

A Mixed Methods Evaluation of The Paediatric Musculoskeletal Matters (PMM) Online Portfolio

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Abstract

Background Electronic resources (e-resources) have considerable potential to reach users around the world to promote awareness and knowledge about musculoskeletal conditions. The 'PMM portfolio' targets non-specialists in musculoskeletal medicine and comprises the Paediatric Musculoskeletal Matters (PMM) website, the paediatric Gait, Arms, Legs and Spine (pGALS) app and e-learning modules (ELM). Our aim was to evaluate the 'PMM portfolio' to gain insights about its impact on learning and clinical practice.

Methods Mixed methods (e-resource analytics, online survey, interviews) with PMM and ELM registered users in addition to purposive sampling of users using UK and international contacts within paediatrics and paediatric rheumatology. Data was analysed using descriptive statistics and free-text comments using qualitative techniques. A Paired T-Test compared self-rated confidence before and after use of the e-resources.

Results There has been wide international reach for all e-resources PMM website (662,827 hits, 262,476 users, 214 countries, data 31st July 2020), pGALS app (12,670 downloads, 70 countries, data 31st July 2020); ELM (150 users, 30 countries, data 30th May 2019). There were 164 responses to the survey from 25 countries from a range of students, trainees and health care professionals. Most deemed the 'PMM portfolio' to be 'useful or very useful' for their learning (or when used to teach others) and reported significantly increased self-rated confidence in their clinical examination and reasoning skills following access to the e-resources (PMM website, $p < 0.01$; pGALS app, $p < 0.01$; ELM, $p < 0.01$). Easy, open access, clinical images, videos and cases were deemed the most valued features of the e-resources. The most popular PMM website pages related to clinical assessment. There was high uptake of the pGALS app and pGALS' ELM especially from trainees and allied health professionals.

Conclusions The 'PMM portfolio' has wide reach amongst a spectrum of our target users to raise awareness and improve knowledge and skills. Ongoing engagement with users will facilitate further iterations of the 'PMM portfolio' to remain relevant for the global context. PMM as a model of e-learning has increasing applicability with the ongoing Covid-19 pandemic and is an important way to expand global paediatric rheumatology.

Background

Musculoskeletal (MSK) presentations in children and young people (CYP) are common (reported prevalence of 1 in 8 (1) and a frequent cause of health care consultations increasing with age (6% of 7 year olds to 16% of 22 year olds in a cohort study from the UK) (2). Delay in diagnosis and access to specialist care is a priority to address amongst parents (3) and is often reported in conditions that present with MSK features (4–9) with adverse impact on clinical outcomes (4, 5, 10). The reasons for such delay are multifactorial (9, 11); including complex care pathways involving community care and various hospital care specialties (usually general paediatrics or emergency care) (8, 11) where self-rated lack of

confidence in paediatric MSK clinical skills is reported (12). Clinicians working in the community play a crucial role to diagnose and instigate specialist referral (2, 7, 8). Family medicine practitioners are often the 'gatekeepers' to specialist services (13) and yet many training schemes do not include paediatrics (14), or MSK medicine (15) despite the learning needs being known (16). Other clinicians including nurses and allied health professionals (AHP) may encounter CYP in their clinical practice and there is need for more knowledge about MSK problems (17, 18)

With these challenges in mind our group developed a portfolio of e-resources (the 'PMM portfolio') to up skill and support all clinicians who play an integral role in the early recognition, diagnosis and initial care of CYP with MSK conditions. The target audiences therefore include a spectrum of clinical learners who are not 'paediatric MSK experts'; ranging from students in medicine and nursing, trainees in family medicine and paediatrics, through to practitioners in general paediatrics, family medicine, nursing and allied health.

The 'PMM portfolio' encompasses the Paediatric Musculoskeletal Matters (PMM) website (launched 2014), the paediatric Gait, Arms, Legs and Spine (pGALS) app (added 2015) and e-learning modules (ELM) (added 2017) to aid signposting through the website.

The PMM website (www.pmmonline.org) is a free and open evidence based, peer reviewed e-resource with user engagement to inform content and website design functionality (19). PMM Nursing (2017) is a further version of PMM to address the needs of the wider nursing community (17). The PMM website includes an open anonymised online survey and since 2014, 84 responses from 19 countries (data not shown but available on request), has informed 'PMM portfolio' development with requests for more global content and signposting. 'PMM International' was hence developed and replaced the original PMM website in September 2018 following collaboration with paediatric rheumatologists in 11 countries (within Asia, Africa, Americas, Australasia and Europe) who developed additional content reflecting case mix and the health care in their country (20). New content focused on infections and infection-related disease with MSK features, or differential diagnoses of rheumatic disease with further cases and images to reflect ethnic diversity. All contributions were subject to editorial review to ensure consistency of language and compliance with our governance framework (19, 20).

