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Investigating a novel population health management system to increase access to healthcare for children: a nested cross-sectional study within a cluster randomised controlled trial

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ABSTRACT

Background Early intervention for unmet needs is essential to improve health. Clear inequalities in healthcare use and outcomes exist. The Children and Young People's Health Partnership (CYPHP) model of care uses population health management methods to (1) identify and proactively reach children with asthma, eczema and constipation (tracer conditions); (2) engage these families, with CYPHP, by sending invitations to complete an online biopsychosocial Healthcheck Questionnaire; and (3) offer early intervention care to those children found to have unmet health needs. We aimed to understand this model's effectiveness to improve equitable access to care.

Methods We used primary care and CYPHP service-linked records and applied the same methods as the CYPHP's population health management process to identify children aged <16 years with a tracer condition between 1 April 2018 and 30 August 2020, those who engaged by completing a Healthcheck and those who received early intervention care. We applied multiple imputation with multilevel logistic regression, clustered by general practitioner (GP) practice, to investigate the association of deprivation and ethnicity, with children's engagement and receiving care.

Results Among 129 412 children, registered with 70 GP practices, 15% (19 773) had a tracer condition and 24% (4719) engaged with CYPHP's population health management system. Children in the most deprived, compared with least deprived communities, had 26% lower odds of engagement (OR 0.74; 95% CI 0.62 to 0.87). Children of Asian or black ethnicity had 31% lower odds of engaging, compared with white children (0.69 (0.59 to 0.81) and 0.69 (0.62 to 0.76), respectively). However, once engaged with the population health management system, black children had 43% higher odds of receiving care, compared with white children (1.43 (1.15 to 1.78)), and children from the most compared with least deprived communities had 50% higher odds of receiving care (1.50 (1.01 to 2.22)).

Conclusion Detection of unmet needs is possible using population health management methods and increases access to care for children from priority populations with the highest needs. Further health system strengthening is needed to improve engagement and enhance proportionate universalist access to healthcare.

Trial registration number ClinicalTrials.gov Registry (NCT03461848).

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Early equitable intervention for unmet needs is essential to improve child health.
⇒ The Children and Young People's Health Partnership model of care uses population health management methods to identify, engage and offer early intervention care to children with unmet health needs.

WHAT THIS STUDY ADDS

⇒ Detection of unmet needs is possible using population health management methods.
⇒ Although engagement with the Children and Young People's Health Partnership model of care is higher in white and less deprived children, once engaged, black children and those from more deprived socioeconomic backgrounds are more likely to receive care.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ With enhancement around engagement, the Children and Young People's Health Partnership model has the potential to reduce health inequality in children.

INTRODUCTION

In the UK and internationally, healthcare is usually reactive, individual focused, and inequitable in access and outcomes, resulting in increasingly unmanageable demand for urgent services and poor health. Children from poor families are more likely to have chronic illnesses and are more than twice as likely to die before reaching adulthood, compared with children from wealthier families.[1] Approximately 20% of childhood deaths may be preventable through early intervention, with higher proportions among children with chronic conditions.[2] However, care tends to vary inversely with population need, known as the inverse care law.[3]

Children with chronic health conditions require early intervention to prevent exacerbation of disease.[4] Even in countries with free, universal healthcare systems such as the UK National Health System, clear inequalities in healthcare use and outcomes persist.[5 6] Access to care is a complex construct, shaped by numerous factors including service availability (sufficient supply), use (overcoming personal, financial and organisational barriers) and relevance (meeting needs, improving health).[7–9]

The Children and Young People's Health Partnership (CYPHP), a collaboration between primary and secondary care, local government public health, clinicians, researchers and parents, was conceived to address the evolving healthcare needs of children and young people and proactively improve access to care.[10 11] The CYPHP model of integrated care is delivered through general practice clusters.

