

Determinants of ePROM Implementation and Scale-Up in Routine Care across a Universal Healthcare System: A Retrospective Population-Based Observational Study

Maria-Mercedes Nogueras

Fundació TIC Salut i Social

Marina Ramiro-Pareta

Fundació TIC Salut i Social

Xavier Alzaga

Institut Català de la Salut

David López

Institut Català de la Salut

Júlia Folguera

Catalan Health Service

Gerard Carot-Sans

Catalan Health Service

Alba Jiménez-Rueda

Fundació TIC Salut i Social

Francisco Lupiáñez-Villanueva

PredictBy

Laura Pinna

Dedalus Italia S.p.A

Davide Guerri

Dedalus Italia S.p.A

Aron Szpisjak

Copenhagen Institute for Futures Studies

Oscar Solans

Institut Català de la Salut

Peter Adal

Copenhagen Institute for Futures Studies

Giuseppe Fico

Universidad Politécnica de Madrid

Jordi Piera-Jiménez

jpiera@ticsalutsocial.cat

Fundació TIC Salut i Social

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Abstract

Background

Electronic patient-reported outcome measures (ePROMs) are complex digital health interventions that integrate patient-reported data into clinical decision-making and healthcare evaluation. Although ePROM implementation has been widely studied in disease-specific and single-site settings, evidence on large-scale implementation across healthcare systems remains limited because of its complexity. This study evaluated the system-wide implementation of ePROMs in a universal public healthcare system and analysed multilevel determinants associated with professional adoption and patient completion patterns.

Methods

We conducted a retrospective population-based observational study using linked routinely collected administrative and registry data from the Catalan public healthcare system (Spain) between November 2022 and November 2024. Implementation dynamics at system level and implementation-related outcomes at professional and patient levels (prescription intensity, overall completion, and patient-managed digital completion) were examined using an implementation outcomes perspective together with a CFIR-informed approach to classify multilevel determinants. Prescription intensity was analysed using multivariable negative binomial regression, whereas completion behaviour was analysed using multivariable logistic regression.

Results

Over two years, 789,294 ePROMs across 42 instruments were prescribed to 417,051 patients by 11,094 professionals. Completion reached 78.5%, with response rates stabilising above 75% shortly after rollout. Adoption followed a diffusion pattern, with acceleration coinciding with training and system integration milestones. Professional role showed a stronger association with prescription than individual demographics, particularly among physiotherapists, dietitians, and community wellbeing professionals working in structured care programmes. At the patient level, the number of ePROMs prescribed per patient showed the strongest association with completion behaviour. Socioeconomic and clinical factors had modest associations with overall completion but stronger association with patient-managed digital completion.

Conclusions

Large-scale ePROM implementation appears feasible within a universal healthcare system when integrated into existing workflows and supported by organisational and technical readiness.

Organisation context and intervention-related factors showed stronger associations with adoption and completion than most individual demographic characteristics. These results underscore the central role of workflow integration, and implementation design in scalable and equitable ePROM implementation.

Contributions to the literature

- This study provides real-world system-level evidence on the large-scale implementation of ePROMs within a universal public healthcare system.
- Professional role and how ePROMs were integrated into routine workflows were more strongly associated with the intensity of ePROM use than individual demographic characteristics.
- Different factors influence overall completion and patient-managed digital completion. The number of ePROMs prescribed to each patient was the factor most strongly associated with both measures, although in opposite directions.
- Patient demographic and socioeconomic characteristics showed weaker associations with patient completion measures than organisational and design factors, suggesting that equitable implementation may be achievable through appropriate service design.

Background

Healthcare systems are increasingly shifting towards a patient-centred model of care. Patient-Reported Outcome Measures (PROMs) are important instruments in this transformation as they recognise patients as experts in their own health and integrate patient-reported data into clinical decision-making and healthcare system evaluation. PROMs are concise, standardized questionnaires that capture patients' self-reported data on health outcomes, quality of life, and care experience, without requiring clinical input or interpretation.¹⁻⁷ They integrate the patient perspective into shared decision-making, quality assessment, and service improvement.^{1,2,6,7} Completing PROMs also promotes patient awareness of their health and encourages patients to become active agents in managing their care.^{7,8} Clinically, PROM use has been associated with shorter consultations, improved communication, better diagnosis and symptom management, fewer emergency visits, enhanced adherence, and improved outcomes, including survival and quality of life.^{4,5,7,9}

The development of digital tools has enabled the effective use of PROMs in clinical practice by allowing data collection through internet-connected devices, either at the point-of-care or remotely and integrating responses into electronic health records (EHR).^{2,6,10} Electronic PROMs (ePROMs) facilitate usability, increase completion, reduce data entry errors or missing information, and provide real-time data to healthcare professionals alongside other clinical information.^{5,11,12} As a result, ePROMs enhance decision-making, patient follow-up, and care management, and allow more accurate predictions of survival and treatment-related outcomes. They also reduce consultation time and costs, increase patient satisfaction, and enable secondary use of data.^{5,6,10,13} However, the implementation of ePROMs in routine clinical practice remains challenging, facing barriers such as the digital divide, organisational

constraints, workflow misalignment, professional and patient burden, and limited contextual adaptation.^{6,9,12,13}

Scaling ePROMs beyond pilot initiatives into routine practice across entire healthcare systems represents a complex implementation challenge. In 2022, the Catalan healthcare system implemented a system-wide ePROM programme through a three-phase rollout: (1) initial use and validation by a centrally coordinated implementation support team (November 14 to December 14, 2022); (2) a pilot in 11 selected primary care centres using four ePROMs (December 15, 2022 to February 21, 2023); and (3) progressive system-wide implementation across primary care and hospital services (from February 22, 2023). Implementing ePROMs at a system-wide level is more complex than deploying them in isolated settings or within specific health conditions, but it provides strategic insights for understanding real-world implementation processes and adoption dynamics. Although there is considerable literature on ePROM implementation in specific contexts, system-level evaluations of large-scale implementation remain scarce.^{4,9,12} Furthermore, most ePROM implementation studies have been conducted in specialised care settings, whereas primary care is expected to encompass a much broader and more diverse patient population.⁶

This study aims to evaluate the large-scale implementation of ePROMs within the Catalan public healthcare system by describing system-level implementation dynamics and analysing professional- and patient-level determinants associated with ePROM prescription and completion, providing real-world evidence to inform implementation and scale-up in healthcare systems.

Methods

Study design, setting, and data sources

This retrospective population-based observational study examined the large-scale implementation of the ePROMs programme integrated into routine clinical care within the Catalan public healthcare system, using routinely collected administrative and population-level registry data. The Catalan public healthcare system provides universal healthcare coverage to approximately 8 million people through the Catalan Health Service, the sole public healthcare insurer in the region. Healthcare is publicly funded across all levels of care, including primary care (369 facilities), specialised care (69 facilities), intermediate and long-term care (96 facilities), and mental health care (42 facilities).¹⁴ To examine implementation dynamics, the study included three analytical components: (1) description of the implementation and scale-up of ePROM use over time; (2) professional-level factors associated with prescription; and (3) patient-level factors associated with completion behaviour.

The study period was defined separately for each component. For the description of ePROM implementation, the period covered November 16, 2022, to November 15, 2024. For the analyses of professional- and patient-level determinants, the period was restricted to November 1, 2023, to October 31, 2024. Separate analysis periods were defined to account for key system features affecting the study

objectives. These included full integration of ePROMs into both primary care and hospital information systems, automated patient reminders (sent on days 7, 14, and 3 days before ePROM expiry, which occurred 30 days post-prescription), and the availability of the electronic patient portal of the Catalan healthcare system (*La Meva Salut – My Health*) for remotely completion.¹⁴ The study population included all healthcare professionals prescribing ePROMs and all patients receiving at least one ePROM during the study period. These populations were identified directly from the ePROM registry using records of ePROM prescription and completion.