Paediatric Gait, Arms, Legs and Spine (pGALS) (21) is a simple MSK examination schedule useful in clinical practice (22–28) and is widely taught (29, 30). The free pGALS app (launched in 2015) was developed with medical students at Newcastle University UK to inform format and content with exam revision notes and links to PMM website key pages (31, 32). Language translations of pGALS produced with our PMM International collaborators (to date 20 languages) and a version for telehealth (V-pGALS) are freely available on the pGALS app and PMM website (<http://www.pmmonline.org/doctor/approach-to-clinical-assessment/examination>).

The PMM E-Learning Modules (ELM) aid navigation through the PMM website and were developed with our multi-professional team (including family medicine doctors, paediatricians, medical students) (30, 32). At the time of our evaluation there were three e-modules (<https://cpd.ncl.ac.uk/courses>)

- i) pGALS and clinical examination skills for medical students
- ii) Assessment of childhood MSK presentations in family medicine
- iii) The paediatricians approach to a child with fever

Aims

This study focuses on evaluation of the 'PMM portfolio' to describe and understand reach and impact on learning and clinical practice. Furthermore the evaluation aimed to inform future development of the 'PMM portfolio' and strategy to optimise impact.

Methods

We adopted a mixed methods approach comprising e-resource analytics, an online survey (including self-rated confidence before and after access to the e-resources) and telephone interviews to explore themes raised by the survey.

Google Analytics described access to PMM website (site hits, page hits, accessing countries) and resource analytics described pGALS App Store data (country and number of downloads) and ELM data (country, number of users, clinician role).

An online survey using ©Survey Monkey (see additional file 1) was used to explore how the 'PMM portfolio' resources impact on learning and clinical practice. The survey included sections about each of the 'PMM portfolio' e-resources and respondents were asked to provide feedback on all the resources including those that they had not accessed. The survey was piloted and included Likert Scale questions (*on perceived usefulness and impact on confidence on MSK knowledge and skills*), free text options and open-ended questions to encourage comment. A random selection of PMM website registered users (n = 450) and all the users registered for the ELM at the time of survey recruitment (n = 142, July 2019) were invited to complete the online survey in addition to purposive sampling amongst user groups within the UK and through our PMM global partners. Selected 1–1 telephone interviews followed the online survey to explore the findings in more detail. Interview participants comprised medical students (n = 2), clinical lecturer paediatricians (n = 2) and family medicine doctors involved in teaching alongside their clinical practice (n = 2); 4/6 were from the UK.

Utilising various recruitment sources was important to include a wide range of target audiences and to enable recruitment of users and non-users of the 'PMM portfolio'. Written consent was obtained from interview participants and survey respondents consented to participation through an online response. All participant information was anonymised. Interviews were audio-recorded and transcripts anonymised before data analysis. E-resource analytic and survey data was analysed using descriptive statistics, with free-text comments and interview transcripts analysed following standard procedures for qualitative analysis, including open and focused coding, constant comparison and deviant case analysis (33).

Reflexivity was maintained throughout the analysis and writing, by recording, discussing and challenging established assumptions. A Paired T Test (©Minitab) compared self-rated confidence scores (Range: 1 not very confident – 5 very confident) before and after use of the e-resources. The study had ethical approval from Newcastle University, UK.

Results

Resource Analytics

The PMM website has had 662,827 hits and 262,476 users across 214 countries (data 31st July 2020 - see Fig. 1 and Table 1). Usage has continued to grow since launch (2014) and furthermore following evolution to PMM International (September 2018). Most PMM users are from the US and UK although the total number of countries accessing PMM has increased over time (see additional file 2).

Table 1
Top 50 Countries Accessing PMM Website

Country	Number of Users	Country	Number of Users
1. US	79,928	26. Spain	962
2. UK	65,417	27. Italy	890
3. Australia	15,487	28. France	865
4. India	13,895	29. Taiwan	804
5. Canada	10,796	30. Sri Lanka	793
6. Malaysia	5,788	31. Colombia	788
7. Ireland	4,825	32. Mexico	780
8. New Zealand	3,840	33. Japan	779
9. Saudi Arabia	3,534	34. China	749
10. Philippines	3,050	35. Israel	749
11. South Africa	2,836	36. Bangladesh	738
12. Pakistan	2,343	37. Sweden	725
13. Indonesia	2,187	38. Greece	608
14. Singapore	2,163	39. Portugal	581
15. Thailand	1,879	40. Norway	569
16. Egypt	1,760	41. Poland	569
17. UAE	1,491	42. Iran	542
18. Brazil	1,488	43. Hungary	532
19. Netherlands	1,431	44. Jordan	527
20. Hong Kong	1,346	45. Belgium	513
21. Germany	1,337	46. Iraq	512
22. South Korea	1,284	47. Czech Republic	489
23. Nigeria	1,151	48. Switzerland	467
24. Kenya	1,072	49. Russia	448
25. Turkey	1,001	50. Nepal	418
Total overall: 262,476 users across 214 countries			
Google Analytic Data from 14th November 2014 (go live date) to 31st July 2020			

