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Implementing patient reported outcomes in cancer care: Lessons and strategies from a large UK Cancer Centre

CL. Moss [a,*], J. Malpass [b], L. Fox [a], T. Guerrero-Urbano [b], A. Aggarwal [b,c], M. Van Hemelrijck [a]

[a] King's College London, School of Cancer and Pharmaceutical Sciences, Transforming cancer OUtcomes through Research (TOUR), London, UK
[b] Comprehensive Cancer Centre, Guy's and St Thomas' NHS Foundation Trust, London, UK
[c] Department of Health Services Research and Policy, Faculty of Public Health and Policy, London School of Hygiene & Tropical Medicine, UK

ABSTRACT

Background: Patient-reported outcome measures (PROMs) are valuable for advancing patient-centred cancer care by capturing patients' views on their health, quality of life, and symptoms. However, routine PROM collection remains difficult to implement in clinical settings. This study evaluated a PROM pilot in the prostate cancer radiotherapy setting at Guy's Cancer Centre, identifying multi-level barriers and facilitators to routine implementation.

Methods: A mixed-methods design was used, comprising qualitative interviews with healthcare professionals and a quantitative questionnaire for patients. The interview guide was informed by the Consolidated Framework for Implementation Research (CFIR). Fourteen healthcare professionals (including clinicians, radiographers, and managers) took part in interviews, and ten of twenty prostate cancer patients completed the evaluative questionnaire.

Results: Key patient-level challenges included digital literacy gaps, limited access to technology, and low understanding of PROMs. Provider-level barriers involved limited PROM training, staff turnover, and concerns about added workload. Administrative issues included funding limitations and logistical complexity across multiple care sites. System-level barriers centred on poor integration between PROM platforms and electronic health record (EHR) systems.

Conclusions: To support sustainable and scalable PROM use, several strategies are proposed: developing patient education tools, setting thresholds for clinically meaningful PROM changes, appointing administrative staff to reduce provider burden, and offering PROM access via devices such as iPads in waiting rooms. Policy recommendations include resourcing PROM-dedicated staff, enabling flexible training for clinical teams, and introducing support mechanisms to reduce inequities in PROM completion. These approaches aim to embed PROMs into routine cancer care, improving clinical outcomes and patient engagement. Future work should explore the scalability of these strategies across other tumour types and settings, ensuring PROMs can inform value-based, equitable cancer care delivery.

Policy summary: This paper seeks to influence policies that promote patient-centred care in oncology, particularly by enhancing the routine collection and integration of PROMs within cancer treatment pathways. It advocates for policies that allocate resources to support sustainable PROM collection, including dedicated staff roles, infrastructure for technological integration, and patient education resources. Additionally, it highlights the need for policy improvements that address health inequities by providing targeted support for populations facing digital literacy and accessibility challenges. By addressing these policy areas, the paper aims to advance frameworks that improve patient engagement, data-informed clinical decision-making, and equitable access to supportive care in oncology.

1. Background

The routine implementation of patient-reported outcome measures (PROMs) is becoming increasingly recognised across cancer landscapes as a critical tool for improving patient-centred care, enhancing quality of life, and informing healthcare system performance [1–3]. PROMs, which are standardised, validated questionnaires completed by patients to indicate perception of their own health status, have particular relevance in cancer settings where treatment decision making processes often involve balancing survival benefits against potential impacts on quality of life (QoL) [4,5].

The capturing of PRO data on the effects of cancer and its treatment can provide insight for clinical decision-making, ensuring that treatments align with the preferences of patients [6]. Additionally, PROMs contribute to improving clinical outcomes by enabling early identification of symptoms and short or long term side effects which may otherwise go unrecognised, leading to a reduction in avoidable hospitalisations and an overall improvement in care quality [7].

Moreover, PROMs are integral in monitoring and addressing disparities in cancer care and unmet burden of disease. A recent study, which involved a national PROMs evaluation of prostate cancer patients following surgery identified that, of 5165 men, 481 (9.3 %) reported a "bad" urinary incontinence score (EPIC-26 < 25) indicating severe incontinence. Despite this figure, only 47 (0.9 % of total cohort) of these

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* Correspondence to: Transforming cancer OUtcomes through Research (TOUR), King's College London, Third Floor Bermondsey Wing, Guy's Hospital, London SE1 9RT, UK.

E-mail address: charlotte.moss@kcl.ac.uk (CL. Moss).

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men underwent urinary incontinence surgery within 6 months of questionnaire completion [8].

