Outcome data were analysed using a paired *t*-test to assess statistical significance between pre- and post-intervention asthma control test scores. Experience and cost data were collected as monthly data over time and displayed using run charts (a standard analytical tool used in quality improvement) to highlight random and non-random variation and identify any improvements over time (Perla et al, 2011). At individual intervention level, data were also collected monthly over time, where possible, using run charts. These run charts were created using QI Macros, a Microsoft Excel-based plug-in software. Median values were calculated, as this is the standard measure of central tendency used on a run chart.

Ethical considerations

Ethical approval was not required for this study, as it was a quality improvement project carried out in the course of routine work. Participation was voluntarily and data collection was carried out ensuring that patient privacy was not compromised.

Results

Between November 2018 and December 2019, 169 children and young people had both a first and follow-up asthma control test score recorded, with 92% (n=144) showing an improvement. Mean asthma control test scores were significantly higher after the interventions compared to before (22.34 ± 4.24 vs 18.56 ± 4.64 ; $t = -9.85$; $P = 0.000$). The mean scores following the intervention was ≥ 20 , indicating clinically well-managed asthma.

The number of emergency department admissions reduced from a median of 27 per month at baseline to 13.5 per month during the testing period, representing a 50% reduction (Figure 3). The cost of accident and emergency admissions of patients aged 0–16 years for asthma reduced from a median of £27 620 per month in the baseline period to a median of £13 305 per month during the testing period, representing a 52% reduction in costs (Figure 4).

Intervention-level results

High-risk asthma clinics

Between January 2019 and March 2020, a total of 1154 consultations took place with children and young people in the high-risk asthma clinics. This included 398 phone consultations, 463 in-person first appointment reviews and 293 follow-up appointments. At the start of the study period, the median number of consultations delivered was 57 per month, increasing to 83 per month by the end of the period (Figure 5).

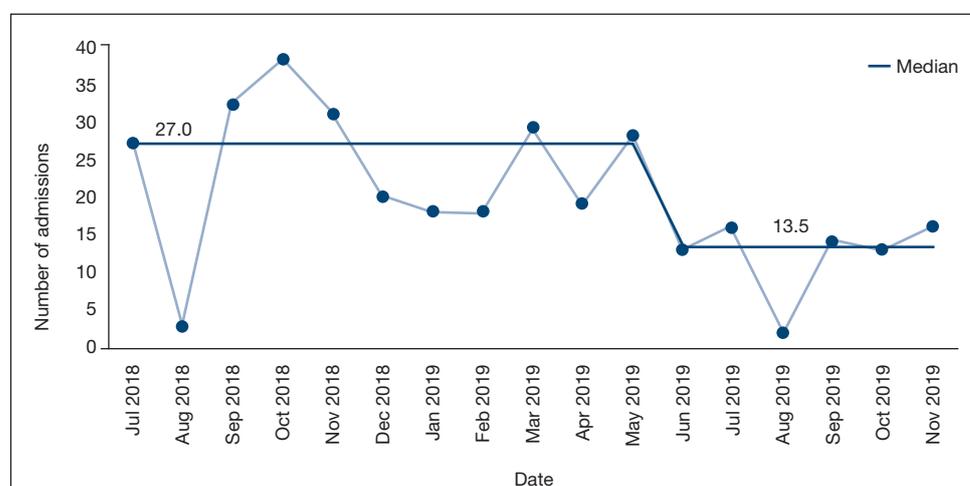


Figure 3. Run chart for admissions of 0–16 year olds to the accident and emergency department for asthma.