Data were collected from the following sources: (1) ePROMs registry: data on ePROM prescription and completion; (2) Healthcare professional registry: information on healthcare professionals' roles and work settings, linked with ePROMs registry through an anonymised healthcare professional identifier; (3) Healthcare provider registry: a catalogue of healthcare centres, primary care teams, and territorial organisational features, linked with ePROMs registry through provider code; (4) Statistical Institute of Catalonia (Idescat): information on territorial socioeconomic index (TSI), linked with ePROMs registry through healthcare area code;¹⁵ (5) Catalan Health Surveillance System, linked through anonymised patient identifier. This is a comprehensive automated administrative database containing validated individual-level data on diagnoses, healthcare utilisation, mortality, and sociodemographic characteristics.¹⁴

Implementation Determinants and Variables Definition

Implementation-related constructs and outcomes were interpreted using concepts derived from implementation outcomes frameworks, while CFIR-informed domains were used to classify available multilevel determinants.^{16–18} Because the study relied on routinely collected administrative and registry data, these constructs were operationalised using observable proxy indicators derived from structural, sociodemographic, clinical, and workflow-related variables available across the healthcare system.

The study examined system-level implementation dynamics together with implementation-related outcomes at system, professional and patient levels: (1) rollout and scale-up of ePROM use over time; (2) professional adoption, operationalised as prescription intensity among prescribing professionals; and (3) patient participation and completion patterns, operationalised through responder status and patient portal use. These outcomes were selected because they could be consistently identified and analysed using routinely collected administrative and registry data across the healthcare system.

Healthcare professionals were the unit of analysis for prescription models, whereas patients were the unit of analysis for completion models. Prescription intensity was defined as the crude number of ePROMs prescribed per professional. Because the total number of professionals potentially eligible to prescribe ePROMs could not be reliably identified across all settings, professional adoption was operationalised through prescription intensity among professionals who used the system, rather than through adoption rates based on an eligible denominator. Responder status, used to analyse overall

completion, was defined as the completion of $\geq 80\%$ prescribed ePROMs. This threshold was selected to identify sustained completion across prescribed ePROMs while allowing comparability between patients with different prescription volumes. Since response rates are mathematically constrained by the number of prescribed ePROMs, this was explicitly considered in subsequent descriptive and multivariable analyses. Because the implementation process incorporated within the registry a variable distinguishing remotely patient-managed digital completion through patient portal from ePROM registration during care encounters, a more detailed characterisation of completion behaviours was possible. Therefore, a second model specifically evaluating patient-managed digital completion was performed. In this model, patient portal use was defined as completion of at least one ePROM through the patient portal. Table 1 summarizes the implementation-related constructs examined in the study, their operationalisation through observable proxy indicators, and the CFIR-informed determinant domains explored.

Table 1

Implementation-related constructs, observable proxy indicators, and CFIR-informed determinant domains examined in the study.

Implementation construct/outcome	Observable proxy indicator used in this study	Level of analysis	Rationale/interpretation	Related determinant domains explored
System-level rollout and scale-up	Temporal evolution of ePROM prescriptions	System	Captures diffusion and expansion of ePROM use across the healthcare system during implementation	Not modelled
Professional adoption	Prescription intensity (number of ePROMs prescribed per professional)	Professional	Reflects the extent to which professionals incorporated ePROMs into routine practice *	Characteristics of Individuals; Inner Setting; Outer Setting
Patient participation	Responder status ($\geq 80\%$ of prescribed ePROMs completed)	Patient	Reflects sustained participation across prescribed ePROMs	Outer Setting; Intervention Characteristics
Patient-managed digital completion	Completion of ≥ 1 ePROM through the patient portal	Patient	Reflects use of the intended patient-managed digital pathway and may represent one observable dimension of adherence to the digital implementation model	Outer Setting; Intervention Characteristics

* Professional adoption was operationalised as prescription intensity among ePROM users, as an eligible denominator was not available.

CFIR-informed domains potentially associated with these outcomes included Characteristics of Individuals (healthcare professional demographics and professional role), Inner Setting (organisational and contextual characteristics), Outer Setting (patient sociodemographic and clinical context), and Intervention Characteristics (features related to ePROM workflows and proxy indicators of response burden, operationalised primarily through the number of ePROMs prescribed per patient). Process-related constructs were not directly assessed because administrative data did not capture implementation activities such as planning, facilitation, champions, adaptation, or reflective evaluation. Given the constraints of routinely collected administrative data, CFIR-informed domains were adapted pragmatically to reflect the available determinants. Although professional category was operationally classified under Characteristics of Individuals, it may also act as a proxy for organisational role, workflow structure, and integration into specific care programmes.

Professional experience was estimated from the date of official professional registration and categorised into career stages: Newcomer (0–4 years), Early career (5–14 years), Consolidated (15–24 years), Senior (25–34 years), and Veteran (≥ 35 years). Age was grouped into five categories (≤ 29 , 30–39, 40–49, 50–59, and ≥ 60 years). Patients' socioeconomic status was assessed both at the territorial level using the TSI and at the individual level using the individual socioeconomic status (ISS). TSI summarises the territorial socioeconomic profile based on six indicators: employment rate, average annual income, the proportion of low-skilled workers, individuals with low educational attainment, individuals without post-compulsory education, and residents from low- or middle-income countries. In Catalonia, the TSI ranges from 61.0 to 133.3 and was analysed using quintile-based categories.¹⁵ ISS derived from pharmaceutical co-payment categories within Catalan healthcare system: high ($> \text{€}100,000$ annual income), medium ($\text{€}18,000\text{--}100,000$), low ($< \text{€}18,000$), and very-low (co-payment exempt). The Adjusted Morbidity Groups (AMG), used to account for clinical complexity, assigns a numerical score to each individual, based on their multimorbidity burden, incorporating all chronic conditions and recent acute events, and classifies the population into health risk groups.¹⁹

Statistical methods

A time-series plot was generated to visualise the daily number of ePROMs prescribed, with a 7-day moving average added to smooth short-term fluctuations. Prescribing trends were further described by thematic area and professional category. Response rate, defined as the percentage of prescribed ePROMs completed, was analysed by individual ePROM, thematic area, and completion workflow. Thematic area was defined by the primary clinical or psychosocial focus of the ePROM.

For professional-level analysis, we applied the non-parametric Mann–Whitney U test for bivariate analyses of dichotomous variables because of the skewed distribution of the number of ePROMs prescribed per professional. When applicable, post-hoc pairwise comparisons were performed using Dunn's test with Bonferroni correction. Effect sizes were estimated using Cliff's delta, interpreted as negligible ($|\delta| < 0.147$), small ($0.147\text{--}0.33$), medium ($0.33\text{--}0.474$), or large (≥ 0.474). Independent

associations were assessed using a multivariable negative binomial regression model fitted on complete-case data.

For patient-level analyses, we summarised the number and percentage of patients, median response rates, and the percentage of responders for each characteristic. Given that the number of prescribed ePROMs mathematically constrains the possible response rate values (e.g. only 0% or 100% for patients prescribed a single ePROM), patients were stratified into four groups according to the number of ePROMs prescribed (1, 2, 3–5, and ≥ 6). For the same reason, median response rates were reported for descriptive purposes but not used in subsequent analyses, which were focused on responder status. Independent associations for overall completion and patient portal use were assessed using two separate multivariable logistic regression models fitted on complete-case data.

Care setting was not included in any multivariable analysis due to limited variability, as more than 98% of professionals and 99% of patients were based in primary care. Collinearity was evaluated in all multivariable analysis using adjusted generalised variance inflation factors ($\text{GVIF}^{(1/(2 \cdot \text{df}))}$), with values < 2 considered negligible, 2–5 acceptable, > 5 moderate, and > 10 severe.

All analyses were performed using R software version 4.1.2. Prior to analysis, datasets were reviewed for consistency, duplicate records, missing values, and implausible observations. Statistical significance was set at $p < 0.05$.

Results

Description of ePROM prescription and completion over time

Between November 16, 2022, and November 15, 2024, a total of 789,294 ePROMs were prescribed across 42 distinct questionnaires (**Table S1, Supplementary material**). Prescriptions increased over time, with an acceleration from the second quarter of 2023 onwards, coinciding with the start of professional training activities (Fig. 1A). Most ePROMs (99.6%) were prescribed in primary care. Information on professional and patient gender was available for 87.1% and 49.7% of ePROMs, respectively. Among these, women accounted for 83.1% of recipients of prescribed ePROMs and 57.1% of completed ePROMs. Professional category was available for 67.5% of ePROMs, with nursing professionals prescribing the majority, and prescription trends similar across categories (Fig. 1B).