Despite the recognised value of routine PROM collection, to date their integration into cancer clinical settings has been limited. Various barriers are contributing to this implementation gap, including logistical challenges and financial constraints such as the cost of digital infrastructure, staff training, and on-going data management. Furthermore, whilst there are often multiple validated PROM tools available per setting, there is a lack of consensus across clinical communities as to which instruments are most applicable, how frequently they should be administered, and the optimal mode of delivery (electronic vs paper). Electronic administration has the potential to streamline data collection, yet most hospitals are not currently equipped to automate PROM collection processes or integrate results into the clinical care records. This lack of standardised processes and infrastructure impedes attempts to embed PROMs into routine cancer care.

To address this, an implementation project was undertaken at Guy's Cancer Centre (London, UK), with men with prostate cancer (PCa), to routinely collect PROMs in clinical practice. The PCa setting was identified as an exemplar setting for this piloting of routine PROM collection owing to its high incidence rates, diverse treatment modalities, and the well-known impacts of such treatment on patient QoL. Furthermore, Guy's Cancer Centre is the hub of one of the largest regional cancer networks in the UK, the Southeast London Cancer Alliance (SELCA). In 2020, among the male population of SELCA (901,789), 111, 798 individuals were living with PCa [9]. Moreover, SELCA serves a highly diverse and socioeconomically varied population; for example, 33 % of PCa patients treated with radiotherapy across the alliance were of Black ethnicity which far exceeds the UK national average.

This initiative aimed to integrate PROM collection into standard care and a mixed methods evaluation, guided by the Consolidated Framework for Implementation Research (CFIR), was conducted to identify key barriers and facilitators impacting the success of the implementation attempt [10]. Here, we report key insights from our evaluation which were utilised to inform the development of implementation strategies with potential applicability beyond this site. These findings offer practical guidance for other Centres embarking on routine cancer PROM implementation and contribute to shaping local, regional, and national approaches to sustainable, scalable PROMs integration in clinical practice.

2. Methods

This study evaluated the implementation of routine clinical PROM collection in a cohort of PCa patients receiving curative radiotherapy at Guy's Cancer Centre. As part of the pilot, patients were asked to complete the EPIC-26 PROM at seven timepoints: prior to commencing radiotherapy, and at 6-weeks, 3-months, 6-months, 12-months, 18-months, and 24-months following completion of treatment [11]. A mixed-methods approach, comprised of qualitative interviews with healthcare professionals (guided by the CFIR) and an evaluative questionnaire distributed to participating patients, was used to assess the feasibility and acceptability of this implementation pilot. Ethical approval was obtained as part of a service evaluation from Guy's and St Thomas' NHS Foundation Trust (Project No: 12416), with data collected between October 2021 and October 2023. The study aimed to identify key barriers and facilitators influencing the success, sustainability, and scalability of routine PROM integration in clinical practice.

2.1. Qualitative interview study (healthcare professionals)

For the qualitative component, semi-structured interviews were guided by the Consolidated Framework for Implementation Research (CFIR) which is comprised of five key domains: **intervention characteristics** *(how the features of the intervention itself influence its uptake in practice)*, **inner setting** *(local environment including culture, resources, readiness for change)*, **outer setting** *(external factors that influence implementation such as healthcare policy)*, **characteristics of individuals** *(knowledge, attitudes and confidence of people involved in delivering or receiving intervention)*, and the **process of implementation** *(steps taken to introduce, plan, and evaluate the intervention)* [10]. This framework was chosen to ensure comprehensive coverage of the factors influencing the implementation and sustainability of routine PROM collection at this Cancer Centre. The interview guide, based on the CFIR tool (cfirguide.org), was adapted to probe issues relevant to implementation and scalability.

To ensure a comprehensive understanding of the implementation challenges, a purposive sampling approach was selected. A broad inclusion criterion was defined to capture diverse insights across a range of roles and clinical contexts. As such, key healthcare professional stakeholders from across Guy's Cancer Centre were invited to participate.

Healthcare professional stakeholders who had been involved in the development and undertaking of the implementation attempt were recruited, as well as those who had previous experiences with PROM implementation in external settings. Additionally, individuals who expressed a professional interest or aspiration to implement PROMs in their own practice were approached. This enabled the research to draw on both practical and aspirational perspectives regarding PROM use in cancer services [12].

Interviews were conducted either face-to-face or via Microsoft Teams, depending on participant preference, and lasted an average of 26 min. Interviews were audio-recorded, transcribed verbatim, and subsequently reviewed for accuracy.

