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Understanding ethnic inequalities in diagnostic intervals of cancer: a cohort study of patients presenting suspected cancer symptoms to general practitioners in England

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Title

Financial incentives and information provision for post-pandemic primary care quality recovery: a longitudinal study in Catalonia

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How this fits in

Financial incentives (pay-for-performance) and information feedback are widely used to improve primary care quality, but their separate effects, especially after major system disruptions like the COVID-19 pandemic, are unclear. In this study of 287 primary care practices in Catalonia (serving 5,250,531 people), early reinstatement of financial incentives led to faster quality-of-care recovery, while information alone was linked to gradual gains in some settings. Indicator type and practice context influenced the patterns of recovery. Overall, results support combining and tailoring financial and non-financial strategies to context for more resilient primary care systems.

Summary sentence

Financial incentives sped primary care quality recovery post-COVID-19, with both incentives and information linked to indicator- and practice-dependent improvements.

Abstract

Background: The COVID-19 pandemic disrupted primary care services worldwide, reducing quality-of-care. Understanding the impact of quality improvement strategies can guide system resilience.

Aim: To assess whether information provision and financial incentives to primary care professionals supported recovery of pre-pandemic quality-of-care after pandemic-related declines.

Design and Setting: Descriptive analysis at the primary care practice (PCP) and aggregated indicator levels in Catalonia, Spain.

Method: Data on 37 quality-of-care indicators from 287 PCPs (5,250,531 adults) were analyzed monthly from 2019–2024. Financial incentives were suspended in 2020; 13 indicators were reintegrated into pay-for-performance schemes in 2021 (early-incentivised), while 24 remained unincentivised until 2023 (late-incentivised). Outcomes were annual changes in indicator results and variability, and time to recover pre-pandemic levels. A multivariate Cox model estimated the effect of incentives; K-means clustering identified PCP recovery profiles.

Results: In 2021, 11/13 (85%) of early-incentivised indicators started recovering versus 5/24 (21%) of late-incentivised. By December 2024, recovery of pre-pandemic results occurred in 85% and 50%, respectively, despite larger pandemic drops in early-incentivised indicators. Early incentivization doubled the likelihood of recovery before 2023 (2.06 times), with effects varying by indicator type. However, many PCPs recovered late-incentivised indicators before incentives resumed, when only informed. Clustering revealed four PCP profiles; faster recoverers were smaller, rural practices with milder declines.

Conclusion: Financial incentives accelerated quality-of-care recovery after a system shock, particularly when tailored to indicator types and practice contexts, and complemented by timely information provision. Policymakers can use these findings to guide recovery strategies and strengthen resilience in primary care.

Keywords: primary care, quality-of-care indicators, economic incentives, health policy, COVID-19

Introduction

Healthcare systems must enhance care quality while ensuring financial sustainability, requiring adaptable strategies during shocks such as the COVID-19 pandemic, which strained capacity and disrupted non-pandemic services.[1,2] Primary care, central to triage and chronic disease management, was particularly affected.[3–6]

Among quality improvement models, pay-for-performance (P4P) schemes link provider reimbursement to measurable outcomes,[7–9] aiming to align professional incentives with organisational and societal goals. [11–13 10]. Evidence of effectiveness is mixed: [14–23] some studies report short-term improvements, [24,25] particularly for targeted indicators, [12,14–16,26–32] while concurrent interventions (e.g., public reporting, updated guidelines) may obscure incentive effects.[11,15,16,23] Slow progress in P4P design and evaluation underscores the need for further evidence, including how financial incentives interact with non-financial strategies. [33,34]

In Catalonia, Spain, the public primary care provider Institut Català de la Salut (ICS) serves about 80% of a population over eight million. Since 2006, ICS has combined online feedback on quality indicators with a P4P scheme (Management by Objectives, DPO).[35–37] In 2020, COVID-19 caused declines in chronic disease management[38,39], prompting the suspension of the P4P programme, although quality monitoring continued. Financial incentives were reinstated in phases: 15 priority indicators in 2021, with full reimplementation in 2023. This created a natural experiment to analyse the differential effects of performance feedback versus financial incentives on primary care quality recovery, and how these effects vary by practice characteristics and patient demographics. Our study aims to analyse how financial and non-financial mechanisms influence recovery from an acute system shock, addressing a gap in prior research that has largely focused on quality improvement under routine conditions. Such findings could inform more targeted and resilient quality improvement strategies for future crises.