CYPHP model of care

The CYPHP designed a three-step population health management (PHM) approach,[12] to enhance equitable access to early intervention care (figure 1). The PHM approach was developed using three 'tracer conditions': asthma, eczema and constipation. These conditions are examples of long-term and common conditions, which impact heavily on children's lives and could provide generalisable lessons about improving outcomes through healthcare. The steps of the PHM approach are as follows: (1) identify: children with ongoing tracer conditions are proactively identified, using primary care records. This process is carried out within general practitioner (GP) practice networks using a CYPHP-developed 'call–recall' tool, adapting a well-established public health system for contacting patients for vaccination and screening. The three GP practice networks are Lambeth, Southwark South and Southwark North. (2) Engage: parents/carers of children identified with a tracer condition are sent text message invitations, by their GP, to complete an online biopsychosocial CYPHP Healthcheck Questionnaire (see online supplemental information). (3) Care: clinicians from the CYPHP service use the Healthcheck data to assess unmet needs and provide tailored biopsychosocial early intervention care. Interventional care is based in the community and carried out by specialist nurse practitioners, with specialist training in asthma, eczema and constipation. To ensure continuity of care, children are booked, if possible, to see the same specialist nurse at initial and subsequent appointments, regardless of condition, until discharge from the service. Data sharing ensures patient information is available to all clinicians and GPs through their electronic patient record systems.

The model was evaluated in a pragmatic two-arm cluster randomised controlled trial,[13 14] which found

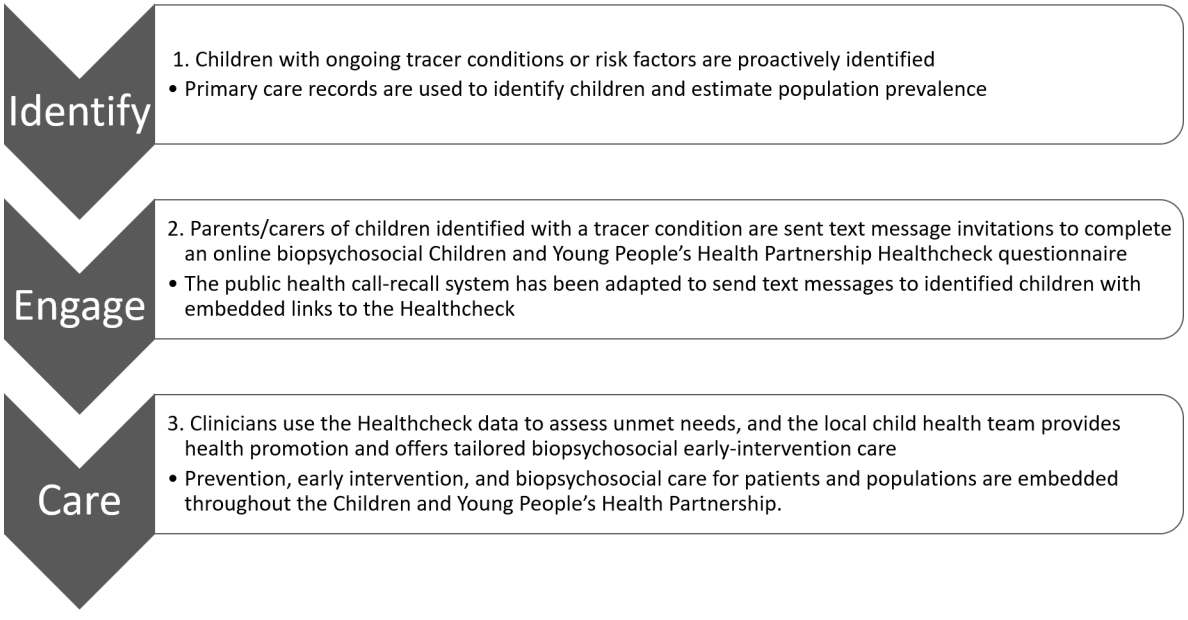

Figure 1 Children and young people's population health management system to identify, engage and care for children and young people with long-term conditions.

improvements in recorded quality of care provided to children with asthma, eczema or constipation, in the intervention compared with control arm. However, no difference in terms of primary outcomes—quality of life and health service use—could be determined over the study period. A process evaluation,[15] to investigate implementation of the model, and economic evaluation were conducted independently. Findings suggested that evaluation was carried out prematurely and trends towards cost-effectiveness were observed once a longer period was considered.[16]

This study extends previous work and aims to explore whether the CYPHP intervention was able to provide equitable access to care by examining inequalities in engagement with the PHM system and delivery of early intervention care.