A deductive thematic analysis approach was employed, with coding guided by the CFIR domains. NVivo software was utilised to manage and organise the data. Coding followed an iterative process, with the codebook revised as new insights emerged. The final analysis focused on identifying key barriers and facilitators to PROM implementation, with a particular emphasis on themes related to sustainability, scalability, and patient and provider engagement. The information power model was employed in the planning of this study to estimate that at least 10 interviews would be required to sufficiently address the study aim and comprehensively identify the contextual factors affecting implementation at this site [13]. Data collection continued until 14 interviews had been conducted and theoretical saturation had been achieved, as indicated by the absence of any new insights from three successive interviews.

2.2. Quantitative evaluative questionnaire (patients)

An evaluative questionnaire was developed using the Grid-Enabled Measures Database (GEM) to capture patient perspectives on acceptability, appropriateness, and feasibility of the routine PROM collection [14]. The questionnaire was distributed to patients electronically via REDCap (https://projectredcap.org/) or by post, depending on their preference, 12-months following completion of radiotherapy and responses were analysed descriptively using Microsoft Excel. Adoption, or compliance, was evaluated from the provider perspective; the uptake of patients at each follow-up timepoint was assessed at the patient and population level in terms of compliance to the implementation schedule of completion of the PROM, and stratified by patient characteristics such as age, ethnicity and socioeconomic status.

3. Results

3.1. Qualitative interview study

In total, 22 healthcare professionals at Guy's Cancer Centre were approached, and 14 participated in interviews. Of the fourteen participants, all held formal positions within the Cancer Centre: nine of the participants were clinicians *(4 x Consultant Clinical Oncologists specialising in the treatment of prostate cancer, 1 x Consultant Haematologist, 2 x*

Consultant Medical Oncologists specialising in the treatment of hepatobiliary cancers, 1 x Consultant Clinical Oncologist specialising in the treatment of gastrointestinal cancers, and 1 x Clinical Oncology Specialist Registrar working in the lung cancer setting), two were radiographers, two held management positions, and one was a clinical nurse specialist working in the prostate cancer setting specifically.

The major findings are presented, according to CFIR domain and construct, in Table 1.

3.2. Patient-level barriers

Several patient-related barriers impacting the sustainability and scalability of routine PROM implementation were identified during the semi-structured interviews with healthcare professional stakeholders. Digital illiteracy emerged as a prominent barrier, particularly with regard to older adults and patients from socioeconomically disadvantaged or minority ethnic backgrounds. Interview participants highlighted that these groups may experience significant difficulties engaging with electronic PROM (ePROM) completion and raised concerns about the potential for programmes solely offering ePROMs to inadvertently reinforce existing health inequalities.

These perceptions were further supported by data from the implementation pilot. Among the recruited prostate cancer patients, 40 % were classified as having low socioeconomic status, and 30 % identified as belonging to a minority ethnic background. Furthermore, 25 % of participants lacked access to the necessary digital infrastructure to complete PROMs electronically and were therefore reliant on paper-based questionnaires.

Healthcare professional stakeholders also reported that limited patient understanding of the purpose and value of PROMs contributed to low levels of motivation and inconsistent engagement. In some cases, patients were described as feeling overwhelmed by the volume of information provided during the course of their cancer care, which may further hinder adherence to PROM completion. These barriers were further reflected in the variability of compliance rates observed across different timepoints during the implementation attempt.

3.3. Provider-level barriers

A further issue which emerged during the qualitative study was the limited training and understanding among clinicians on how to integrate and use PROM data in practice. A participant expressed the need for additional education on PROM utilisation among staff. The high turnover and shortage of staff at Guy’s Cancer Centre exacerbated these challenges, as recruitment and retention were described as “fundamental barriers”. Furthermore, ensuring staff engagement was seen as essential for successful PROM implementation, with one interviewee stressing that any staff interacting with patients should be involved in the process. However, there was a perceived lack of understanding and commitment among some stakeholders regarding the purpose and value of PROMs.

Another key provider-level barrier identified was the absence of clearly defined roles and responsibilities related to the collection, review and utilisation of PROM information which contributed to inefficiencies. Interviewed healthcare professionals noted that without established workflows and accountability, PROMs risked being underutilised or inconsistently administered. In particular, they emphasised the need for clarity around who would be responsible for following up with patients who had missing PROM data, and who should interpret the data and communicate results back to the patient and clinical teams. This lack of clarity was identified as a core barrier impacting the sustainability of routine PROM collection. A broader cultural shift was therefore identified as a necessity to empower all staff involved in the clinical setting, from administrators to clinicians, to understand their specific responsibilities and how they contribute to the overall workflow. Addressing this barrier was identified as critical to embed PROMs into

Table 1

Major barriers & facilitators reported from qualitative interview study with healthcare professionals and key stakeholders at Guy’s Cancer Centre.