Methods

Study design

This retrospective longitudinal study used data from 37 quality-of-care indicators across 287 PCPs managed by ICS (2019-2024). Thirteen were re-incentivised in 2021 ("Early-incentivised"); the remaining 24 were re-incentivised in 2023 ("Late-incentivised"), having only been reported to professionals until then. Recovery was assessed via: (a) year-over-year percentage change (mean % change and coefficient of variation [CV]); (b) intra-annual % change (January–December); and (c) time to recovery, the months from January 2021 until results returned to pre-pandemic range. The relationship between incentive status and recovery time was analysed using a mixed-effects Cox proportional hazards model. Unsupervised clustering identified recovery patterns among PCPs. All 287 PCPs managed by ICS with complete indicator reporting were included; no additional sampling or recruitment pathway of individual professionals or patients was required, as the study relied on routinely collected practice-level administrative data.

Data sources and outcome calculations

Monthly indicator data from the EQA framework [35] were obtained at the PCP level from the SISAP databases.[40] The study covered January 2019-December 2024, with 2019 as the pre-pandemic reference. SISAP provided indicator features (e.g., incentive status, type) and PCP characteristics (e.g., socioeconomic deprivation index,[41] rurality, demographics, workforce size). No missing data were identified for the selected indicators or PCPs during the study period, as these routinely monitored indicators are validated and curated for clinical and management purposes.

Time to recovery was calculated projecting 2019 monthly results, except for EQA0403 (2018 values, **Supplementary Table 1** and **Supplementary Figures 1-2**). Recovery was the number of months from January 2021 until the average PCP result (with 95% CI) re-entered and remained within the 2019 range for six consecutive months. Indicators unaffected by the pandemic showed negative recovery times; those unrecovered by December 2024 were assigned 60 months for graphical/clustering use, but excluded from other analyses. For PCP-level analysis, 2019 projections used each PCP's monthly values, with confidence intervals from the standard deviation across all PCPs.

Indicator selection

Indicators were included if they: (1) had high EQA evidence;[35] (2) were financially incentivised for ≥5 years pre-pandemic; (3) focused on adults (>14 years); and (4) were re-incentivised between 2021–2024. The 37 selected indicators (**Supplementary Table 1**) spanned control, diagnosis, follow-up, screening, treatment, and vaccination (**Supplementary Table 2**). Of these, 13 (35%) were re-incentivised in 2021 ("Early-incentivised"; 7 control, 3 screening, 3 treatment). The remaining two of the 15 priority indicators were excluded based on the selection criteria. Although 2021 P4P funds were ultimatelydistributed universally as a pandemic reward, professionals were exposed to the P4P stimulus and unaware of the distribution change until the last quarter of 2021. The remaining 24 indicators (65%) were informed but unincentivised until 2023 ("Late-incentivised"; **Supplementary Table 1**: 7 diagnosis, 7 treatment, 5 screening, 2 control, 2 follow-up, 1 vaccination).