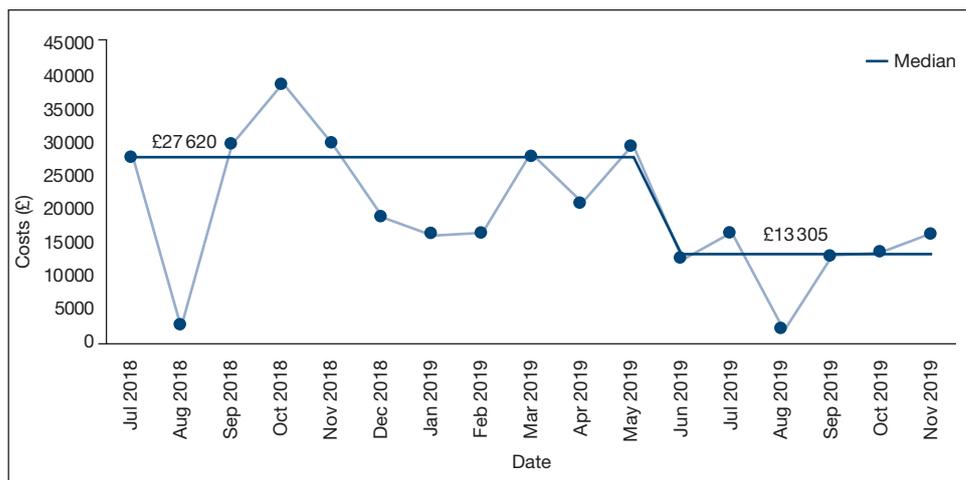


Figure 4. Run chart for acute costs of admissions of 0–16 year olds to the accident and emergency department for asthma.

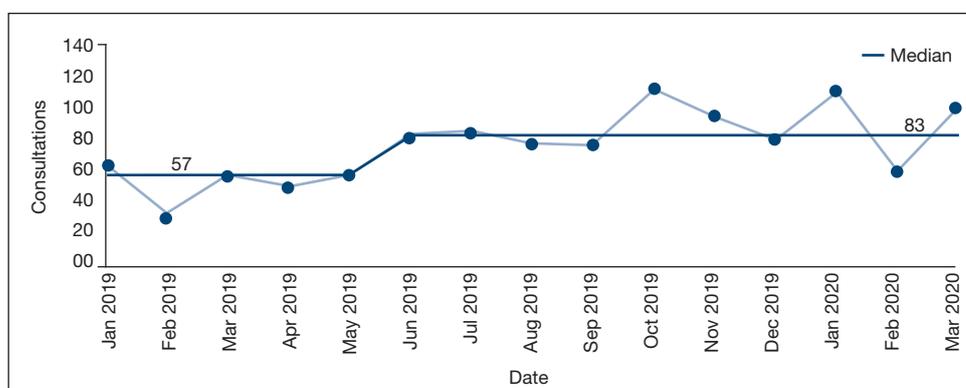


Figure 5. Run chart showing the total number of consultations held with children and young people in the high-risk asthma clinics.

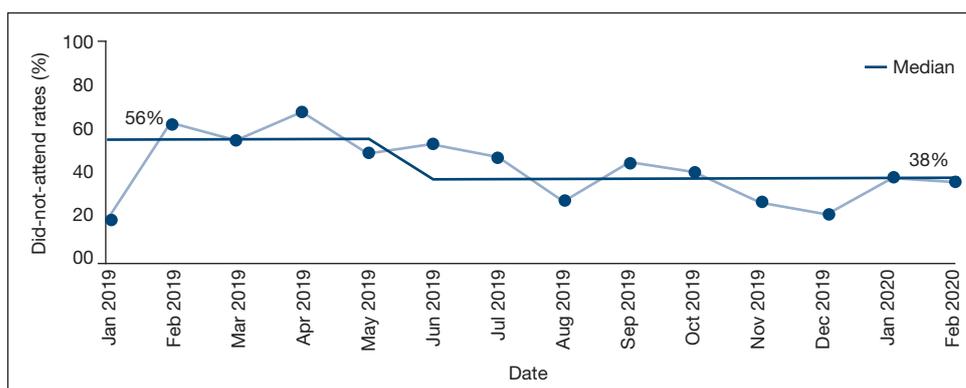


Figure 6. Run chart showing the proportion of consultations not attended at the community high-risk asthma clinics.