CFIR domain	Barriers & facilitators to implementation	Key quote(s)
Innovation domain - Adaptability	• The implementation process will need to be adapted to enable scale-up across Guy’s Cancer	"when you roll it out it’s going to be a very big scale number of patients, hopefully we’ll get that all worked out electronically and there will be some kind of way to highlight that to make that a bit less labour intensive" "I think when it gets rolled out, all tumour groups need somebody in a full time post to be doing it"
Outer Setting - Local Conditions	• The implementation process will need to be aligned across the Hospital sites which collectively form the South East London Cancer Alliance (SELCA), tumour types and treatment modalities • It is unclear what the impact of roll out of the new electronic health record platform will be on routine PROM collection	"kind of being really aware of what patients are also receiving outside of this particular service is really, really important, which is another…It would be different for different patient groups particularly with comorbidities and things like, people are in all different sorts of different departments at the same time" "Do we as an organisation want something that talks to EPIC? Probably"
Outer Setting - External Pressure	• The clinical teams implementing the routine collection of PROMs have many competing time demands	"In terms of clinician collecting them, this all comes down to time doesn’t it" "I guess for for clinicians the key things is is getting support in time to read the the PROMs and act on the PROMs"
Outer Setting domain - Performance-Measurement Pressure	• The routine PROM collection process needs to be aligned with national and international policy	"Yeah and it is, it can be used, it’s not just I guess for like patient level, informing clinical consultations but also kind of use patient aggregated data to inform local and national guidelines" "We do, we have use it nationally and internationally"
Inner Setting domain - Work Infrastructure	• It is perceived that the implementation will result in an increase in workload of clinical teams	"Introducing PROMs is not going to reduce workload. It’s gonna increase work it, it’s potentially going to increase workload" "I think as soon as clinicians get the feeling that this is creating more work, then engagement drops"
Inner Setting domain - Access to Knowledge & Information	• Healthcare professionals lack knowledge on how to implement and/or utilise PROMs	"So I think some general education to start with and understanding what a PROM is yeah, what a PROM is would be the starting point" "But the bit that I think is lacking at the moment is a general education of the use of PROMs"
Inner Setting domain - Available Resources	• Lack of resource available to ensure compliance across each follow-up timepoint	"I think one thing is going to be compliance, we’re going to the patients to

(*continued on next page*)

Table 1 (*continued*)

CFIR domain	Barriers & facilitators to implementation	Key quote(s)
		complete it and I can't say at this stage, they've all agreed to it, they're all going to actually send those questionnaires back, and send them back in a timely manner"
Inner Setting domain - Information Technology InfrastructureI	• Implemented PROM eplatforms are unable to be integrated with electronic health records	"And as I said before, ideally it should be integrated into our electronic note system"
Individuals domain - Innovation Recipients	• Proportion of patients are digitally illiterate • Health inequality: certain demographics of patients experience difficulties with completing PROMs • Patient disability impacting ability to complete PROMs • Patient burden	"there's language barriers, people who might be hard of hearing, or struggle to access the technology, or don't have any of that support at home yeah I guess issues around reading and that kind of thing" "then I think that we will have a problem especially in our area with the demographic that we have, with some patients not having access to um to tablets etcetera to complete them" "You know that we we inundate them with information time after time. So I think that could that could have an implication on take up"
Individuals domain - Capability	• Lack of patient understanding	"So patient information is pretty pivotal in education"

routine practice and facilitate their sustained use.

3.4. Administrative-level barriers

Administrative challenges, including logistical and funding issues, also affected the sustainability of routine PROM collection. Although the implementation pilot was conducted at Guy's Cancer Centre (Guy's and St Thomas' Trust (GSTT)), SELCA comprises multiple hospital sites situated across South East London. The healthcare professional stakeholders noted that patients often receive care at different hospital sites within this network during their cancer journey, necessitating alignment of PROM collection efforts. Furthermore, interview participants highlighted the importance of reducing the burden on patients, with one clinician describing the idea of frequent PROMs as excessive. Moving forward, and to ensure the sustainability and scalability of this implementation, healthcare professional stakeholders emphasised the need for coordination across SELCA sites to align PROM initiatives, minimise patient burden, and establish common PROM administration schedules.