METHODS

Study design and setting

We conducted a cross-sectional analysis of data collected within the clinical service as part of a large cluster randomised controlled trial,[14] to assess access to care. Our population comprised of children with tracer conditions in Lambeth and Southwark who were part of the CYPHP trial control and intervention arms, and preceding pilot. CYPHP's PHM system for improving access to care was assessed by examining steps 2 (engagement) and 3 (receiving care) of the PHM system described above.

Study data

We used pseudonymised data from primary care to identify children with a tracer condition (asthma, eczema, constipation), aged <16 years who were registered with all Lambeth and Southwark GP practices between 1 April 2018 and 30 September 2020. Data extracted included child demographics (sex, ethnicity and geographical deprivation measures); month and year of birth; diagnoses and medications to ascertain tracer condition status; and GP practice used to determine trial status (intervention, control or pilot).

We used pseudonymised CYPHP service data 1 April 2018 and 31 December 2020 to determine children who engaged with the PHM system and received early intervention from the CYPHP service (intervention and pilot practices). The externally assigned pseudonymised National Health Service (NHS) number enabled linkage for an individual child across primary care and service records.

Study populations

Children with asthma were defined as aged between 2 and <16 years, who, in primary care records, ever had a diagnosis of asthma and/or prescribed 3+ asthma medications within 1 year of the study start date. Children with eczema were defined as having a diagnosis of eczema and prescribed 3+ emollients within a 6-month period of the study start. Children with constipation were aged 6 months–<16 years, with a diagnosis of constipation or prescribed 3+ laxatives in a 6-month period of the study start date. Full details of the codes used for data extraction are published.[13 14] Criteria for identifying children with eczema, asthma and constipation differ due to the nature of each disease. Each criterion was determined by an expert panel of paediatricians and GPs and was refined over the embedding period of CYPHP service.

For the study, we defined the following linked populations, shown as a flow chart in figure 2:

Population 1: children with a tracer condition (asthma, eczema or constipation). A subset, population 1a, comprised of those registered with the trial intervention or pilot practices only. Children registered within 'control practices' were not triaged for early intervention care and were excluded when exploring which children received early intervention care.

Population 2: children who engaged with the PHM system by completing a Healthcheck. Population 2a

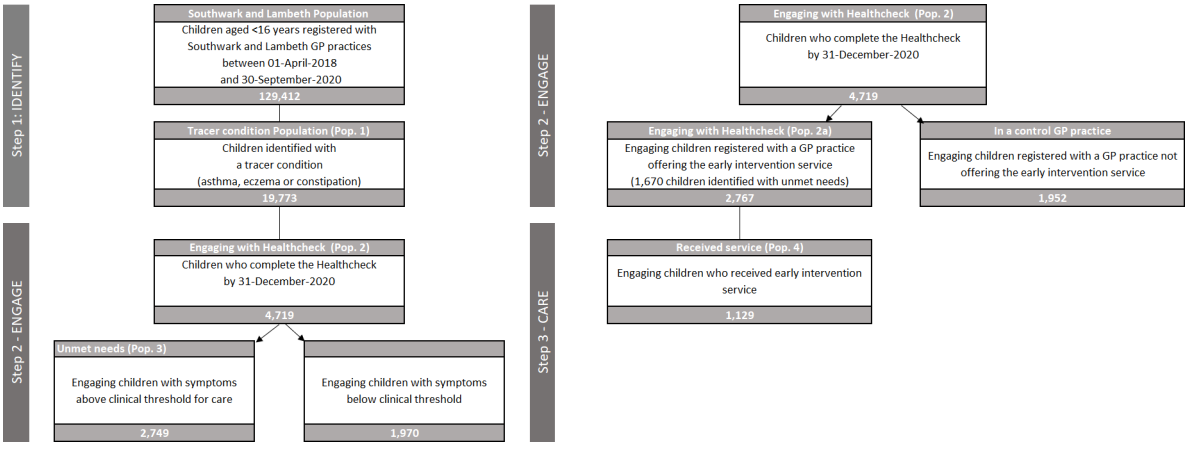

Figure 2 A flow chart of Southwark and Lambeth children, identified with a tracer condition (step 1), completing a Healthcheck (step 2), with reported high needs and received early intervention care (step 3). GP, general practitioner.

were those engaging children registered with the trial intervention or pilot practices only.