Non-attendance rates at the community high-risk asthma clinics between January 2019 and March 2020 are shown in **Figure 6**. During this period, the percentage of total consultations that were not attended reduced from a median of 56% at the start of the study period to a median of 38% by the end of the study period.

Asthma-friendly school groups

A total of 354 children, parents and staff attended the group sessions between January 2019 and January 2020. Of the attendees, 252 were children, 77 were parents and 25 were

© 2023 MA Healthcare Ltd

Table 1. Responses to asthma-friendly school group evaluation questions

Question	Stage	Response		
		Yes	Sometimes	No
Are you confident in managing asthma day to day?	Pre-session (n=68)	54%	35%	10%
	Post-session (n=68)	91%	2%	7%
Are you confident in managing asthma in an emergency?	Pre-session (n=33)	62%	27%	11%
	Post-session (n=66)	88%	0%	12%

school staff. The children who attended represented 87% of all children on the asthma school registers across the 12 primary schools.

A relatively small proportion of participants responded to the evaluation questions (Table 1). A total of 68 participants responded to the question ‘Are you confident in managing asthma day to day?’ at the beginning of their session, with 54% saying ‘yes’, 35% saying ‘sometimes’ and 10% saying ‘no’. Of these respondents, 37% were children, 27% were parents, 1% were staff and the remaining 35% did not give their details. A total of 68 participants responded to the same question at the end of their session, with 91% saying yes. Of these 68 respondents, 54% were parents, 43% were children, 1% were staff and 2% did not give their details.

A total of 33 participants responded to the question ‘Are you confident in managing asthma in an emergency?’ at the beginning of their session, with 63% saying yes, 27% saying sometimes and 11% saying no. Of these respondents, 56% were children, 38% were parents, 0% were staff and 6% did not give their details. A total of 66 participants responded to the same question at the end of their session, with 88% saying yes. Of these 66 respondents, 53% were parents, 42% were children, 2% were staff and 3% did not give their details.

Discussion

The results indicate that the introduction of community high-risk asthma clinics and a school-based educational intervention helped to improve the triple aim of outcomes, experience and cost for children and young people with asthma in Tower Hamlets. The number of admissions to the accident and emergency department were reduced by 52% and the cost of these admissions by 50%.

The number of consultations held per month at the high-risk asthma clinics between January 2019 and January 2020 increased from 57 to 83, suggesting that awareness of the clinics increased over time. This is likely a result of the work done to raise awareness via the asthma bundle as part of the intervention, which included information on the high-risk clinics, referral guidelines, asthma guidelines, wheeze discharge checklists and smoking cessation services for parents. The percentage of people who did not attend their appointments also declined during this period, which could be attributed to the clarification of appointment location on letters. This is important, as high non-attendance rates waste capacity in the system (McLean et al, 2016)

Patients’ asthma control test scores increased significantly to an average of 22.4, meeting the threshold for clinically well-managed asthma (20 or above) (Nathan et al 2004). Overall, 92% of patients who attended follow up had higher scores compared to their first appointment. In the asthma-friendly school groups, attendees reported feeling more confident in managing asthma on a day-to-day basis and in emergency situations following the session.

As a result of these improvements, plans are now in place for NHS North East London integrated care system to scale-up the community high-risk asthma clinic across north east London. As part of this, funding was made available to commission the appointment of eight more specialist asthma nurses, who are continuing to deliver the clinics. More widely across the system, a clinical network for asthma in children and young people has

been established to share best practice and learning across north east London. A common asthma action plan has also been agreed across the local system, with plans for discharge summaries from acute hospitals to be sent to the specialised asthma nurses to highlight patients who may benefit from a review. The authors believe that this continued investment in the community high-risk asthma clinics will help to prevent children and young people with asthma requiring treatment in emergency settings. This would not only lead to better outcomes and experiences for patients, it would also reduce pressures and costs on the system.