3.5. System-level barriers

The lack of interoperability between platforms like REDCap (used for ePROMs) and the electronic health record (EHR) systems complicated data collection. The introduction of a new centralised system, EPIC, in April 2023 added further uncertainty, with participants expressing concerns about how PROMs would be affected by this change. The IT department's prioritisation of the EPIC rollout delayed the integration of REDCap's interoperability features, creating a disconnect between systems and limiting the efficacy of PROM collection.

4. Quantitative evaluative questionnaire

Of the 20 PCa patients who participated in the implementation pilot, 10 completed the quantitative evaluative questionnaire (50 %).

4.1. Patient-level barriers

A significant portion of patients faced challenges regarding access to support and understanding the purpose of PROMs. Of the 10 who completed the evaluative questionnaire, 9 had opted for electronic administration of the PROM. While 9 (78 %) of the patients who completed PROMs electronically found the platform easy to access via an email link, and 6 (67 %) found it easy to navigate, 7 (70 %) reported they would not know whom to contact if they encountered issues with the questionnaire's content, language, or format. Compliance rates also highlighted patient-specific barriers; only 59 % of patients completed PROMs as scheduled across all timepoints, with some patients consistently failing to complete follow-ups.

Additionally, demographic variations were observed, with Black men demonstrating lower compliance (40 % at 6 weeks and 20 % at 6 months) compared to White men, who showed a compliance rate of 64.3 % at 6 weeks, increasing to over 78 % by the 6-month and 1-year marks. Age-related differences also emerged, with older patients (aged 60–84) showing higher compliance than younger patients.

4.2. Provider-level barriers

Clinical/administrative support was a potential gap identified by patients, with many unsure whom to contact for assistance with completing PROMs. This indicates a need for providers to be more accessible and to clearly communicate available support channels. Additionally, 89 % of patients expressed that an educational tool would help them understand the purpose and role of PROMs in their care. This suggests that provider-led initiatives to educate patients could enhance PROM engagement and improve compliance rates over time.

4.3. Administrative-level barriers

The administration of PROMs was another area of concern, particularly around the timing and frequency of follow-ups. Although 40 % of patients felt that the follow-up schedule was adequate, 60 % indicated that PROMs were not administered frequently enough, with most patients preferring a schedule of every three to six months, while only a few preferred monthly follow-ups. These preferences highlight the importance of aligning administrative scheduling practices with patient expectations to maintain engagement and improve compliance.

4.4. System-level barriers

System-level enhancements were suggested, particularly around educational tools that could be implemented to increase PROM compliance. Of the patients who felt an educational resource could be beneficial, 45 % preferred an online video format, and 44 % favoured a printed leaflet. An additional 11 % suggested a dedicated website or webpage for information on PROMs. These tools could address systemic gaps in patient understanding and engagement by providing accessible, comprehensive information across multiple platforms.

5. Discussion

The findings from this study highlight several critical barriers to the routine implementation and scale up of PROMs in cancer care, particularly at Guy's Cancer Centre. Addressing these barriers through strategic interventions will not only facilitate the successful adoption of prostate PROMs but also form the basis of scale up to other hospital sites and across tumour types enhancing patient-centred care, and the evaluation of patient care [15].

Findings from both the quantitative survey and qualitative interviews observed comparable emerging concerns between both patients and healthcare professionals, reinforcing the value of this mixed methodological approach [16]. Key intersecting barriers included: the need for defined roles and responsibilities to support routine PROM collection, interpretation, and communication; the necessity of tailored educational tools to improve engagement among both patients and healthcare professionals; and the value of establishing clinically meaningful thresholds to ensure PROMs can inform clinical practice.

While the majority of patients reported no issues with completing PROMs, 70 % indicated uncertainty about who to contact for help highlighting a gap in visible support structures. This aligns with insights from healthcare professionals, who identified during the qualitative interviews the absence of defined roles and responsibilities in PROM delivery as a core provider-level barrier. Both patients and healthcare professionals also emphasised the need for tailored educational resources; patients suggested tools such as online videos and printed materials, while clinicians advocated for dynamic and ongoing role-specific training. These findings support the importance of a coordinated, multi-level approach to routine PROM implementation, and align with other UK initiatives such as the routine clinical implementation of ePROMs at the Christie NHS Trust [17]. Their work, in the lung and head & neck cancer settings, identified the need for defined clinical pathways, dedicated staff roles, and training to empower all stakeholders and facilitate routine PROM data use.