The most popular PMM website pages (Table 2) relate to clinical assessment (pGALS, pREMS (34) normal development [gait/milestones], normal variants), frequent falls, fractures, MSK infections, limping child and guidance on when to be concerned ('red flags'). Users spend approximately 2 minutes on the site (Mean: 01.58, Range: 5 seconds to 5 minutes, 53 seconds) and view 2 pages per session (Mean: 2.08, Range 1–24).

Table 2
Top 20 PMM Website Pages

Page Title	Page views
1. Gait and motor milestones	41,539
2. Frequent falls case	27,661
3. Common fractures in children	20,509
4. Septic Arthritis & Osteomyelitis	20,130
5. Limping child - abnormal gait patterns	15,327
6. pGALS	15,146
7. Tip toe walking	13,558
8. Clinical assessment - children differ from adults	12,627
9. pREMS	9,261
10. Causes of foot, heel and ankle pain	8,621
11. Clinical examination	8,449
12. Arthritis module homepage	7,965
13. Non accidental injury	7,794
14. Red flags	7,782
15. Personal dashboard	6,394
16. Normal variants - when to refer	5,902
17. Red flags - knee pain	5,873
18. Kawasaki Disease	5,761
19. Resources	5,610
20. Clinical assessment top tips	4,842
Google Analytic Data from 14th November 2014 (go live date) to 31st July 2020	

The pGALS app has had 12,670 downloads from 70 countries (data 31st July 2020). The iOS version had 8,067 downloads from 54 countries (Top 3: China (2,372), UK (1,498) and US (706) (see additional file 3).

The android version had 4,603 downloads from 63 countries (Top 3: UK (940), Mexico (756) and India (358)) (see additional file 4).

The ELM data includes 150 registered users from 30 countries across Asia, Africa, America, Europe and Oceania (data 30th May 2019, updated data in progress). Most (n = 101, 68%) are from the UK and Ireland with a range of clinical roles: nurse and AHP (n = 50), training doctors (n = 36) and clinicians (n = 35) (see additional files 5 and 6). Most users completed one ELM (n = 128) and the remainder completed > 1 (n = 22); 'pGALS and clinical examination skills for medical students' had the highest uptake (n = 130 users) followed by 'Assessment of childhood MSK presentations in family medicine' (n = 31 users), and 'The paediatricians approach to a child with fever' (n = 11 users).

Survey and Interview Data

The response rate to the survey is not clear as the link to the survey was sent to PMM collaborators and forwarded to students and trainees. We do however know that minimum of 592 received the invite (from our random selection of PMM website users and all the ELM registered users at that time) - we received 164 completed responses to the survey, hence we can assume a maximum response rate of 28%. Survey respondents from 25 countries (across Africa, Asia, Europe, North and South America) comprised a range of roles and levels of experience within community and hospital care (see additional files 7 and 8). Table 3 describes feedback on all three e-resources within the 'PMM portfolio' (n = 120) and an additional 44 provided feedback on 2 or less (PMM website and pGALS app (n = 10), PMM website and ELM (n = 3), PMM website alone (n = 31). Some had experience using the e-resources (PMM website n = 103/164, 63%; pGALS app n = 48/131, 37% ELM n = 50/123, 41%) and others did not have experience (PMM website n = 61/164, 37%; pGALS app n = 83/131, 63%; ELM n = 73/123, 59%). Users and non-users held comparable job profiles and were from a similar varied mix of countries (see additional files 7 and 8).

Table 3
Use of E-Resources

Frequency of Reported Use	PMM n (%)	pGALS n (%)	Reported Use	ELM
Use of Resource	103 (62.80%)	48 (36.64%)	Completed short course	50 (40.65%)
- Daily	14 (13.59%)	6 (12.50%)	- pGALS and clinical examination skills for medical students	42 (34.15%)
- Weekly	15 (14.56%)	10 (20.83%)	- Assessment of childhood MSK presentations in family medicine	21 (17.07%)
- Fortnightly	7 (6.80%)	3 (6.25%)	- The paediatricians approach to a child with fever	14 (11.38%)
- Monthly	29 (28.16%)	11 (22.92%)		
- Less often	32 (31.07%)	12 (25%)		
Other*	6 (5.83%)	6 (12.50%)		
Not Used Resource	61 (37.20%)	83 (63.36%)	Not completed short course	73 (59.35%)
	Total n = 164	Total n = 131		Total n = 123
<i>*Other included: PMM portfolio recent users accessing resources for the first time on in progress with ELM</i>				