The distribution of ePROM prescriptions varied across thematic areas, reflecting heterogeneous uptake of the different instruments within routine clinical practice (Fig. 2A). Addictions and substance use accounted for the largest share of prescriptions (37.6%), followed by general quality of life, mental health and emotional well-being, perceived social support, and pain-related conditions. Figure 2B shows monthly prescription patterns by instrument and thematic area. While some instruments within a

thematic area showed widespread and continued uptake across the study period, others remained marginal or declined after initial adoption.

In total, 619,261 ePROMs responses were recorded (78.5% of those prescribed). The monthly response rate initially fluctuated between 60% and 70% and stabilized around 75%–80% from mid-2023 onwards (Fig. 3A). Following the activation of the patient portal in June 2023, 65,148 responses were completed through this channel, representing 12.1% of those prescribed from that date onwards. Response through the patient portal increased modestly during the initial months and subsequently stabilized at low levels (Fig. 3A).

Average response rate by thematic area ranged from 85.6% in *Perceived social support* to 6.6% in *Oncology* (Fig. 3B). Patient completion also varied across instruments within thematic areas. For example, within the addictions domain, AUDIT-C achieved a response rate of 81.8%, whereas AUDIT (pregnancy) reached 16.9%. Similar contrasts were observed in mental health (SWEMWBS 79.1% vs DME-C 16.0%) and gastrointestinal instruments (EAT-10 68.6% vs IBD-Control 20.3%). Patient-managed digital completion through the patient portal also varied widely across instruments, ranging from below 5% to above 85%. Detailed results for all instruments are provided in **Table S1**.

Professional-level factors influencing ePROM prescription

Between November 1, 2023, and October 31, 2024, 685,130 ePROMs were prescribed by 11,094 professionals. The number of ePROMs prescribed per professional ranged from 1 to 2,937, with a median of 13 (IQR: 3–55), showing a right-skewed distribution (Fig. 4A). Professionals had a mean age of 43.3 years (SD 11.2; range: 21–69) and a mean experience of 17.5 years (SD 11.1; 0–45). The mean TSI of the prescribing area was 98.7 (SD 12.9; 61.0–133.3).

Professional characteristics and the distribution of ePROM prescriptions per professional are summarised in **Table S2 (Supplementary material)**. Prescription intensity varied across professionals and contextual characteristics. Lower prescription volumes were observed among male professionals, those aged ≥ 60 years, and professionals at the earliest and latest career stages. Higher volumes were found in very high TSI areas and rural settings. These variables showed negligible effect size (Cliff's delta), except rurality, which showed a moderate effect size ($\delta = 0.416$) (**Table S3, Supplementary material**). Comparisons by care setting and professional categories showed large effect size (**Table S3, Supplementary material**). Primary care was associated with higher prescription.

Differences in ePROM prescription volumes were observed across professional categories. Nursing staff and physicians, who represent the largest professional groups, accounted for the highest total number of prescriptions. In contrast, physiotherapists, dietitians/nutritionists, and Emotional and Community Wellbeing Referents (ECWR) showed the highest prescription intensity (Fig. 4B). The distribution of the number of ePROMs per professional across categories is further detailed in Fig. 4C.

In the multivariable negative binomial regression model, which analysed 7,519 professionals (67.78%), professional role showed stronger associations with ePROM prescription intensity than individual demographic characteristics alone (Fig. 5). In fact, female professionals prescribed significantly more ePROMs than males (IRR 1.15). Compared with professionals aged ≤ 29 years, all age categories showed higher prescription rates, particularly those aged 40–59 (IRRs 1.44–1.49). Professional experience was not significantly associated with prescription, although veterans (≥ 35 years) showed a non-significant tendency towards lower rates (IRR 0.81, 95% CI 0.65–1.01). Professionals working in urban areas prescribed fewer ePROMs than those in rural settings (IRR 0.84). Higher prescription rates were observed in medium and very high TSI settings (IRRs 1.20 and 1.60, respectively). Compared with nurses, physiotherapists (IRR 8.20), dietitians/nutritionists (IRR 3.75), and ECWR (IRR 3.60) showed higher prescription rates, while physicians prescribed fewer ePROMs (IRR 0.52). All adjusted GVIF values were < 1.4 .

Patient-level factors influencing ePROM completion

Between November 1, 2023, and October 31, 2024, 417,051 unique patients were prescribed ePROMs. Most received only one ePROM (66.8%), 19.6% two, 11.4% three to five, and 2.2% six or more (maximum = 35). Among all patients, 367,537 (88.1%) completed at least one ePROM, and 319,904 (76.7%) were classified as responders.

Patient characteristics and ePROM completion are summarised in **Table S4 (Supplementary material)**. Overall, median response rates and percentage of responders were highest when only one ePROM was prescribed and decreased progressively with increasing burden. Women comprised 56.8% of the population, increasing their proportion in higher-burden groups. Completion was similar between sexes at low burden, declining more in men at higher burden. The proportion of middle-aged patients increased with prescription load, whereas it declined for younger and older patients, who also showed the sharpest response rate drops beyond ≥ 3 prescribed ePROMs. Low and moderate risk AMG groups were most common, with moderate-risk patients increasing with ePROMs volume. Responders declined with burden across all AMG levels, particularly among very high-risk patients. Most patients belonged to intermediate ISS. The lowest categories showed reduced adherence across all prescription strata. Primary care accounted for almost all prescriptions and maintained the highest response rates. Urban patients predominated; response was similar across areas.

The multivariable logistic regression to identify factors associated with overall completion (Fig. 6A) included 324,418 patients (77.8%). Number of ePROMs prescribed per patient showed stronger associations with completion than demographics. Indeed, each additional ePROM reduced the odds of being a responder (OR 0.56). Female sex was associated with significantly higher odds of response (OR 1.17). Compared with children, young adults had significantly lower odds (OR 0.79), while other age groups did not differ. Patients with low-to-high AMG risk had slightly higher odds than those at baseline (ORs 1.04–1.09), whereas very high-risk patients did not differ. ISS showed weak and borderline associations. Compared to very low TSI areas, medium and high TSI areas were associated with lower

response (ORs 0.89 and 0.94), while no differences were observed for low and very high TSI. Urban residence was marginally associated with lower response (OR 0.98). No collinearity was detected (all adjusted GVIF < 1.1).

All patients were prescribed at least one ePROM after the patient portal became available. Among those who completed at least one ePROM, 31,623 (8.6%) used the portal at least once (**Table S5, Supplementary material**). The multivariable logistic regression to identify factors associated with use of the patient portal included 308,756 patients (74.0%) (Fig. 6B). Patient portal use was more likely among women (OR 1.12) and urban residents (OR 1.30). Compared to children, patients aged 15–64 had significantly higher odds (ORs 2.34–3.02), while those aged ≥ 80 had reduced odds (OR 0.61). Patients with moderate AMG index had the highest likelihood of portal use (OR 1.31), followed by those at low risk (OR 1.25) and high risk (OR 1.16). A socioeconomic gradient was observed: patients with low and very low ISS were less likely to use the patient portal (ORs 0.63 and 0.76, respectively), while those with medium ISS showed increased odds (OR 1.18). Higher TSI was associated with a greater patient portal use (ORs 1.22–1.37), while low TSI had reduced odds (OR 0.93). The number of ePROM prescribed per patient showed the strongest association with patient portal use: each additional ePROM increased the odds of portal use by 65%. No collinearity was detected (all adjusted GVIF < 1.05).

Discussion

This study provides one of the system-wide evaluations of ePROM implementation in a universal public healthcare system, linking system-scale rollout with professional use and patient completion behaviour. Health system-level ePROM implementation enables standardized data collection and comprehensive evaluation to inform national policy. However, examples of their systematic and widespread use remain scarce, partly because of the complexity of scaling across care settings and collecting large-scale data, compared with implementation within well-defined clinical contexts.^{4,9,12} By combining routinely collected system-wide administrative data across system-, professional-, and patient-level, this study offers a real-world evaluation of a large-scale ePROM implementation dynamics across an entire healthcare system.