Population 3: children with unmet health needs were those who responded to the Healthcheck and who met clinical threshold for care in the Healthcheck parent-reported questionnaires. Questionnaire scores above threshold for care were defined as: Asthma Control Test score of 19 or less[17]; a CYPHP clinically accepted Constipation Questionnaire, based on national guidelines[18] and the Bristol stool chart,[19] score of 3 or more; and a Patient Oriented Eczema Management score of 8 or more.[20]

Population 4: children who received early intervention care were defined as children with at least one consultation with a CYPHP nurse.

Outcomes

The odds of engaging with the PHM system and the odds of receiving early intervention in children who engaged.

Covariates

Age was determined at the start of the study period or the age when the tracer condition was identified, whichever was the later. Index of Multiple Deprivation (2015) quintiles were based on residential postcode. Ethnicity was categorised into five groups: Asian, black, mixed ethnicity, other and white.[21] There was a high level of missing recorded ethnicity data. All data were obtained from linked primary care records for consistency and not as self-reported in the Healthcheck.

Statistical analysis

Data were initially described using contingency tables. We applied random-effects logistic regression models, with random intercept clustered by GP practice, to investigate child characteristics (age, gender, ethnicity and deprivation) associated with engaging with the service and with receiving early intervention care. Multiple imputation was used (100 imputations) to account for missing ethnicity data.[22] Age and deprivation level were modelled as continuous variables. We carried out sensitivity analyses using (1) complete case data and (2) excluding data from an area in Lambeth that struggled to establish the PHM system. ORs with CIs are reported and a statistical test p value of <0.05 was considered statistically significant. All data management and analyses were carried out in Stata V.16.0.[23]

Patient and public involvement

The CYPHP model was developed after significant community consultation. We asked children, young people and their carers, living across Lambeth and Southwark, to provide information on the content and layout of all evaluation patient-facing materials for the trial including how they would like to be informed of the CYPHP model of care. The feedback was incorporated into developing CYPHP patient-facing materials and has supported evaluation dissemination.

RESULTS

Step 1: characteristics of children identified with a tracer condition

There were 129 412 children, aged <16 years, between April 2018 and September 2020, registered with 70 GP practices, in Lambeth and Southwark, South London. 15% (19 773) of the total child population were identified through primary care records as having at least one tracer condition (table 1). There were 8725 of 129 412 (6.7%) children identified with asthma only (10 566 children with asthma overall (8.2%)), 4549 (3.5%) with constipation only (5788 with constipation overall (4.4%)), 4149 (3.2%) with eczema only (5911 with eczema overall (4.6%)), and 2350 (1.8%) had two or more tracer conditions (table 1). Tracer condition prevalence was higher among black children at 20% (5160 of 26 399), compared with white children at 13% (4571 of 35 616), and higher in the most deprived communities at 17% (8835 of 51 723), compared with the least deprived communities at 12% (110 of 912).

Step 2: characteristics of children who engaged with the PHM system

In total, 24% (4719 of 19 773) of the children with a tracer condition engaged with the PHM approach by completing a Healthcheck (figure 1 and table 1), by 31 December 2020. As a new service, the response rate was noted to increase steadily over the study period, though the COVID-19 pandemic lockdowns led to an interruption of the service and study between April and July 2020 (online supplemental figure 1). The proportions of children who engaged with the PHM system varied between conditions (table 1). Children with asthma or eczema were the most likely to engage: 24% (2124 of 8725) and 26% (1061 of 4149), respectively. 37% (873 of 2350) of children with more than one tracer condition engaged. Only 15% (661 of 4549) of children with constipation engaged. The adjusted ORs and 95% CI of engaging were 2.35 (2.12 to 2.62), 2.27 (2.03 to 2.54) and 4.23 (3.74 to 4.79) comparing asthma, eczema or multiple tracer conditions, respectively, with constipation, as shown in table 2.