Users of the 'PMM portfolio' e-resources who completed the survey comprised mainly AHP (PMM website n = 49/103, 48%; pGALS app n = 17/48, 35%; ELM n = 33/50, 66%), followed by general paediatricians (PMM website n = 13/103, 13%; pGALS app n = 7/48, 15%), paediatric rheumatologists (PMM website n = 16/103, 16%; pGALS app n = 11/48, 23%) and medical students (n = 4/50, 8%) for the ELM. They resided across 24 countries with highest survey uptake in India (PMM website n = 38/98, 39%; pGALS app n = 13/44, 30%; ELM n = 21/44, 48%). See additional files 7 and 8.

Most respondents judged the e-resources to be 'useful' or 'very useful' and reported being able to use them quickly and easily (Table 4). The main reasons to access the PMM website and ELM were Continuing Professional Development (CPD)/Continuing Medical Education (CME) and 'to understand a clinical problem', whereas to 'help examine a patient' and 'teaching' were reported as the main reasons to access the pGALS app. There was a difference by user group (see Table 5), with students and trainees reporting pGALS guidance relating to patient examination and 'exam revision' being the main reasons to access the PMM website and pGALS app; 'CPD/CME' and 'exam revision' the main reasons to access the ELM. In contrast, clinicians reported 'teaching' as the main reasons to access the e-resources with nurses and AHP citing 'CPD/CME' (PMM website), 'to help examine a patient (pGALS app) and 'to understand a clinical problem' (ELM) as their main indications.

Table 4
Resource Use and Impact on Education or Clinical Practice

	PMM Website	pGALS App	ELM
How useful did you find the resource?			
Very useful	54 (52.43%)	25 (53.19%)	23 (46.94%)
Useful	46 (44.66%)	20 (42.55%)	26 (53.06%)
Neither	2 (1.94%)	1 (2.13%)	0
Not useful	1 (0.97%)	1 (2.13%)	0
Not very useful	0	0	0
	n = 103	n = 47 (1 did not answer this question)	n = 49 (1 did not answer this question)
Are you able to use the resource for your required purpose quickly and easily?			
Yes	92 (89.32%)	44 (91.67%)	41 (89.13%)
No	11 (10.68%)	4 (8.33%)	5 (10.87%)
	n = 103	n = 48	n = 46 (4 did not answer this question)
Do you feel the resource has or could have any impact on the medical education of yourself or others?			
Yes myself	69 (67.65%)	31 (65.96%)	35 (77.78%)
Yes others	26 (25.49%)	14 (29.79%)	7 (15.56%)
No	7 (6.86%)	2 (4.26%)	3 (6.67%)
	n = 102 (1 did not answer this question)	n = 47 (1 did not answer this question)	n = 45 (5 did not answer this question)
Do you feel the resource has or could have any impact on your clinical practice?			
Yes	87 (88.78%)	40 (85.11%)	40 (90.91%)
No	11 (11.22%)	7 (14.89%)	4 (9.09%)
	n = 98 (5 did not answer this question)	n = 47 (1 did not answer this question)	n = 44 (6 did not answer this question)
Do you use any of the resources/ information available in the resource within your clinical practice?			
Yes	66 (66%)	33 (70.21%)	33 (78.57%)
No	34 (34%)	14 (29.79%)	9 (21.43%)
	n = 100 (3 did not answer this question)	n = 47 (1 did not answer this question)	n = 42 (8 did not answer this question)