Over two years, 789,294 ePROMs were prescribed, suggesting a diffusion pattern in which early adoption was followed by a broader uptake alongside system upgrades and rapid and continuous increases in prescription volume. The temporal increase in prescriptions coincided with the introduction of professional training activities, commonly described as implementation strategies that may facilitate adoption.^{5,8,11,20}

Primary care prescribed nearly all ePROMs during this period. This pattern likely reflected the phased rollout strategy, which leveraged existing workflow and technical integration conditions within primary care settings. In primary care, some PROMs had been already routinely used in paper-based before ePROMs implementation. The ePROM module was integrated into the same clinical workflow location previously used to access PROMs, potentially reducing disruption to routine practice and facilitating

uptake. In addition, primary care in Catalonia operates under a shared EHR infrastructure, which facilitated rapid large-scale integration of the ePROM programme. In contrast, implementation in hospital and other care settings required specific integration across multiple heterogeneous information systems.¹⁴ Together, these findings suggest that successful large-scale adoption of ePROMs may depend on compatibility with existing clinical workflows and technical integration capacity within routine care settings, as previously highlighted in literature.^{5,8,10,11,20} In addition, primary care professionals may also be more likely to adopt patient-centred digital tools because of patient proximity and their roles in chronic care, prevention, and education, as previously described.^{2,21,22}

Selecting instruments requires balancing diversity with usability. The most prescribed tools were related to addictions and substance use, quality of life, social support, and mental health. This aligns with evidence suggesting that ePROMs are more readily adopted in chronic and cross-cutting areas of care.²³ Within areas, while some instruments showed continued uptake throughout the study period, others remained marginal or declined after initial adoption, patterns that were not always explained by deployment timing alone. Despite differing rollout schedules, which could be a limitation, analysing individual adoption curves helped assess acceptability. Although instrument-level characteristics were not formally modelled, ePROMs combining brevity, strong validation, and clear clinical interpretability appeared to achieve greater uptake and completion consistent with previous studies.^{1,2,7,20,22,24,25} Interestingly, several instruments with high response rates were introduced later in the implementation period, suggesting again that increasing technological maturity and professional familiarity might facilitate adoption.^{5,8,10,11,20}

Adoption of ePROMs by professionals was broad (11,094 prescribers in one year) but right-skewed, with most prescribing few ePROMs and a small group accounting for most activity. This distribution is consistent with innovation diffusion patterns, where a relatively small group of highly engaged adopters accounts for a large share of implementation activity. Professionals' demographics played a minor role, with a modest gender effect. Women represented 83.2% and prescribed 15% more per professional, which could partially reflect both their predominance in the healthcare workforce and greater involvement in patient-centred and digital health practices, as it was previously described.^{21,26} Age and experience followed the inverted U-shape often described in digital adoption, where mid-career professionals combine experience with receptiveness to innovation;²¹ however, associations were not significant, except a borderline lower prescription volume among the most experienced professionals. Previous studies also reported limited or non-significance associations between professional age or experience and digital tool adoption.^{21,27}

Contextual factors showed stronger association with professional adoption. Urban professionals prescribed 16% fewer ePROMs, challenging common assumptions that rural settings lag in digital adoption. This finding aligns with previous evidence indicating that despite structural barriers often described in rural areas, uptake can remain high, possibly because of stronger patient-professional relationships, greater continuity of care, and the perceived usefulness of remote monitoring in

geographically dispersed populations.²⁸ Prescription intensity also varied according to territorial socioeconomic. Professionals working in areas with medium or very high TSI prescribed significantly more ePROMs than those in very low TSI areas. This suggests that ePROM adoption may be favoured in better-resourced territories, possibly due to stronger institutional support, local leadership, or infrastructure facilitating digital innovation. However, the absence of a linear gradient and the lack of association in low and high TSI groups suggest that other unmeasured local factors may also influence implementation dynamics.

Professional category was the strongest determinant of prescription intensity. Nurses accounted for 69.8% of prescribers, reflecting their workforce dominance, broader population coverage and roles in chronic care management and health promotion, which may facilitate the integration of digital tools supporting patient monitoring and empowerment.^{22,23,26,29} However, their moderate prescription intensity suggests that ePROMs may often be used opportunistically within routine consultations. Conversely, physiotherapists, dietitians/nutritionists, and ECWR showed higher prescription intensity despite their small workforce size. In the Catalan primary care system, these roles have been incorporated to deliver structured, group- and community-based programmes with predefined assessment workflows, which may facilitate more systematic integration of ePROMs into routine care. This suggests that professional category may partly capture differences in organisational workflows and integration into care programmes, beyond individual professional characteristics alone. These findings are also consistent with the high use and response rates observed for ePROMs such as SWEMWBS, Oslo-3, EQ-5D-5L, Roland-Morris, SPADI, NPQ, WOMAC, and PREDIMED.

At patient level, implementation achieved broad coverage and high completion rates, which are high compared with previous literature, particularly for a system-level deployment.^{3,9,13,30–32} However, beyond participation rates, understanding how ePROMs are completed, particularly the extent of patient-managed remote completion, is also important for interpreting implementation dynamics. In our study, the inclusion within the implementation process of a variable distinguishing different completion patterns enabled a more nuanced interpretation of patient participation and completion behaviours.

Our results showed that remote completion through the patient portal remained low. This pattern may partly reflect the implementation model itself. As described above, there had already been some questionnaires integrated into pre-existing primary care workflows and ePROMs module was integrated into the same clinical workflow location. Although this integration strategy may have facilitated adoption, professionals may also have continued administering instruments as previously, during care encounters, with the distinction that patient-reported response were entered into the EHR. While this approach preserves some advantages of ePROM, such as availability of structured real-time data, it may be less effective in preserving patient perspective, reducing professional workload, and minimising transcription errors or other biases associated with professional workflows.^{5,10,25}

Workflow integration alone is unlikely to fully explain the low levels of remote completion. Patient-level determinants may also influence the use of patient portal. Therefore, to better characterise patient

response patterns, we separately analysed overall completion and patient-managed digital completion. In addition, analyses of individual ePROM instruments showed variability in remote completion rates across questionnaires, suggesting that instrument-related characteristics may also play a role. Because patients could receive multiple types of ePROMs during the study period, instrument type could not be directly incorporated into the patient-level multivariable models.

Patient burden—such as stress, repeated visits or treatments, time-consuming questionnaires, or high prescription volume—has been identified as a key barrier to patient participation.^{9,33} Routinely collected administrative data allowed examination of one measurable dimension of response burden: the number of ePROMs prescribed per patient. This factor showed stronger association with patient completion behaviour, although in opposite directions: Each additional ePROM reduced response odds by 44%, while increasing patient portal use by 65%. This association may partly reflect a probabilistic effect, as prescribing more ePROMs increases the likelihood of completing at least one questionnaire through the patient portal. However, the findings also suggest that higher questionnaire burden may discourage overall completion, while favoring use of the patient portal.

Most patient characteristics showed modest associations with response but stronger patterns for patient portal use. Women were more likely to respond and use the patient portal and showed less pronounced burden-related declines when exposed to ≥ 3 ePROMs. This aligns with previous evidence describing greater participation in health-related and digital activities among women.^{3,30,34,35} Older patients maintained high participation despite requiring greater digital support, as patient portal use peaked between ages 15–64, whereas young adults showed lower response and sharper burden-related decline, possibly reflecting lower health awareness or lack of tailored formats.^{3,32,35} Contrary to some studies linking clinical complexity to lower adherence,^{3,32} higher morbidity did not appear to substantially limit completion in our cohort. Patients with low-to-high AMG index were more likely to respond than at very-low risk patients, possibly because of stronger clinical engagement. Indeed, multimorbidity has been described as an enabler of patient portal use.^{36,37} However, the most clinically complex patients showed lower completion, particularly under higher burden, and reduced patient portal use, suggesting a need for tailored support strategies for this subgroup.