Statistical analysis

A mixed-effects Cox proportional hazards model estimated the effect of incentives on recovery likelihood, accounting for covariates and data hierarchy. Covariates were selected via bivariate analyses (**Supplementary Table 3**). The model:

$$h_{ij}(t) = h_{0k}(t)\, exp(\beta_1 IncentiveScheme_{ij} + \beta_2 \%ResultDrop_{ij} + b_{0j})$$

where $h_{ij}(t)$ is the recovery hazard at time t for indicator i in practice j, $h_{0k}(t)$ the baseline hazard by indicator type k, $IncentiveScheme_{ij}$ the incentive exposure, $\%Resultdrop_{ij}$ the post-COVID-19 drop, and $b_{0j} \sim N(0,\sigma^2)$ a PCP-level random intercept. The model stratified by indicator type and included a random effect for PCPs. Schoenfeld residuals were inspected to assess proportional hazards (**Supplementary Figure 3**).

K-means clustering (R *stats* package) of PCP-level recovery times was applied separately for early- and late-incentivised indicators. The optimal number of clusters (K=2) was chosen using within-cluster sum of squares and silhouette width, classifying PCPs into four recovery profiles: fast recoverers, fast for incentivised, fast for informed, and slow recoverers. Profiles were characterised by contextual and organisational variables.

Descriptive statistics summarised trends. Normality guided parametric (t-tests, ANOVA) or non-parametric (Wilcoxon, Kruskal-Wallis) tests for group comparisons. Spearman's rank correlation assessed continuous associations, and chi-square or Fisher's exact tests were used for categorical comparisons. False discovery rate correction addressed multiple testing, with significance set at 0.05. Analyses and visualizations were performed in R 4.3.1.[42]

Ethics considerations

This study was approved by the Clinical Research Ethics Committee of IDIAP Jordi Gol (Ref. 23/160-P).

Patient and public involvement

This study used pre-existing administrative, aggregate data from pre-established interventions, limiting opportunities for meaningful public engagement. Given the retrospective nature and focus on existing interventions, we opted for not integrating PPI in the study.

Results

The impact of early incentivization on initial indicator responses

We analysed quality-of-care indicator data from 287 PCPs in Catalonia (**Supplementary Table 4**): 100 (35%) rural and 187 (65%) urban, including 56 (19.5%) in highly deprived areas. The average population per PCP was 18,295 (21,318 in urban vs. 12,641 in rural PCPs, p<0.001). Mean patient age was 49 years (48.5 vs. 50, p<0.001), 50.6% were females (51.3% vs. 49.3%, p<0.001) and 18.4% immigrants (19.8% vs. 15.9%, p<0.001). PCPs averaged 26.6 professionals (29.8 urban vs. 20.7 rural, p<0.001).

In 2020, 35 of 37 indicators (95%) dropped significantly in results and/or increased variability (CV) compared to 2019 (average 15.26% drop and 115.6% CV increase; **Figure 1, Supplementary Figure 4**); only 2 treatment indicators did not. Early-incentivised indicators started recovering sooner: by December 2021, 11/13 (85%) showed improvements, defined as statistically significant increases in indicator value and/or decreases in variability compared to the previous year, rising to 12/13 (92%) in 2022 and sustaining gains through 2024 (**Figure 1, Supplementary Figure 4**). In contrast, late-incentivised indicators improved later: only 5/24 (21%) improved by 2021, increasing to 13/24 (54%) in 2022, when still only informed. Once reintroduced to P4P in 2023, 20/24 (83%) improved, with sustained gains in 2024 (**Figure 1, Supplementary Figure 4**). Intra-annual changes mirrored this trend: 12/13 (92%) early-incentivised indicators improved from January to December 2021, and all by 2022. For late-incentivised indicators, intra-annual improvements rose from 8/24 (33%) in 2021 to 22/24 (92%) in 2023 (**Supplementary Figures 5-6**).

Recovery times among early- and late-incentivised indicators

We assessed differences in indicator average recovery times between treatment arms (**Figure 2**, **Supplementary Figures 1-2**). By December 2024, 11/13 (85%) early-incentivised indicators had returned to 2019 levels, compared to 12/24 (50%) late-incentivised indicators. Among recovered indicators, average recovery times were not significantly different (21.9 months for early-incentivised vs. 17.5 months for late-incentivised, p=0.45). However, treatment indicators recovered significantly faster than control indicators (4.7 vs. 28.6 months, p<0.05).