Table 5
Resource Use by User Group

	Training Doctors	Clinicians	Nurses & AHP	Overall
PMM Website Main Reason of Use				
To find the answer to a clinical problem	7 (53.85%)	17 (45.95%)	26 (49.06%)	50 (48.54%)
To find an answer for an educational reason (e.g. essay, MCQ, exam)	5 (38.46%)	13 (35.14%)	15 (28.30%)	33 (32.04%)
For Continuing Professional Development (CPD) / For Continuing Medical Education (CME)	4 (30.77%)	15 (40.54%)	38 (71.70%)	57 (55.34%)
For exam revision	8 (61.54%)	8 (21.62%)	9 (16.98%)	25 (24.27%)
For teaching	5 (38.46%)	24 (64.86%)	15 (28.30%)	44 (42.71%)
To access pGALS guidance	9 (69.23%)	15 (40.54%)	15 (28.30%)	39 (37.86%)
To access pREMS guidance	6 (46.15%)	9 (24.32%)	14 (26.42%)	29 (28.16%)
Other	0	2 (5.41%) General learning. Improve skills in MSK assessment.	3 (5.66%) Improve knowledge and experience. Assess milestone.	5 (4.85%)
	n = 13	n = 37	n = 53	n = 103
pGALS App Main Reason of Use				
To help examine a patient	4 (40%)	10 (47.62%)	14 (82.35%)	28 (58.33%)
To improve my examination technique	5 (50%)	10 (47.62%)	11 (64.71%)	26 (54.17%)
To improve the examination technique of others	2 (20%)	12 (57.14%)	8 (47.06%)	22 (45.83%)
For exam revision	5 (50%)	8 (38.10%)	4 (23.53%)	17 (35.42%)
For teaching	4 (40%)	19 (90.48%)	5 (29.41%)	28 (58.33%)
	n = 10	n = 21	n = 17	n = 48
ELM Main Reason of Use				
To understand a clinical problem	2 (33%)	4 (40%)	25 (73.53%)	31 (62%)
To learn more for an educational reason (e.g. essay, MCQ, exam)	3 (50%)	4 (40%)	13 (38.24%)	20 (40%)
For continuing professional development (CPD)/continuing medical education (CME)	3 (50%)	5 (50%)	23 (67.65%)	31 (62%)
For exam revision	3 (50%)	4 (40%)	6 (17.65%)	13 (26%)
For teaching	1 (16.67)	6 (60%)	10 (29.41%)	17 (34%)
Other	0	0	1 (2.94%) Updated.	1 (2%)
	n = 6	n = 10	n = 34	n = 50
<i>*'Training doctor' included medical student, general paediatric trainee, paediatric rheumatology trainee, family medicine trainee; 'Clinician' included, general paediatrician, paediatric rheumatologist, family medicine doctors, orthopaedic surgeon & clinical lecturer/ research fellow/medical laboratory; 'Nurses & AHP' included nurse/nurse practitioner, physiotherapist, podiatrist, occupational therapist, extended scope practitioner & additional needs practitioner – see additional file 7 for breakdown.</i>				

Most users reported that the e-resources 'have' or 'could have' an impact on their current clinical practice and the education of themselves or others (Table 4); improved clinical skills and knowledge, aiding

teaching and increasing awareness about MSK issues in CYP amongst other providers cited as the main benefits (Table 6).

Table 6
Impact of E-resources on Clinical Practice and Learning

1. Improved clinical skills and knowledge in practice		
PMM website	pGALS app	ELM
<ul style="list-style-type: none"> • Used to improve knowledge within this area and as a refresher to update and review current knowledge base. Not all countries have access to a paediatric rheumatology specialism and for these people the site enables them to view clinical cases they might otherwise not have access to within their learning environment. • Provides an intuitive source to better inform decision-making and practice, guide patient treatment and aid explaining condition to families. In particular, it informs users about systematic approach to examination and this in turn thought to enhance confidence and ability to examine children proficiently. 	<ul style="list-style-type: none"> • Informs users about simple systematic approach to examination and serves as useful refresher or revision aid. Increased knowledge gained from the app thought to make examination easier, enhance confidence and improve examination technique. • Equips the user with the necessary knowledge and skills to discern between abnormal and normal, screen asymptomatic and symptomatic patients and distinguish musculoskeletal conditions. 	<ul style="list-style-type: none"> • Used to expand knowledge within a particular area of interest and to consolidate and review current knowledge base or as part of CPD. • Provides content to better inform decision-making and practice and give additional reasoning that can be applied when assessing patients or explaining condition to families. Increased knowledge gained from ELM thought to aid clinical reasoning and make MSK examination easier, improve examination technique and enhance confidence particularly in relation to assessment and examination.
<p><i>"It has improved my confidence and skills to facilitate better outcomes".</i></p> <p><i>"In my country no one have a paediatric rheumatology specialty so we can learn a lot about cases from PMM and teach our student".</i></p> <p><i>"When I don't have any protocol (in Brazil some hospitals doesn't have at all) to guide me, I choose PMM to help me and solve some problems".</i></p> <p><i>"Its easy, for free and intuitive way to find answers and guide a treatment for a patient".</i></p> <p><i>"It will enhance my capability to check paediatrics efficiently".</i></p>	<p><i>"Making easier the clinical examination".</i></p> <p><i>"Increases my capability in diagnosis".</i></p> <p><i>"Improve in terms of examination, assessment, investigation and management".</i></p>	<p><i>"Gaining wider knowledge of signs, symptoms and examination of a child".</i></p> <p><i>"It helped me improve my technique to perform pGALS".</i></p> <p><i>"I think it came from wanting to consolidate what I had read. It was almost like a test to yourself. Did I actually understand what I read and what would I be inclined to do if I were presented with a certain situation".</i></p>
2. Improved Teaching of others		
PMM website	pGALS app	ELM
<ul style="list-style-type: none"> • Used within undergraduate and trainee teaching material and students and trainees directed to site for self-directed learning or review. 	<ul style="list-style-type: none"> • Used within undergraduate and trainee teaching material and students and trainees directed to app for self-directed learning. 	<ul style="list-style-type: none"> • Used to prepare teaching material and inform teaching topics; and students and trainees directed to ELM for self-directed learning.