Socioeconomic factors have often been described as barriers for adopting digital tools, including ePROMs.^{3,8,9,34,37} In this study, two socioeconomic dimensions were analysed: individual (ISS) and territorial (TSI). Collinearity diagnosis confirmed that they capture distinct aspects of socioeconomic context. ISS showed a weak and borderline associations with ePROM completion, whereas TSI had mild effects on response. Therefore, individual socioeconomic disadvantage may not necessarily limit patient completion when favourable healthcare contexts are present. Interestingly, both very-high and very-low TSI areas were associated with high response. This pattern may point to stronger professional-patient relationships and/or a greater likelihood of assisted completion. However, ISS and TSI were closely associated with patient portal use, suggesting that while centres in disadvantaged areas may partially offset inequalities through assisted completion, digital inequities may remain less effectively addressed.

Finally, rurality was slightly associated with higher response, possibly due to stronger professional-patient relationships in rural areas that enhance trust, continuity of care, and assisted completion.³⁸ However, rurality showed lower patient portal use, consistent with prior evidence on digital access and literacy barriers in non-urban populations.^{28,38}

This study has several strengths. It provides a real-world, system-wide evaluation of large-scale ePROM implementation within a universal public healthcare system, using routinely collected administrative and population-level data across routine care settings. By analysing system-, professional-, and patient-level, the study was able to characterise implementation dynamics, not only through individual demographic characteristics, but also through organisational workflows, care programme structure, and intervention-related factors embedded within routine clinical practice. Importantly, the availability of data distinguishing completion behaviours enabled a more nuanced characterisation of response patterns. Such distinction, which is not always explicitly addressed in large-scale implementation studies despite its relevance, may help inform future implementation strategies aimed at strengthening patient-managed digital completion pathways, maximising the meaningful use of ePROMs in routine care.

Beyond the limitations already noted, additional considerations include the observational design and reliance on routinely collected data, which limits causal inference, clinical interpretability, assessment of user experience, and direct assessment of several implementation determinants. Although implementation-related constructs were operationalised using observable indicators, some CFIR domains and implementation mechanisms, particularly Process-related constructs and organisational factors such as leadership engagement, compatibility, and implementation climate, could not be directly evaluated. In addition, responder status and median response rate definition is inherently influenced by the number of prescribed ePROMs but this was mitigated through burden-based stratification, using median values only for descriptive overview and focussing on responder status and complementary completion indicators. Complete-case analyses may introduce selection bias; however, descriptive, bivariate, and multivariate results were aligned.

Conclusions

This system-wide evaluation provides real-world evidence on the feasibility and complexity of large-scale ePROM implementation within a universal public healthcare system. Our findings suggest that organisational and workflow-related determinants, together with implementation strategies such as training, may play a more important role in supporting professional adoption operationalised through prescription intensity than most individual demographic characteristics alone. Response burden, operationalised through the number of prescribed ePROMs per patient, showed stronger associations with completion behaviour than most measured patients characteristics. Importantly, high overall completion rates did not necessarily translate into high levels of patient-managed digital completion. Therefore, equitable completion patterns with ePROMs may be achievable by careful intervention design and professionals' involvement. Strengthening both professional understanding of the value of patient-managed digital completion and tailored patient support for remote participation may help maximise the

meaningful use of ePROMs in routine care. Future research should complement routinely collected administrative data with richer assessment of implementation processes, user experience, and clinical impact to better understand the long-term effects of large-scale ePROM integration in healthcare systems.

Abbreviations

AMG	
Adjusted Morbidity Groups	
CFIR	
Consolidated Framework for Implementation Research	
ECWR	
Emotional and Community Wellbeing Referents	
EHR	
Electronic Health Record	
ePROM	
electronic Patient-Reported Outcome Measure	
GVI	
Generalised Variance Inflation Factor	
IRR	
Incidence Rate Ratio	
ISS	
Individual Socioeconomic Status	
OR	
Odds Ratio	
PROM	
Patient-Reported Outcome Measure	
TSI	
Territorial Socioeconomic Index	

Declarations

Ethics approval and consent to participate

The study was conducted in accordance with the Declaration of Helsinki. The study protocol was approved by the Independent Ethics Committee of the Bellvitge Hospital (code: PR057/24), which waived the collection of informed consent as the study utilized anonymized data routinely gathered for administrative, benchmarking, and other operational purposes. All data were managed in strict compliance with the General Data Protection Regulation (GDPR) 2016/679 and the local regulatory framework.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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Author Contribution

This study was originally conceived and designed by MMN, GCS and JPJ. JF and MMN were responsible for data curation and MMN conducted the formal analysis and visualization. Results were interpreted by MMN, MRP, XA, DL, JF, GC-S, AJR, FLV, LP, DG, AS, OS, PA, GF and JPJ. The manuscript was first drafted by MMN, MRP and GCS, and thoroughly revised by MMN, MRP, XA, DL, JF, GC-S, AJR, FLV, LP, DG, AS, OS, PA, GF and JPJ. All co-authors approved the final version, agreed for publication are accountable for the results and conclusions.

Acknowledgements

Not applicable.

Data Availability

The data that support the findings of this study are available from the Government of the Catalan public healthcare system, but restrictions apply to the availability of these data, which were used under license for the current study, and so are not publicly available. Data are however available from the authors upon reasonable request and subject to approval by the Catalan healthcare system data custodians and regulatory authorities.

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Figures

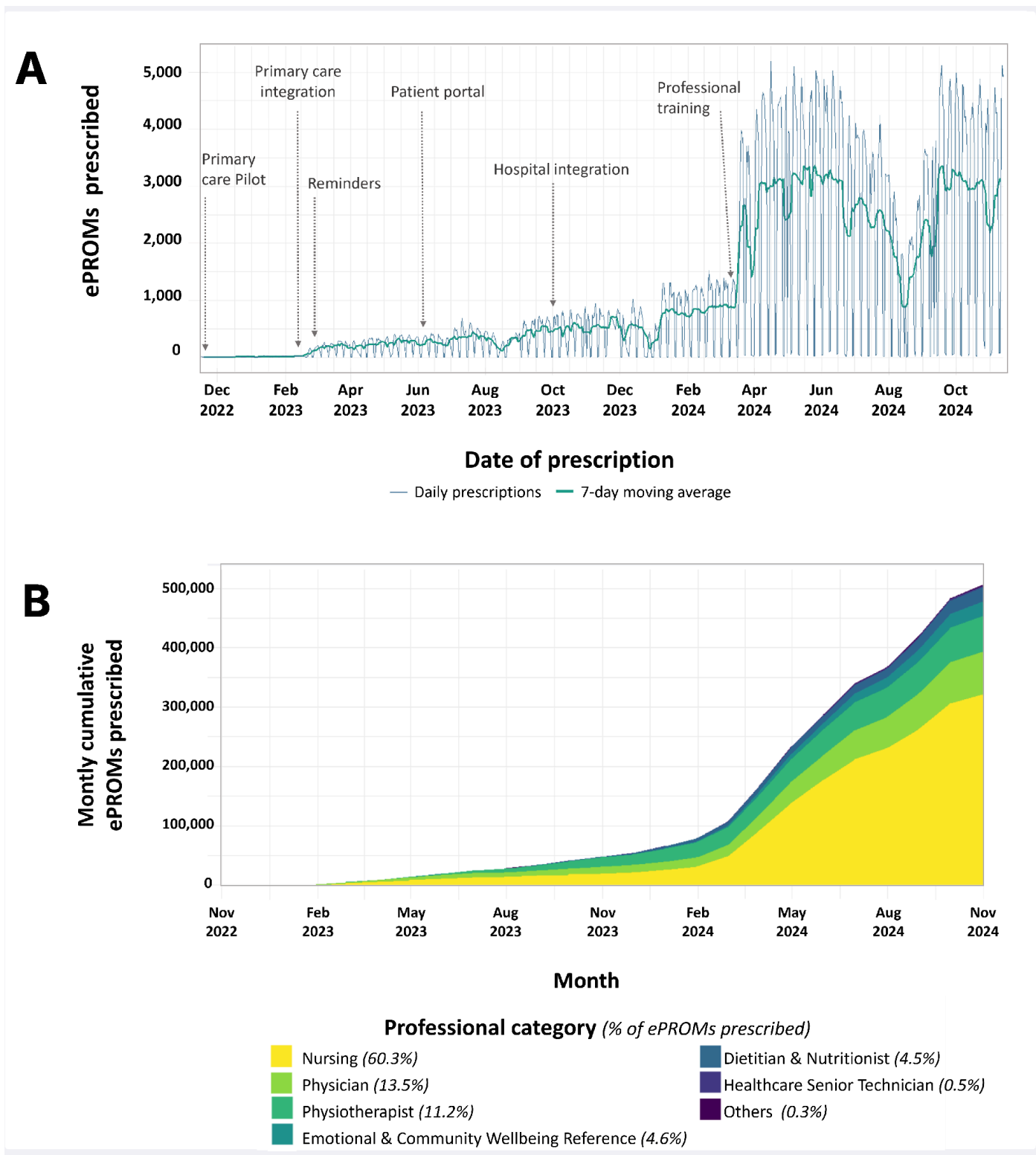


Figure 1

Temporal evolution of ePROM prescriptions during system-wide implementation. (A) Daily number of ePROM prescriptions and temporal trends during implementation, with key rollout and integration milestones annotated. *Primary care pilot*: initial pilot deployment in primary care, *Primary care integration*: integration into the primary care electronic health record system, *Reminders*: deployment of automated patient reminders, *Patient portal*: availability of patient-managed completion through the patient portal,