Infants and children aged 13 years and older were less likely to engage with the PHM system than other age groups (table 1). Children of minority ethnic groups were less likely than children of white recorded ethnicity to engage (23% (2039 of 9035) compared with 28% (1282 of 4571)). The adjusted odds and 95% CI of engaging were 31% (OR: 0.69 (0.59 to 0.81)), 31% (0.73 (0.62 to 0.78)) and 37% (0.63 (0.51 to 0.76)) lower among Asian, black and other ethnic groups, respectively, compared with white children (table 2). Ethnicity information was

Table 1 Study populations and their characteristics

			Step 1 Identify			Step 2 Engagement				Step 3 Care		
	Southwark Lambeth population N=129 412		Population 1 Tracer condition N=19 773			Population 2 Engaged with population health management system N=4719			Population 2a Engaged subset in GP practices offering care N=2767	Population 4 Children with unmet needs and received care N=1129		
	Number	Col* %	Number	Col* %	Row %	Number	Col* %	Row %		Number	Col %	Row %
All tracer conditions	19 773	15	–	–	–	4719	–	24	2767	1129	–	40.8
Asthma	8725	6.7	8725	44	–	2124	45	24	1214	347	31	29
Constipation	4549	3.5	4549	23	–	661	14	15	373	189	17	51
Eczema	4149	3.2	4149	21	–	1061	23	26	586	251	22	43
More than 1 condition	2350	1.8	2350	12	–	873	19	37	594	342	30	58
No tracer condition	109 639	85	–	–	–	–	–	–		–	–	–
Age												
<2 years	29 226	23	3157	16	11	647	14	21	351	143	13	41
2–<5 years	22 286	17	4030	20	18	1099	23	27	660	299	26	45
5–<8 years	22 154	17	3390	17	15	969	21	29	572	245	22	43
8–<13 years	36 833	28	6091	31	17	1570	33	26	964	363	32	38
13–<16 years	18 913	15	3105	16	16	434	9.2	14	220	79	7.0	36
Sex												
Female	63 419	49	9177	46	14	2181	46	24	1255	532	47	42
Male	65 993	51	10 596	54	16	2538	54	24	1512	597	53	39
Ethnicity												
Asian	6812	5.3	1283	6.5	19	284	6.0	22	180	70	6.2	39
Black	26 399	20	5160	26	20	1116	24	22	669	315	28	47
Mixed	11 111	8.6	1837	9.3	17	478	10	26	306	115	10	38
Other	5858	4.5	755	3.8	13	161	3.4	21	64	23	2.0	36
White	35 616	28	4571	23	13	1282	27	28	794	294	26	37
Missing data	43 616	34	6167	31	14	1398	30	23	754	312	28	41
Deprivation†												
1 (most deprived)	51 723		8835	45	17.1	1988	42	23	1077	466	41	43
2	45 423	35	6855	35	15.1	1652	35	24	1101	461	41	42
3	24 450	19	3151	16	12.9	786	17	25	431	157	14	36
4	6807	5.3	810	4.1	11.9	259	5.5	32	134	38	3.4	28
5 (least deprived)	912	0.7	110	0.6	12.1	33	0.7	30	23	6	0.5	26
Missing data	97	0.1	12	0.1	–	1	–	–	1	1	–	–

These data are from a total population of 129 412 children aged <16 years, between April 2018 and September 2020, registered with 70 GP practices, in Lambeth and Southwark, South London. Tracer condition population (population 1) are children those identified through primary care records as having a tracer condition. The 'engaged' population (population 2) are those children who responded to an invitation and completed a health check. Only children registered with intervention or pilot practices, who completed the health check, were eligible for service triage (population 2a). Population 4 are those children who completed a health check, reported symptoms above threshold and received early intervention care.

*Both column and row percentages (%) are displayed. Column % helps to describe demographic breakdown within each population, while row % helps to describe the proportion of children who are represented in each stage of the population health management process.

†Indices of Multiple Deprivation 2019 levels determined by England population quintiles.

Col, column; GP, general practitioner.