1. Improved clinical skills and knowledge in practice		
<i>"I refer all trainees and CME candidates to it". "I can revise the knowledge of clinical history and examination skills before my teaching session". "Clear, focused especially on the basics that were not taught in med school. Therefore this resource is excellent as I want to teach the topics to medical students".</i>	<i>"I use for teaching and signpost students to it".</i>	<i>"Acts as an introduction for me before lectures". "This is very informative and attractive for us...by this we can increase our capabilities to give suggestions to others". "I really want to do as much online courses as possible to have edge when enrolling for my masters".</i>
3. Raised awareness in other providers		
PMM website	pGALS app	ELM
<ul style="list-style-type: none"> Enables clinicians working in different specialties or areas to consider things from a rheumatology perspective. Highlights key issues with MSK medicine. Increases awareness of JIA and other rheumatological conditions in children in healthcare providers within and outside of the specialism. 	<ul style="list-style-type: none"> Increases knowledge in colleagues and AHP. 	<ul style="list-style-type: none"> Completion of the courses thought to increase awareness of rheumatological conditions in children and encourage those outside the specialism to consider MSK diagnoses when assessing patients.
<i>"Being an orthopaedic surgeon its useful to see problems from a rheumatological perspective". "PMM is a very useful website for non paediatric rheumatologists. Highly recommend as a learning resource".</i>	<i>"Increases knowledge in colleagues and AHP".</i>	<i>"List out the common MSK problems of paediatrics".</i>

Most users reported using the 'PMM portfolio' within their own learning, clinical practice or teaching (Table 4). The PMM website content deemed most useful related to clinical assessment and examination skills (e.g. pGALS and pREMS), normal variants, red flags, limping child guidance, links to guidelines and access to videos. The pGALS guidance, 'Top Tips' and translations were highly rated in the pGALS app. The ELM users most valued clinical assessment of common MSK presentations, cases and images to illustrate abnormalities and when to be concerned ('red flags').

Self-rated confidence (before and after accessing the PMM portfolio, using a Likert scale range: 1 (not very confident) – 5 (very confident)), about MSK knowledge and skills increased for all three e-resources: PMM Website $p < 0.01$ $t(99) = -6.59$. Before: Mean score: 3.51 (S.D. 1.19). After: Mean score: 4.23 (S.D. 0.87)

pGALS App: $p < 0.01$ $t(46) = -3.94$. Before: Mean: 3.70 (S.D. 1.38). After: Mean: 4.30 (S.D. 1.02)

ELM: $p < 0.01$ $t(43) = -4.37$. Before: Mean: 3.57 (S.D. 1.21). After: Mean: 4.16 (S.D. 0.91)

Non-users of the e-resources (PMM website $n = 61$, pGALS App $n = 83$, ELM $n = 73$) reported lack of awareness of their existence as the main reason (PMM website: $n = 48/60$, 80%; pGALS app: $n = 66/83$, 80%; ELM: $n = 48/73$, 66%). Most non-users reported that following the study participation they were planning to access the e-resources for their clinical practice and / or teaching.

Increasing awareness of the 'PMM portfolio', especially amongst junior clinicians and AHPs, integration into local training systems or curricula, linking with professional organisations, CME/CPD and existing meetings were suggested ways to increase reach and impact of all the e-resources. In addition, expanding

the ELM topics, further signposting to key content targeted to user groups, providing offline access (e.g. apps) and maintaining content pertinent to global practice were suggestions for future development of the 'PMM portfolio'

Discussion

The 'PMM portfolio' has been developed to address the reality that many CYP will present to a myriad of clinicians and in most health care systems, not directly to a paediatric MSK specialist. Making a prompt correct diagnosis and to know when a specialist referral is needed (or not), are important to optimise clinical outcomes. Many clinicians who are involved in care pathways do not have experience or training in paediatric MSK medicine (12, 14, 15, 35). Hence the range of target audiences for the 'PMM portfolio' is wide with the aim of improving awareness, knowledge and clinical skills and ultimately improving access to the 'right care'. Furthermore nursing and medical students are an important target audience as embedding essential skills early is beneficial (18, 29, 36).