Hospital integration: integration into hospital information systems. *Professional training:* deployment of professionals training activities. **(B)** Cumulative distribution of ePROM prescriptions by professional category over time. Other professional categories included occupational therapist, dentist, speech and language therapist, and pharmacist.

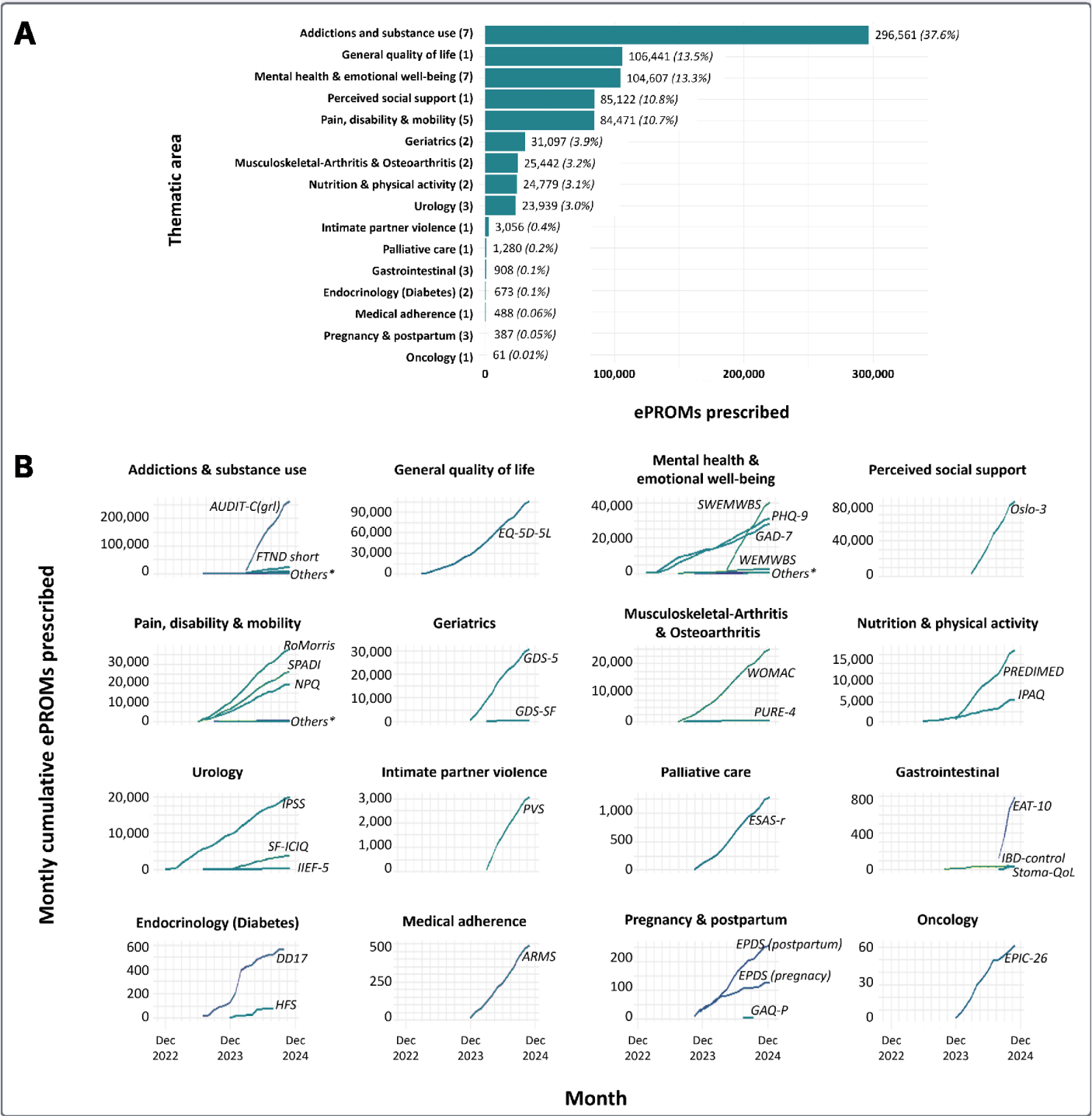


Figure 2

Distribution and temporal uptake patterns of ePROM prescriptions by thematic area (A) Total number and proportion of ePROM prescriptions across thematic area. Numbers in parentheses indicate the number of ePROM instruments included within each thematic area. **(B)** Cumulative monthly prescription of individual ePROM instrument grouped by thematic area. *Other instruments: Addictions & substance use (FTND, AUDITs, ASSIST, AUDIT-C (pregnancy)), Mental Health & emotional well-being (ISI, DME-E, DME-C), Pain, disability & mobility (DHI, SF-MPQ)