Table 2 Factors associated with engaging with CYPHP's population health management (PHM) system: step 1 (engagement) and step 2 (receiving care)

	Outcomes	
	Step 1: engaging with PHM system*	Step 2: receiving care*
	Adjusted OR (95% CI)	Adjusted OR (95% CI)
Age at start of study	1.05 (1.03 to 1.06)	NS
Age squared†	0.99 (0.99 to 0.99)	NS
Sex		NS
Most vs least deprived‡	0.74 (0.62 to 0.87)	1.50 (1.01 to 2.22)
Ethnicity		
White	Reference	Reference
Asian	0.69 (0.59 to 0.81)	1.02 (0.72 to 1.45)
Black	0.69 (0.62 to 0.76)	1.43 (1.15 to 1.78)
Mixed	0.88 (0.78 to 1.00)	1.01 (0.76 to 1.33)
Other ethnicity	0.63 (0.52 to 0.76)	0.92 (0.54 to 1.56)
Condition		
Constipation	Reference	
Asthma	2.35 (2.12 to 2.62)	N/A
Eczema	2.27 (2.03 to 2.54)	N/A
2+ conditions	4.23 (3.74 to 4.79)	N/A
GP federation		
Southwark North	Reference	
Southwark South	1.14 (0.94 to 1.38)	N/A
Lambeth	0.49 (0.42 to 0.58)	N/A

*Outcomes: (1) The odds of engaging with the PHM system are the number of children identified with a tracer condition (among 19 773 total children), who completed a health check compared with those identified as having the condition who did not. (2) The odds of receiving care are the number, among 2767 eligible children, who received early intervention care compared with those who did not.
†Age is not linearly associated with Healthcheck uptake; a quadratic variable was added to the model to improve fit.
‡Measures of deprivation were Indices of Multiple Deprivation 2019 levels, determined by England population quintiles. Random-effects multivariable models with multiple imputed ethnicity to account for missing data, clustered by GP practice. Model 1 controlled for the federation conducting PHM and health condition. Due to small numbers, we did not control for additional variables in model 2.
CYPHP, Children and Young People's Health Partnership; GP, general practitioner; N/A, not applicable; NS, not significant.

missing in 31% (6167 of 19 773) of children's records. Complete case sensitivity analysis showed similar results (online supplemental table 1). Engagement in children with eczema was particularly low in minority ethnic groups. For example, children with eczema of black compared with white ethnicity had 40% lower odds of engagement (OR: 0.60 (0.50 to 0.72); online supplemental table 2). Children from more deprived communities were less likely to engage: 23% (1988 of 8835) in the most deprived quintile compared with 32% (292 of 920) in the two least deprived quintiles (table 1). Children from the most deprived communities, compared with the least, had 26% (0.74 (0.62 to 0.87)) lower odds of engaging (table 2). Children registered with GP practices in Lambeth had 51% lower odds of engaging (OR: 0.49 (0.42 to 0.58)) compared with those in Southwark. Sensitivity analyses had little impact on the estimates of interest (online supplemental table 3).

58% (2749 of 4719) of children who engaged with the PHM system had unmet needs, reporting symptoms above the clinical threshold for care (online supplemental table 3).

Step 3: characteristics of children who receive early intervention care

Among children who engaged, 2767 of 4719 were registered with intervention or pilot practices, practices offering early intervention care (figure 2). 41% (1129 of 2767) of these children received care (table 1), which was 68% (1129 of 1670) of children identified with unmet needs. 29% of children with asthma, who engaged, received care, while 51%, 43% and 58% of those children with constipation, eczema or more than one tracer condition, respectively, received care.

Children who engaged from the most compared with least deprived communities were more likely to receive CYPHP care (43% vs 26%, table 1; OR: 1.50 (1.01 to 2.22), table 2). The impact of deprivation on receiving care was particularly striking for children with asthma. Children from the most, compared with least, deprived communities had 83% higher odds of receiving care (1.83 (1.09 to 3.08); online supplemental table 4). Children of black ethnicity were more likely to receive care, compared with white children (1.43 (1.15 to 1.78); table 2). This ethnic difference was again more pronounced for

children with asthma (1.70 (1.29 to 2.23); online supplemental table 4).

Among all children with a tracer condition registered with GP practices offering CYPHP care, there was no evidence that deprivation or black ethnicity overall was associated with receiving care (online supplemental table 5).