The lack of clinical awareness on how to interpret and apply PROM data also emerged as a barrier to successful PROM implementation. Without clear guidance on how PROM data should inform clinical management, there is a risk that PROMs are administered purely as a bureaucratic exercise, with little discernible benefit for patients or clinicians. Although minimally important differences (MIDs) have been defined for the EPIC-26 PROM, and can be used to interpret changes in PROM scores over time, their utility in routine clinical practice is limited by the need for complete longitudinal data which can be compromised by patient non-compliance or loss to follow-up. This limitation further underscores the need for definition of interpretative frameworks and actionable cross-sectional thresholds that can support clinical decision-making even in the presence of incomplete data. This finding aligns with other literature demonstrating the clinical value of integrating PROMs routinely in cancer settings to facilitate shared decision-making, identify unmet need and guide timely intervention [18–20].

Infrastructure and staffing issues also emerged as critical barriers in this study. Staff shortages, limited clinical time, and fragmented workflows impacted PROM implementation, aligning with findings from wider studies [21–23]. Practical solutions, such as the provision of administrative support staff, the installation of devices to collect PROMs in waiting areas, and offering in-person assistance, emerged as strategies to alleviate burden and support patients with lower digital or health literacy. These strategies further highlight the need for targeted investment and resource planning to ensure PROM delivery is both equitable and scalable across diverse healthcare settings.

These strategies—enhanced patient education, establishment of thresholds for clinical importance, dedicated staffing, ongoing professional training, and structural adjustments—are essential for overcoming barriers to PROM implementation. By embedding these approaches within cancer policy, PROMs can be integrated successfully into routine care, facilitating more responsive, patient-centred healthcare systems.

6. Strengths and limitations

A major strength of this study relates to its mixed-methods design, which enabled a comprehensive evaluation of the barriers and facilitators impacting routine PROM implementation across multiple levels. By integrating qualitative insights from healthcare professionals with quantitative feedback from patients, this study provides a comprehensive understanding of both practical/logistical challenges and stakeholder perceptions. This methodological triangulation strengthens the reliability of findings and offers valuable, context-sensitive recommendations for embedding PROMs into clinical workflows. Furthermore, the use of the CFIR framework ensured a systematic exploration of implementation determinants relevant to both policy and practice.

Another further strength refers to this study’s setting within a large NHS Cancer Centre that serves a diverse and socioeconomically varied patient population. The setting of this study enhances the relevance of the findings for other similar Cancer Centres aiming to deliver equitable, patient-centred care. While local context is critical, the methods used in this evaluation can be translated to other sites considering routine implementation to identify context-specific barriers.

Additionally, the small sample size of patients who completed the quantitative evaluative questionnaire limits the breadth of patient perspectives captured, particularly regarding PROM preferences and experiences across different age, ethnic, and literacy groups.

7. Conclusions

In conclusion, addressing the barriers to implementing routine PROM collection requires a multi-level strategy focused on patient support, provider training, administrative alignment, and system-level adjustments. Key interventions such as enhancing patient education through online videos, printed leaflets, and dedicated informational websites can bridge the gap in patient understanding and access to support, thereby improving compliance. Additionally, establishing clear clinical thresholds for PROM interpretation, regardless of missing data, would enhance the utility of PROMs in individualised patient care. Future work should focus on creating dedicated roles to support PROM administration and data management, alleviating provider workload, and ensuring sustainability. Integrating ongoing training for staff and implementing practical resources like iPads in waiting rooms will accommodate patients with varying levels of digital literacy, further promoting equity in care delivery. Through these targeted strategies, PROMs can become a foundational component of patient-centred care, driving improvements in clinical outcomes and patient engagement in cancer care.

CRediT authorship contribution statement

J. Malpass: Data curation, Resources, Writing – review & editing. **A. Aggarwal:** Formal analysis, Writing – review & editing, Conceptualization, Validation, Methodology, Supervision. **M. Van Hemelrijck:** Conceptualization, Supervision, Methodology, Formal analysis, Validation, Investigation, Writing – review & editing. **L. Fox:** Writing – review & editing, Methodology, Formal analysis. **T. Guerrero-Urbano:** Conceptualization, Writing – review & editing, Methodology, Supervision. **Moss Charlotte L:** Formal analysis, Validation, Data curation, Project administration, Investigation, Writing – original draft, Conceptualization, Methodology, Writing – review & editing.

Declaration of Competing Interest

The authors have declared no conflicts of interest.

Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.jcpo.2025.100618.

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