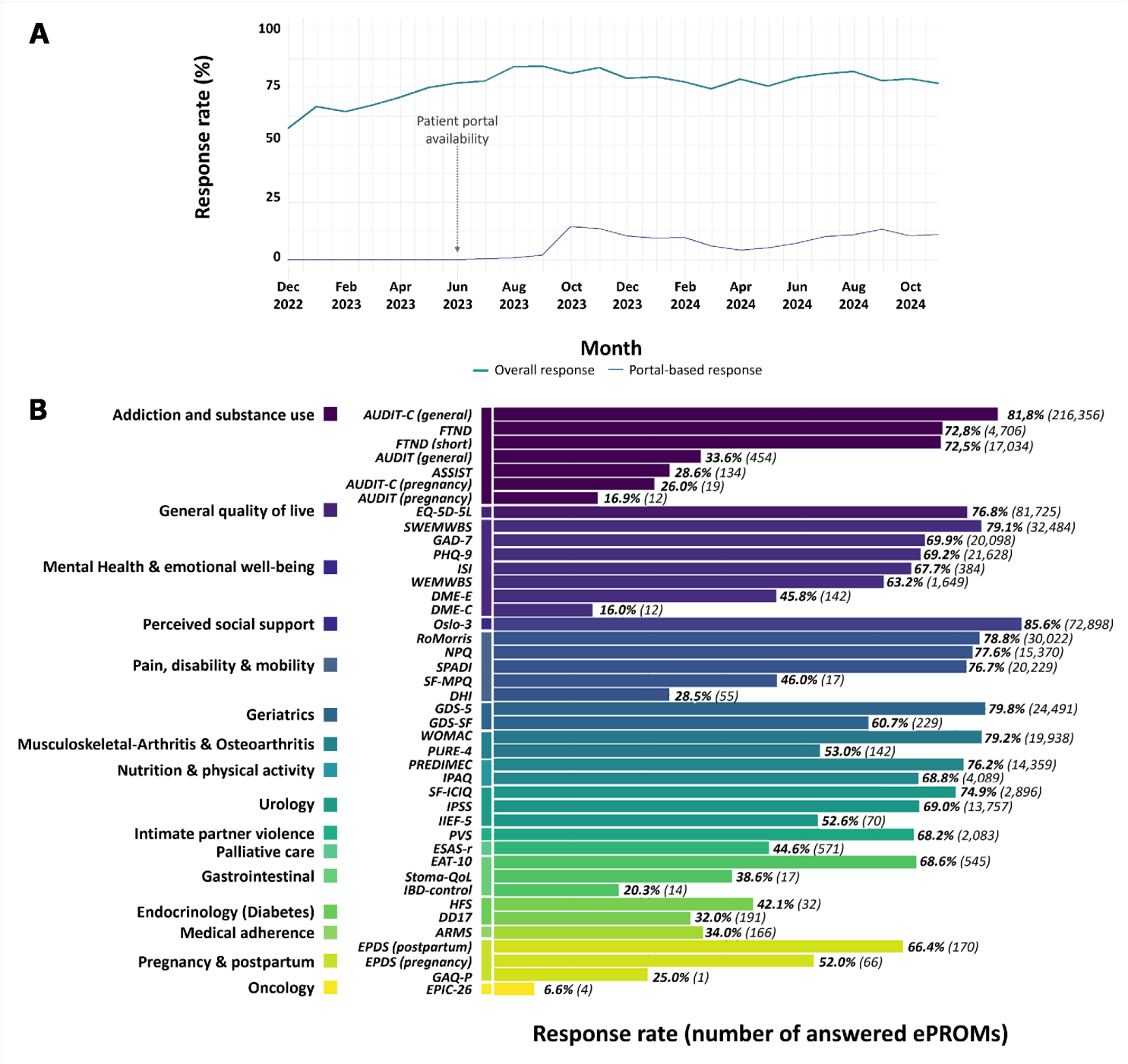


Figure 3

Response patterns over time and across thematic areas. (A) Monthly overall and portal-based response. *Overall response*: percentage of prescribed ePROMs completed. *Portal-based response*: percentage of prescribed ePROMs completed through the patient portal, available from June 2023 onwards, reflecting patient-managed digital completion. **(B)** Response rate by individual ePROM grouped by thematic area. Average response rates per thematic area were as follows: perceived social support (85.6%), addictions and substance use (80.5%), geriatrics (79.5%), musculoskeletal conditions (78.9%), pain and mobility (77.8%), general quality of life (76.8%), nutrition and physical activity (74.5%), mental health (73.0%), urology (69.9%), intimate partner violence (68.2%), gastrointestinal (63.4%), pregnancy and postpartum (61.2%), palliative care (44.6%), medication adherence (34.0%), endocrinology (33.1%), and oncology (6.6%).

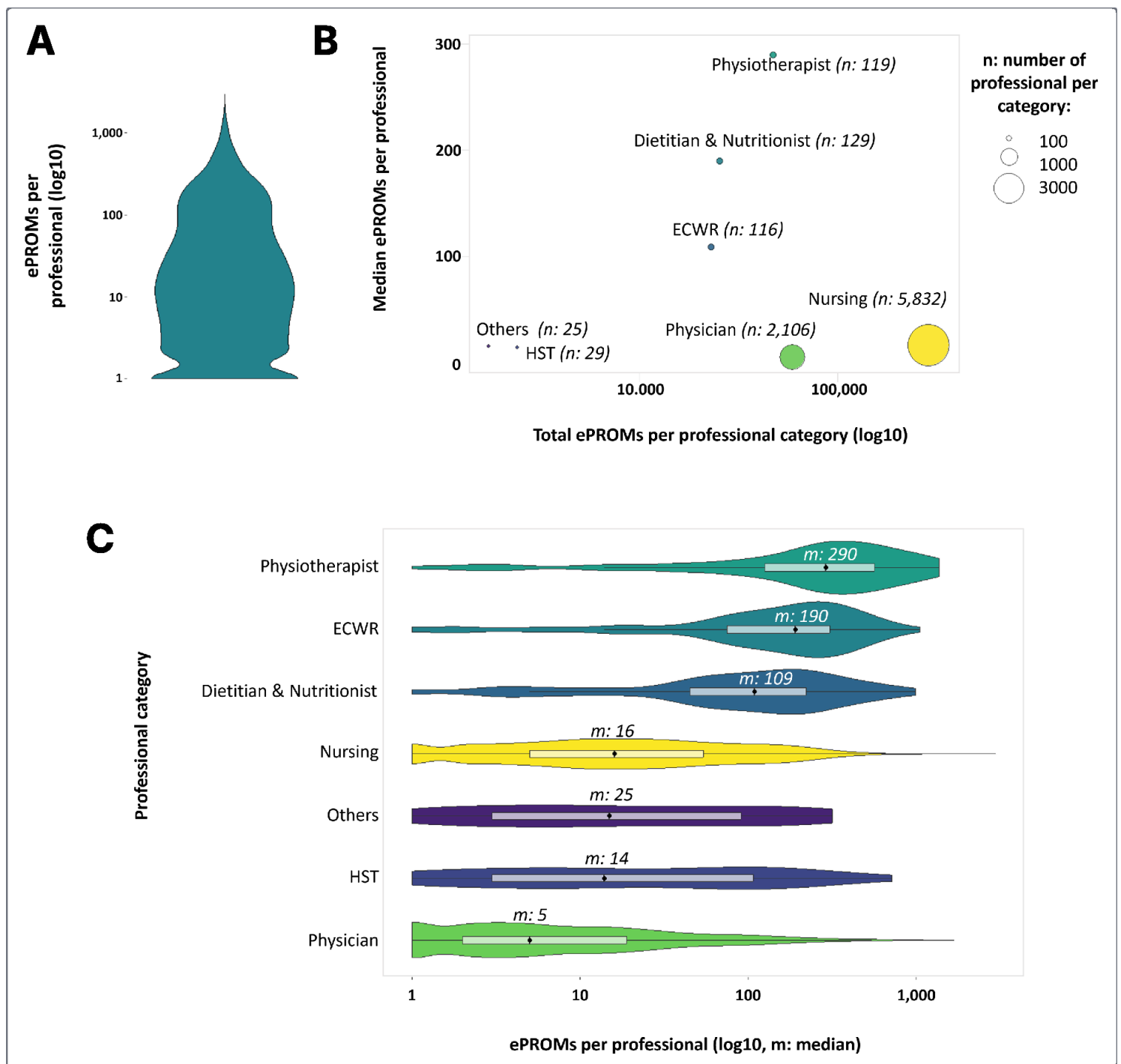


Figure 4

Distribution and intensity of ePROM prescription across professional categories. (A) Distribution of ePROM prescription per professional, shown on a log10 scale because of skewness. (B) Relationship between total ePROM prescriptions, median prescriptions per professional, and workforce size across professional category. (C) Distribution of ePROM prescriptions across professional category (Violin plot with embedded boxplot; distribution shown on a log10 scale; point = median; box = interquartile range [IQR]). ECWR: Emotional and Community Wellbeing Reference HST: Healthcare Senior Technician, Others: Pharmacist, speech and language therapist, dentist, podiatrist, and occupational therapist.