The specialist asthma nurse played an important role in both interventions included in this project, developing relationships to facilitate easy information sharing and championing the work. In this way, the specialist asthma nurse can be seen as a key change agent, allowing change to be diffused through the system. The specialist asthma nurse also had close links with the hospital team, school nurses and primary care teams. This is aligned with the wider literature on the importance of dedicated asthma professionals, particularly nurses, in delivering care to children and young people (Haltermann et al, 2011; Kuethe et al, 2011; McClure et al, 2017; Isik et al, 2019).

The authors recognise the importance of partnership working across the system and having a multidisciplinary team to tackle this issue, given its complex nature. There was a core team that met fortnightly, with other members brought in to support the delivery of certain parts of the portfolio when required. This has been highlighted as a key aspect of using a triple aim approach to improve outcomes for a certain population (Whittington et al, 2015). Logistical support was also key to the delivery of this project. There was a dedicated programme manager to help oversee the portfolio of activities, support meeting logistics and provide regular updates. Senior support was also provided by a clinical lead, who helped to overcome barriers to progress, such as access to data. As this was a new way of working for the team, having support around quality improvement methodology was also important.

A quality improvement approach to tackling the triple aim outcomes for children and young people with asthma was a novel approach in this setting, offering an effective way of addressing a complex problem. The simple tools it offered helped the team to work through a set of steps, to break down and understand the problem that they were trying to address. Testing ideas iteratively allowed the team to learn what worked and what did not, using simple data over time. The method also allowed different stakeholders to be brought together to work on a common problem, while the use of a three-part data review meant that service users were included as part of the design of the work.

Limitations

The use of data was important to this study, but at times proved challenging. Using data from different organisations highlighted variations in how asthma was recorded across the system. This variation also meant that identifying all high-risk patients in the area was challenging. The authors considered collecting data on GP prescriptions of oral corticosteroids as a surrogate marker of asthma attacks, but this could not be included because of challenges in collecting these data.

A further limitation of this study is that, although changes in costs and presentations to the accident and emergency department were demonstrated over time, the results do not show if the increased asthma control scores, and knowledge and confidence in managing asthma, will be maintained long term. Further research would be beneficial to explore the long-term sustainability of this, especially following the onset of the COVID-19 pandemic in March 2020, shortly after this study ended.

The data collection tool used to understand the confidence scores of participants before and after the asthma-friendly schools intervention was not validated. The authors would encourage other authors to consider the use of validated tools such as the Pediatric Asthma Quality of Life Questionnaire, which has been shown to be effective in understanding the impact of asthma on children's quality of life (Juniper et al, 1996; Reichenberg and Broberg, 2000).

There was a low response rate to the evaluation of the asthma-friendly school groups. Although a low response rate can introduce bias into results (Mazor et al, 2002; Sedgwick, 2011), this is not always the case (Choung et al, 2013; Hendra and Hill, 2019). However,

Key points

- The introduction of a high-risk nurse-led asthma clinic and asthma-friendly school-based interventions were effective in helping to improve the management of asthma in children and young people.
- Quality improvement methodology can be effective in achieving the triple aim of outcomes, experience and costs for a defined population.
- Further work should be considered by those using quality improvement tools to understand the long-term sustainability of interventions in practice.

the authors would encourage others conducting similar work to consider multiple ways of gathering information in real time to ensure a higher response rate. This could be achieved by considering the demographics of the survey population to ensure data collection tools are translated into different languages (Moradi et al, 2010), offering incentives for completion (David and Ware, 2014) and considering the number of questions asked.