DISCUSSION

We evaluated a novel PHM system designed to identify unmet health needs and enable early intervention for children with long-term medical conditions and improve child health outcomes, as part of an integrated care intervention trialled in a population of over 129 000 children. We sought to assess whether CYPHP's three-step PHM system could improve access to care, defined as engagement with the PHM system and uptake of early intervention care. Although children of ethnic minorities and children from deprived communities were less likely to respond to an invitation for early intervention, we found that children who responded from these communities were more likely to receive care from the service. This suggests that the intervention is reaching many of the children most in need, regardless of ethnicity or deprivation status, but targeted engagement strategies are needed to improve engagement.

Identifying unmet needs

An effective PHM approach to meeting unmet needs relies on the ability to identify children correctly. The prevalence of one or more tracer conditions among children in our study population was 15%. The prevalence of asthma was 8.2%, which is higher than the reported prevalence of 4.7% among children and adults aged 6 years and over, in Southwark and Lambeth.[24] The low reported prevalence by Quality and Outcomes Framework highlights weaknesses, for children's health, of this widely used general practice incentive scheme in England.[25]

Once identified, an appropriate health systems response is needed. Early access to good public health is delivered through primary care. For example, childhood vaccinations and screening are effective preventive care measures.[26 27] The CYPHP model of care adapted this public health system for healthcare as part of the PHM system, embedded within a local child health team, believing a proactive approach would reduce health inequality in access. The model takes advantage of the population-level data, public health approach and continuity of primary care, enabling specialist paediatric care close to home, including health promotion and effective, supported self-management for all.[28]

Engaging with PHM

In total, 24% of parents who were contacted using the PHM system responded to the invitation to complete the CYPHP Healthcheck to assess unmet needs. The proportion of parents who engaged increased with time, likely reflecting the process of embedding the new CYPHP service. By comparison, the first year of the NHS Healthcheck, a highly promoted national screening service for adult cardiovascular risk, achieved a 33.9% uptake.[29] Furthermore, COVID-19 interrupting the service is likely to have impeded engagement.

Children with asthma were 2.32 times more likely to respond than those with constipation, children with eczema were 2.17 times more likely to respond, and children with two or more tracer conditions were 3.85 times as likely to respond, likely reflecting the nature and urgency of the conditions.

We found that black and Asian children were less likely to respond to an initial Healthcheck invitation compared with white children. A recent scoping review of studies of ethnic differences in paediatric healthcare use in the UK (2001–2021) found that many studies reported ethnic differences, but only around half investigated whether differences represented inequities.[30] In our study, children from the most deprived communities were 26% less likely to engage with the Healthcheck invitation, highlighting systemic inequity. Although the NHS provides universal coverage to health services, inequities in access persist. As such, it is not surprising that differences in engagement between social and ethnic groups were found in this study. Previous studies have found children from more deprived and minority ethnic communities are less likely to use planned care, and more likely to use unplanned or urgent care, than affluent and white children.[5]

Access is contingent on multiple interacting contextual, social and personal factors. A systematic review of the literature investigating barriers to access[31] highlights communication (language, culture, health literacy and the alienating effect of professional jargon), lack of access to smartphones or computers to receive contact, involuntary or voluntary isolation, and parental reservations of services as key factors. In the case of CYPHP, these will include access to technology to complete the Healthcheck and an understanding of personal health management for their condition. Parental perception of 'need' as opposed to clinical 'need' determined by Healthcheck Questionnaires is also likely to differ across populations. For example, less deprived, white families may be more familiar with engaging with healthcare systems for non-urgent care.[32] Improving engagement is likely to require adaptation to improve communication, service visibility within the community, and building stronger relationships and networks with the population in need. Further research is needed to unpick these factors to produce a truly equitable service.

Crucially, among children who did engage with the Healthcheck invitation, 58% had unmet healthcare

needs. There was a huge variation across conditions: 42% of engaging children with asthma had unmet needs compared with 85% and 65% in constipation and eczema, respectively. It is not clear why children who are known to primary care as having a long-term condition have such high proportions of unmet needs. This may represent insufficient capacity in primary care which is widely known to be under significant strain.[33 34] Interestingly, unmet need is lower in asthma, a highly monitored condition.[25] The CYPHP model offers a way forward for identifying priority populations with unmet need and directing resources from the wider system accordingly.