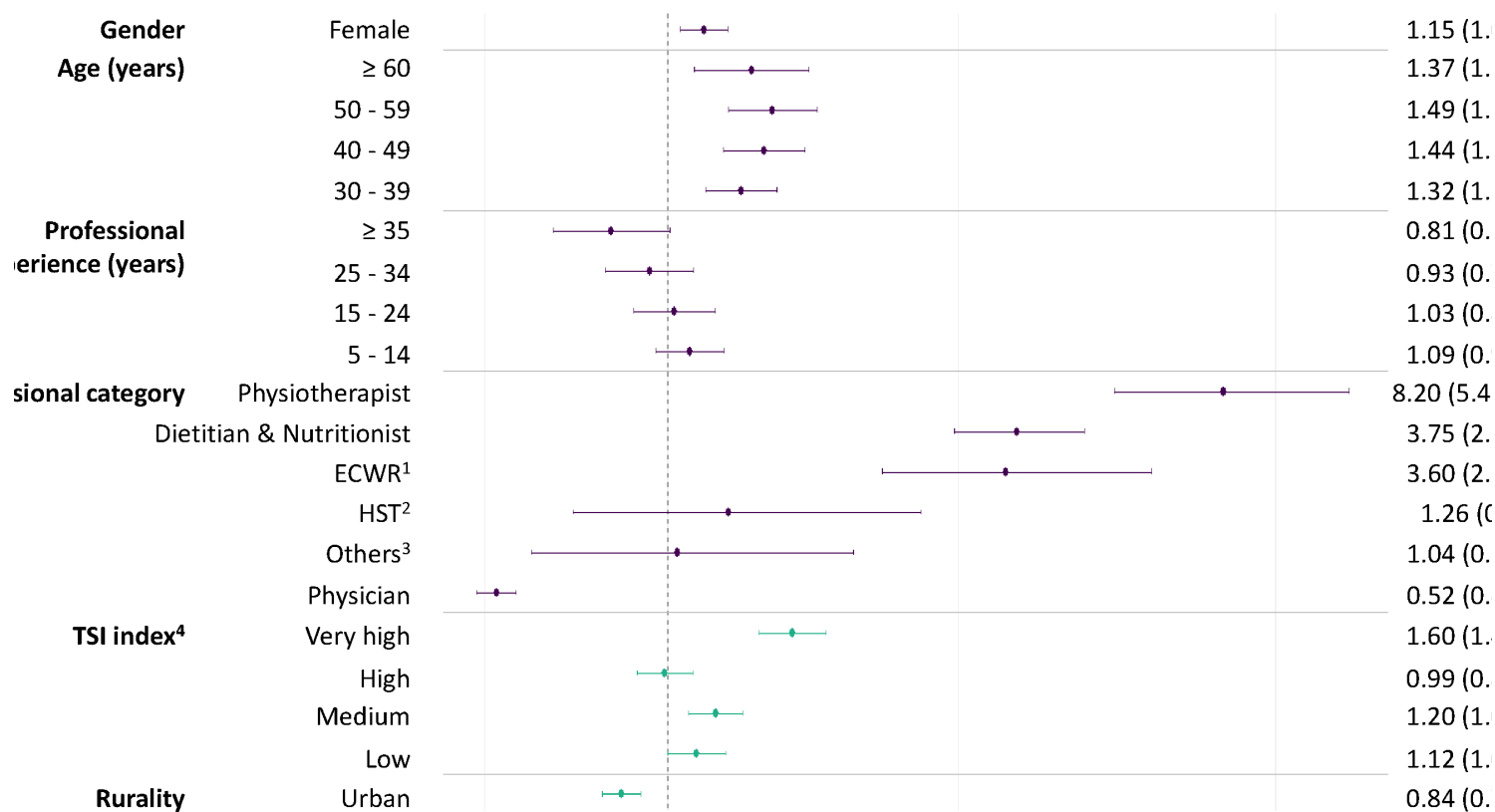


Figure 5

Factors associated with ePROM prescription intensity among healthcare professionals. Adjusted incidence rate ratios (IRR) and 95% confidence intervals from a multivariable negative binomial regression model. The outcome was prescription intensity, defined as the number of ePROMs prescribed per professional. Variables are presented according to CFIR-informed determinant domains. *Reference categories:* male sex, ≤ 29 years (age), newcomer (0 – 4 years), nursing professional category, very low TSI index, rural area. ¹ ECWR: Emotional and Community Wellbeing Referent; ² HST: Healthcare Senior Technician; ³ Others (*Professional category*): Pharmacist, speech and language therapist, dentist, podiatrist, and occupational therapist; ⁴ TSI index: Territorial socioeconomic index of the care setting where ePROMs were prescribed.

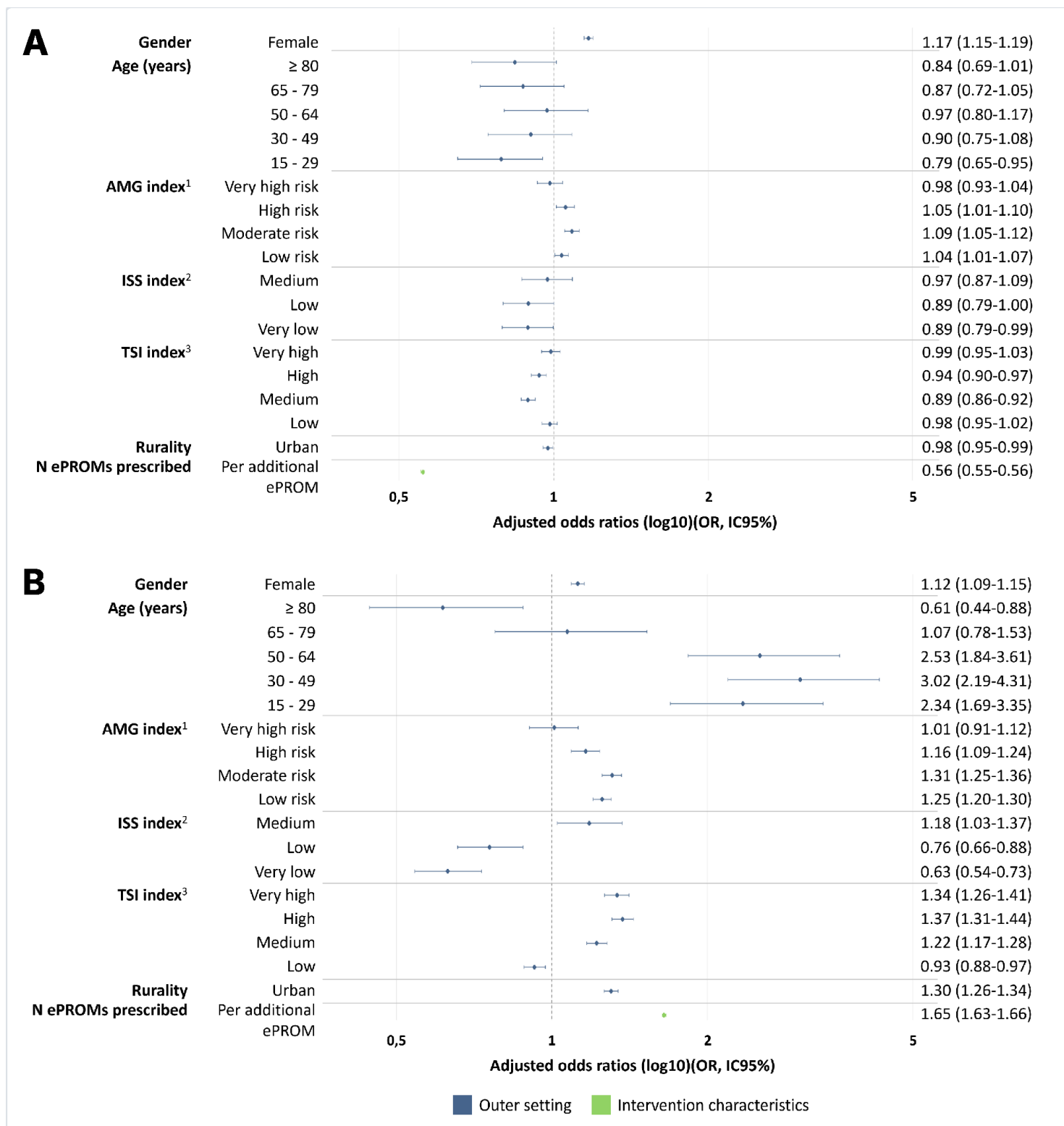


Figure 6

Factors associated with ePROM completion and patient-managed digital completion. Adjusted odds ratios (OR) and 95% confidence intervals from multivariable logistic regression models **(A)** Factors associated with responder status (≥80% of prescribed ePROMs completed). **(B)** Factors associated with patient-managed digital completion (completion of ≥1 ePROM through the patient portal). Variables are presented according to CFIR-informed determinant domains. The Intervention Characteristics domain

was operationalised using the number of prescribed ePROMs per patient as a proxy for response burden. *Reference categories*: male sex, children (≤ 14 years), rural area, AMG Baseline risk, high individual socioeconomic status, and very low TSI. ¹ *AMG index*: Adjusted Morbidity Groups index; ² *ISS*: individual socioeconomic level based on pharmaceutical co-payment thresholds: high ($>€100,000$ income), medium ($€18,000–100,000$), low ($<€18,000$), and very low (co-payment exempt), ³ *TSI*: Territorial socioeconomic index.

Supplementary Files

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