Our evaluation demonstrates wide spread use of the 'PMM portfolio' which has expanded since launch in 2014 and provides substantial evidence that we are reaching our target audiences. The most popular pages of the PMM website judged by the analytics, survey and interviews, focus on clinical assessment (including pGALS, pREMS, normal development, normal variants), limping, MSK infection and indicators of when to be concerned (red flags); these observations reflect users being non-experts in paediatric MSK medicine and the known learning outcomes for medical students (37) and family medicine (16).

We have shown that most users of the PMM website were initially from the UK and US but over time, uptake has increased across many countries around the world and amongst trainees and AHPs. Positive feedback included ease of use, open access and content being appropriate for users (either for their own learning needs or to aid the teaching of others). Notably there was variation by user groups for accessing the e-resource; e.g. students and trainees use of the PMM website and pGALS app for clinical skills guidance and revision, AHPs reporting use of the ELM (which focus on cased based common MSK conditions) and clinicians accessing the PMM website and pGALS app for teaching. There was a significant increase in self rated confidence in clinical skills and knowledge following access to all e-resources and many users reported using the e-resources having a positive impact on their learning, their clinical practice and the teaching of others to raise awareness.

The international uptake of the e-resources reflects the wide stakeholder engagement utilised in the 'PMM portfolio' development (design, format and content). Our global partners are integral to the PMM website content and pGALS translations ensuring relevance to target audiences. The global partners have also likely facilitated dissemination and reach; notably the countries of several PMM global partners rank highly in those accessing the 'PMM portfolio'. Dissemination has been further facilitated through endorsement by professional societies (e.g. Paediatric Rheumatology European Society (PReS), Royal College of Paediatrics and Child Health (RCPCH), Royal College of Nursing (RCN), India Rheumatology Society and National Institute for Health and Care Excellence (NICE)). The 'PMM portfolio' is embedded in NICE Clinical Knowledge Summaries for family medicine, PReS Basic Courses for paediatric

rheumatology, RCPCH guidance for postgraduate examinations, the RCN Competency Framework, postgraduate paediatric rheumatology training programmes (e.g. India and Kenya) and the strategy of the Paediatric Task Force for Global Musculoskeletal Health (38).

Our evaluation gave insights for additional content and to further increase reach. We firmly believe that ongoing engagement of users is integral to iterative development and optimising impact as a means of knowledge transfer (39). Increasing awareness of the 'PMM portfolio' especially amongst students, trainees and AHPs is important and notably was the most cited reason amongst non-users for lack of access to the e-resources. Despite high interest within the ELM from the survey respondents most ELM registered users reside in the UK/Ireland suggesting more work is needed to promote these. More needs to be done to integrate the 'PMM portfolio' into curricula, training programmes through links with professional organisations, training bodies and increasing exposure at CME/CPD events. Furthermore, expanding the current range of ELMs, offline access and addressing the global context for content would facilitate uptake and impact of the 'PMM portfolio'. With this in mind, work is already underway to develop a PMM app and the ELM now includes a module targeting physiotherapists, and a further ELM for school teachers is planned. All the e-resources are free of charge other than one ELM ('The paediatricians approach to a child with fever'), which had higher development costs; the charge may have contributed to the low uptake of this ELM. We aim for all the e-resources to be free and funding is a major barrier to further 'PMM portfolio' development. To date all contributions have been forthcoming without financial reimbursement and we gratefully acknowledge the valuable input from all our PMM partners. We are actively working on ways to secure sustainability and growth whilst maintaining the ethos of PMM being free and open to all.

Limitations of our study. Our informal approach to recruitment resulted in the survey response rate being imprecise. However, this approach to recruitment enabled reach to both users and non-users of the e-resources and gave valuable insights into barriers to use and ways to encourage uptake further. There was not an even spread amongst the numbers of responders per user group or by country and this may have introduced bias. For example, there was a high proportion of survey respondents from India and amongst AHPs (who gave very favorable feedback). Their responses were nonetheless comparable to other respondent groups so we suggest that any effect on the overall findings is minimal. Their feedback was very valuable for future work to target clinicians, especially AHPs who are integral to paediatric MSK care in areas of the world with workforce challenges (35, 38, 40, 41). Our methods explored reach and impact on learning and clinical practice; ideally evaluation would include influence on clinical outcomes (such as access to specialist care) but given that referrals are dependent on several variables (including local referral pathways and availability of specialists), a different evaluation approach would be needed.