Early intervention care

Among children who engaged with the PHM system, 41% received care. A larger proportion of black children overall (47%) received care than white children (37%). Similarly, a larger proportion of children from the most deprived communities (43%), compared with the least deprived (23%), received care. These findings suggest that although inequalities remain within the service, once engagement happened, children with the most need received care.

All children with an unmet clinical need were offered CYPHP care but only 68% of those children received care. There are many possible reasons to why families do not take up the offer of care. Parents may see an improvement in a child's condition between completing a Healthcheck and being offered care. Parents may not feel there is an issue, particularly if the disease scores are close to triage thresholds. Families may be satisfied with conventional primary care or may find the CYPHP clinics inconvenient in location or time.

Strengths and limitations

To our knowledge, the CYPHP evaluation, involving 129 000 children, is the largest ever randomised controlled trial of integrated care for children, and it was unusual in using PHM as part of a health system-strengthening approach. A clear strength of this study is the effective use of clinical service algorithms and shared data to identify children with specific long-term conditions. As virtually every child in the UK is registered with their local GP, which provides children with free care and medications, this approach enables an accurate disease prevalence to be determined and services planned accordingly. Hence, the data-rich Learning Health System approach allows planning and delivering care, evaluation and identification of areas for improvement.

A limitation of our study is the system fragmentation that persisted despite the advent of Integrated Care Systems and our health system-strengthening programme. As the PHM system was administered through primary care, neither the CYPHP clinical team nor the research team were able to directly control the process for sending out Healthcheck invitations, and did not have accurate records of which children were invited to complete a Healthcheck. In our analyses, we therefore assumed that all children identified with a tracer condition would have been contacted, but we believe this is unlikely due to the lower response rate in Lambeth. However, a sensitivity analysis, which excluded Lambeth, demonstrated little impact on the model estimates of interest.

Our final analysis used the population who completed the Healthcheck, but we also investigated receiving care in the wider tracer condition population. From the wider population, we found that deprivation and ethnicity were not associated with receiving care. Our previous work has shown that black children and those from lower socioeconomic groups had greater clinical need,[35] but within the engaged population. More research is needed to investigate healthcare needs in the unengaged population, to fully assess equity of the CYPHP PHM system.

A further limitation was that a large proportion of children's primary care records were missing data on ethnicity. Using ethnicity data from the Healthcheck would have biased our findings, as only those children who engaged had additional ethnicity data. We used multiple imputation as a widely accepted valid method for handling missing data.[22] Our findings from the complete case analysis were similar to that from our imputed dataset.

There is known variation in access and quality of care between practices.[36 37] These factors may contribute to the decision on whether a family engages with CYPHP or taking up the offer of care. A strength of this study is the application of a random-effects model, clustered at a GP practice level, with random intercept, so any practice-level variation (in access or quality) is measured and accounted for in the statistical modelling.

Future research and wider implications

Unmet need is high,[35] and health systems can make inroads into decreasing health inequalities, through improving access to high-quality care proportionate to need.[12] The CYPHP model, using PHM methods, has been shown to be successful at identifying children with unmet healthcare needs and proactively providing early intervention for children with the highest needs.

Although the model is successful at identifying children with a tracer condition, our findings demonstrated inequalities among children engaging with the service, despite being known to primary care as having a long-term condition. It is not known whether families who do not respond are healthy or have unmet needs. Future research will be needed to better understand the needs and barriers to care of the non-responding population. However, once engagement happened, patterns of service use mirror those of need, suggesting care delivery to children most in need

has been successful. Optimisation of identification and early intervention delivery systems such as the CYPHP is needed to improve equity of access to care.

Having proved the concept, the model can be adapted for other childhood conditions to provide early intervention or secondary prevention to improve outcomes for children with long-term conditions. The concept is not constrained to use within the UK NHS; a similar system of identifying and engaging children with unmet need, to provide specialised care, could be adapted for use in any country with a strong primary healthcare system.

CONCLUSION

PHM is an effective way to identify child health needs and offer early intervention at the population level. The CYPHP service reached children with unmet needs but will need further adaptations to achieve full equity of access. Health systems in countries such as the UK need to be strengthened, using proportionate universalism principles and PHM tools such as those developed by the CYPHP, to increase access and engagement with care for children from priority populations with the highest needs who experience the most difficult barriers to accessing care.

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