Conclusions

A quality improvement approach was an effective way of bringing a group of stakeholders together around an important problem, using simple tools to understand the target population and quickly testing change ideas to learn what might help make a difference. The results suggest that establishing a specialist asthma clinic and developing a school-based education programme, led by specialist nurses, can improve outcomes, experiences and costs for children and young people with asthma. These interventions have potential in terms of their scalability across different contexts and systems.

Author details

¹East London NHS Foundation Trust, London, UK

²Sussex NHS Commissioners, Warnham, UK

³Musgrove Park Hospital, Taunton, UK

⁴North East London Health and Care Partnership, London, UK

⁵Chrip Street Health Centre, Tower Hamlets, London, UK

⁶Royal College of Psychiatrists, London, UK

Conflicts of interest

The authors declare that there are no conflicts of interest.

Declaration of funding

No external funding was provided for this study. Funding for the Open Access license was provided by East London NHS Foundation Trust.

Data availability statement

The data that support the findings of this study are available from the corresponding author on reasonable request.

References

- Berwick DM, Nolan TW, Whittington J. The triple aim: care, health, and cost. *Health Affairs*. 2008;27(3):759–769. <https://doi.org/10.1377/hlthaff.27.3.759>
- Bush A, Fleming L. Diagnosis and management of asthma in children. *BMJ*. 2015;350(9):h996–h996. <https://doi.org/10.1136/bmj.h996>
- Carroll W, Clayton S, Frost S et al. If it's 'only' asthma, why are children still dying? *Archives of Disease in Childhood*. 2020;105(5):494–498. <https://doi.org/10.1136/archdischild-2019-318215>