Implications for research and practice

Our work is timely and relevant given the COVID-19 pandemic and rapid escalation of e-learning in clinical education (42). E-learning platforms are now increasingly utilised (43) and there is great potential for e-

technology and telehealth (44) to reach many users around the world at relatively low cost. This is particularly relevant to the 'PMM portfolio' given the evidence that many CYP with MSK conditions live in parts of the world (Asia and Africa) with little or no access to specialist care (45). Our evaluation and iterative approach highlights the importance of user engagement to optimise reach and impact. The 'PMM portfolio' is an exemplar model to facilitate workforce capacity building in global paediatric rheumatology (38) and more work is needed to integrate e-learning with face to face training schemes. The role of e-resources and understanding how to tailor them for maximum impact is of increasing importance given the financial investment needed to set up and sustain e-learning programmes.

Conclusions

The 'PMM portfolio' is fulfilling an important role reaching many target user groups across the world. The 'PMM portfolio' continues to grow and engagement with users will facilitate future iterations maintaining relevance for the global context.

List Of Abbreviations

AHP Allied Health Professionals

CME Continuing Medical Education

CPD Continuing Professional Development

CYP Children and Young People

ELM E Learning Module

HCP's Health Care Professionals

NICE National Institute for Health and Care Excellence

pGALS Paediatric Gait, Arms, Legs and Spine

pREMS Paediatric Regional Examination of the Musculoskeletal System

PRoS Paediatric Rheumatology European Society

PMM Paediatric Musculoskeletal Matters

RCN Royal College of Nursing

RCPCH Royal College of Pediatrics and Child Health

Declarations

Ethics approval and consent to participate

Ethical approval obtained from Newcastle University UK Ethics Committee.

Consent for publication

Informed consent was obtained for all participants. As part of this, participants were informed that anonymised, exemplar, extracts of their data may be used in a study report.

Availability of data and materials

To maintain anonymity no additional data is available. Participants only consented to anonymised, exemplar, extracts of the data to being shared.

Competing interests

The authors declare they have no competing interests.

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Authors' contributions

HF/SJ conceived the concept of the e-learning resources, led the development of the resources and contributed to study design, analysis and writing of the manuscript. NS contributed to the study design, undertook the evaluation work and contributed to analysis and writing of the manuscript. All authors read and approved the final manuscript.

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Figures

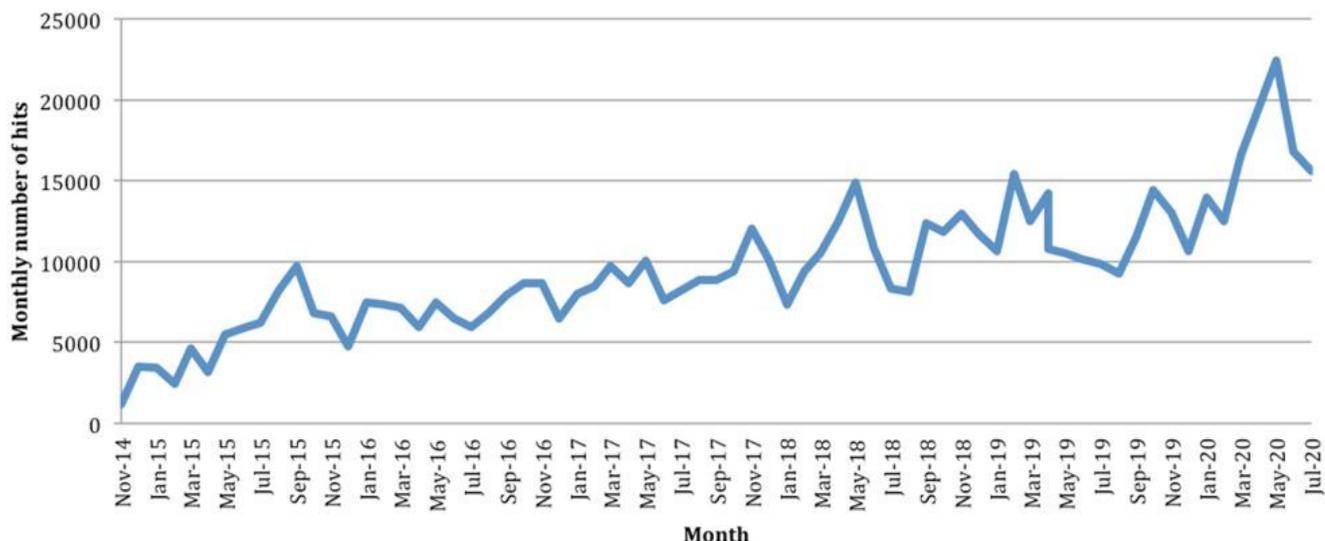


Figure 1

Total Number of PMM website hits each month Google Analytic Data from 14th November 2014 (go live date) to 31st July 2020

Supplementary Files

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