- Caruana M, West LM, Cordina M. Current asthma management practices by primary school teaching staff: a systematic review. *Journal of School Health*. 2021;91(3):227–238. <https://doi.org/10.1111/josh.12992>
- Choung RS, Locke GR, Schleck CD et al. A low response rate does not necessarily indicate non-response bias in gastroenterology survey research: a population-based study. *J Public Health (Germany)*. 2013;21:87–95
- David MC, Ware RS. Meta-analysis of randomized controlled trials supports the use of incentives for inducing response to electronic health surveys. *J Clin Epidemiol*. 2014;67(11):1210–1221
- Dick S, Doust E, Cowie H et al. Associations between environmental exposures and asthma control and exacerbations in young children: a systematic review. *BMJ open*. 2014;4(2):e003827. <http://dx.doi.org/10.1136/bmjopen-2013-003827>
- Fleetcroft R, Noble M, Martin A et al. Emergency hospital admissions for asthma and access to primary care: cross-sectional analysis. *British Journal of General Practice*. 2016;66(650):e640–e646. <https://doi.org/10.3399/bjgp16X686089>
- Fleming M, Fitton CA, Steiner MF et al. Educational and health outcomes of children treated for asthma: Scotland-wide record linkage study of 683 716 children. *European Respiratory Journal*. 2019;54(3). <https://doi.org/10.1183/13993003.02309-2018>
- Halterman JS, Szilagyi PG, Fisher SG et al. Randomized controlled trial to improve care for urban children with asthma: results of the School-Based Asthma Therapy trial. *Archives of pediatrics & adolescent medicine*. 2011;165(3):262–268. <https://doi.org/10.1001/archpediatrics.2011.1>
- Harder VS, Shaw JS, McCulloch CE et al. Statewide asthma learning collaborative participation and asthma-related emergency department use. *Pediatrics*. 2020;146(6):e20200213. <https://doi.org/10.1542/peds.2020-0213>
- Hendra R, Hill A. Rethinking response rates: new evidence of little relationship between survey response rates and nonresponse bias. *Eval Rev*. 2019. 43(5):307–330. <https://doi.org/10.1177/0193841X18807719>
- Isik E, Fredland NM, Freysteinson WM. School and community-based nurse-led asthma interventions for school-aged children and their parents: a systematic literature review. *Journal of Pediatric Nursing*. 2019;44: 107–114. <https://doi.org/10.1016/j.pedn.2018.11.007>
- Juniper EF, Guyatt GH, Feeny DH et al. Measuring quality of life in children with asthma. *Quality of life research*. 1996;5:35–46. <https://doi.org/10.1007/BF00435967>
- Kueth M, Vaessen-Verberne A, Mulder P et al. Paediatric asthma outpatient care by asthma nurse, paediatrician or general practitioner: randomised controlled trial with two-year follow-up. *Prim Care Respir J*. 2011;20(1):84–91. <https://doi.org/10.4104/pcrj.2011.00003>
- Lai CK, Beasley R, Crane J et al. Global variation in the prevalence and severity of asthma symptoms: phase three of the International Study of Asthma and Allergies in Childhood (ISAAC). *Thorax*. 2009;64(6):476–483. <https://doi.org/10.1136/thx.2008.106609>
- Langley GJ, Moen RD, Nolan KM et al. *The improvement guide: a practical approach to enhancing organizational performance*. Hoboken (NJ): John Wiley and Sons; 2009
- Levy ML. The national review of asthma deaths: what did we learn and what needs to change? *Breathe*. 2015;11(1):14–24. <https://doi.org/10.1183/20734735.008914>
- Lowden R, Turner S. Past asthma exacerbation in children predicting future exacerbation: a systematic review. *ERJ Open Research*. 2022;8(4). <https://doi.org/10.1183/23120541.00174-2022>
- Mazor KM, Clauser BE, Field T et al. A demonstration of the impact of response bias on the results of patient satisfaction surveys. *Health Serv Res*. 2002;37(5):1403–1417. <https://doi.org/10.1111/1475-6773.11194>
- McLean SM, Booth A, Gee M et al. Appointment reminder systems are effective but not optimal: results of a systematic review and evidence synthesis employing realist principles. *Patient preference and adherence*. 2016;10:479–499. <https://doi.org/10.2147/PPA.S93046>
- McClure N, Lutenbacher M, O'Kelley E et al. Enhancing pediatric asthma care and nursing education through an academic practice partnership. *Journal of Pediatric Nursing*. 2017;36:64–69. <https://doi.org/10.1016/j.pedn.2017.04.008>
- Mery G, Majumder S, Brown A et al. What do we mean when we talk about the triple aim? A systematic review of evolving definitions and adaptations of the framework at the health system level. *Health Policy*. 2017;121(6):629–636. <https://doi.org/10.1016/j.healthpol.2017.03.014>
- Milton B, Whitehead M, Holland P et al. The social and economic consequences of childhood asthma across the lifecourse: a systematic review. *Child Care Health Dev*. 2004;30(6):711–728. <https://doi.org/10.1111/j.1365-2214.2004.00486.x>

- Moradi T, Sidorchuk A, Hallqvist J. Translation of questionnaire increases the response rate in immigrants: filling the language gap or feeling of inclusion? *Scand J Public Health*. 2010;38(8):889–892. <https://doi.org/10.1177/1403494810374220>
- Mukherjee M, Stoddart A, Gupta RP et al. The epidemiology, healthcare and societal burden and costs of asthma in the UK and its member nations: analyses of standalone and linked national databases. *BMC Med*. 2016;14(1):1–15. <https://doi.org/10.1186/s12916-016-0657-8>
- Nathan RA, Sorkness CA, Kosinski M et al. Development of the asthma control test: a survey for assessing asthma control. *J Allergy Clin Immunol*. 2004;113(1):59–65. <https://doi.org/10.1016/j.jaci.2003.09.008>
- National Institute for Health and Care Excellence. Asthma: diagnosis, monitoring and chronic asthma management. [NG80]. 2021. <https://www.nice.org.uk/guidance/ng80> (accessed 12 July 2023)
- Office for National Statistics. How life has changed in Tower Hamlets: census 2021. 2023. <https://www.ons.gov.uk/visualisations/censusareachanges/E09000030> (accessed 12 July 2023)
- Parker R, Whitehouse A, Hadaway T et al. 1157 Let's talk air pollution – it's everyone's responsibility. *Archives of Disease in Childhood*. 2021;106:A253. [10.1136/archdischild-2021-rcpch.439](https://doi.org/10.1136/archdischild-2021-rcpch.439)
- Perla RJ, Provost LP, Murray SK. The run chart: a simple analytical tool for learning from variation in healthcare processes. *BMJ Qual Saf*. 2011;20(1):46–51. <http://dx.doi.org/10.1136/bmjqs.2009.037895>
- Procter S, Brooks F, Wilson P et al. A case study of asthma care in school age children using nurse-coordinated multidisciplinary collaborative practices. *J Multidiscip Healthc*. 2015;8:181–188. <https://doi.org/10.2147/JMDH.S71030>
- Reichenberg K, Broberg AG. Quality of life in childhood asthma: use of the Paediatric Asthma Quality of Life Questionnaire in a Swedish sample of children 7 to 9 years old. *Acta paediatrica (Oslo, Norway)*. 2000;89(8):989–995. <https://doi.org/10.1080/080352500750043495>
- Sedgwick P. Bias in clinical trials. *BMJ*. 2011;343:d4176. <https://doi.org/10.1136/bmj.d4176>
- Shah A, Aurelio M, Frاسquilho F et al. Quality improvement in practice—part three: achieving the triple aim through the systematic application of quality improvement. *Br J Healthc Manage*. 2021;27(10):1–10. <https://doi.org/10.12968/bjhc.2021.0041>
- Scottish Intercollegiate Guidelines Network, British Thoracic Society. SIGN158: British guideline on the management of asthma. 2019. <https://www.sign.ac.uk/media/1773/sign158-updated.pdf> (accessed 12 July 2023)
- Silva N, Carona C, Crespo C et al. Quality of life in pediatric asthma patients and their parents: a meta-analysis on 20 years of research. *Expert Rev Pharmacoecon Outcomes Res*. 2015;15(3):499–519. <https://doi.org/10.1586/14737167.2015.1008459>
- Sudhanthar S, Turner J, Sigal Y et al. Improving asthma severity and control screening in a primary care pediatric practice. *BMJ Open Qual*. 2016;5(1):u209517–w4133
- Suruki RY, Daugherty JB, Boudiaf N et al. The frequency of asthma exacerbations and healthcare utilization in patients with asthma from the UK and USA. *BMC Pulm Med*. 2017;17(1):1–11. <https://doi.org/10.1186/s12890-017-0409-3>
- Tower Hamlets Council. Factsheet: asthma in children and adolescents. Tower Hamlets joint strategic needs assessment 2016. 2016. https://www.towerhamlets.gov.uk/Documents/Public-Health/JSNA/Childhood_Asthma_JSNA_Factsheet.pdf (accessed 12 July 2023)
- To T, Cicutto L, Degani N et al. Can a community evidence-based asthma care program improve clinical outcomes? A longitudinal study. *Med Care*. 2008;46(12):1257–1266. <https://doi.org/10.1097/MLR.0b013e31817d6990>
- Whittington JW, Nolan K, Lewis N et al. Pursuing the triple aim: the first 7 years. *Milbank Q*. 2015;93(2):263–300. <https://doi.org/10.1111/1468-0009.12122>
- Wolfe I, Thompson M, Gill P et al. Health services for children in western Europe. *The Lancet*. 2013;381(9873):1224–1234. [https://doi.org/10.1016/S0140-6736\(12\)62085-6](https://doi.org/10.1016/S0140-6736(12)62085-6)
- Woods ER, Bhaumik U, Sommer SJ et al. Community asthma initiative: evaluation of a quality improvement program for comprehensive asthma care. *Pediatrics*. 2012;129(3):465–472. <https://doi.org/10.1542/peds.2010-3472>