Early-incentivised indicators, while showing higher recovery rates, also experienced steeper 2020 declines (−24.3% vs. −9.2% for late-incentivised indicators, p<0.05),

suggesting greater pandemic impact (**Figure 2**). The severity of the drop also varied by indicator type: control, screening, and follow-up indicators saw the largest declines (25%, 21.7%, 18.1% in 2019 results, respectively), while diagnosis, treatment, and vaccination indicators were less affected (9.4%, 3.5%, 1.5%; $p<0.05$ for treatment vs. control/screening, **Figure 2**).

Using the recovery times across PCPs (**Supplementary Figure 7**), we identified PCPs that recovered results by December 2024, those that did not, and those that had already recovered before January 2021 for each indicator (**Figure 3**). Early-incentivised indicators had higher numbers of PCPs dropping results during the pandemic (lower % of PCPs recovered before 2021 vs. late-incentivised indicators, $p<0.01$). However, a higher percentage of the PCPs that dropped early-incentivised indicator results recovered them before December 2024 ($p<0.01$ vs. late-incentivised indicators). Although late-incentivised indicators had more PCPs unable to recover results in the study period ($p<0.05$ vs. early-incentivised, **Figure 3**), a higher percentage of the PCPs that recovered the results of late-incentivised indicators did so before 2023, when they were only informed ($p<0.001$, **Supplementary Figure 8A**).

Further stratification by indicator types revealed differences in recovery patterns (**Supplementary Figure 8B**): while most PCPs already showed recovered results for treatment and vaccination indicators during 2020, this was not the case for the rest of indicators. Among control and screening indicators, those incentivised early were able to recover dropped results in almost all the PCPs, while those incentivised late had higher rates of PCP that did not recover. Around a third of PCPs did not manage to recover diagnostic indicator results, all of which were incentivised in 2023.

To assess the impact of early financial incentivization on the recovery of quality-of-care indicators, we fit a mixed-effects Cox proportional hazards model using recovery time data (per indicator and PCP) from January 2021 to December 2022. During this period, late-incentivised indicators remained informed, allowing a direct comparison between incentivised and informed indicators. Initial bivariate analyses (**Supplementary Table 3**) showed a significantly greater drop in results among incentivised indicators, which were also more frequently control indicators, with no diagnostic or follow-up indicators represented. The Cox model included incentive scheme and 2020 result drop as covariates, was stratified by indicator type, and included a random effect for primary care practice to account for clustering and unmeasured heterogeneity (see Methods). Indicators that remained incentivised during 2021–2022 had a significantly higher

recovery likelihood (HR = 2.06; 95% CI, 1.88–2.25), indicating a 106% greater probability of recovery at any time point than informed-only indicators, adjusting for baseline drop and clustering. Greater 2020 result drops were associated with slower recovery (HR = 0.988; 95% CI, 0.986–0.990).

Recovery patterns among PCPs

To identify recovery patterns across PCPs, we applied unsupervised K-means clustering to 2021-2024 recovery time data by PCP and indicator. Based on results across incentivised and informed indicators, four PCP clusters were defined: fast recoverers (low recovery times for both types of indicators), fast for incentivised, fast for informed and slow recoverers (with the highest overall recovery times) (**Figure 4**).

Fast and fast for incentivised recoverers showed quicker recovery for 10/13 (77%) incentivised indicators ($p<0.05$ vs. other clusters). Fast recoverers also recovered 13/24 (54%) of the late-incentivised indicators (12 indicators vs. *slow* and 10 vs. *fast for incentivised* PCPs, $p<0.05$), spanning 6 diagnostic, 3 screening, 2 control, 1 follow-up and 1 treatment indicator. Fast for informed recoverers showed better recovery only in 5/24 indicators (21%, 4 diagnostic and 1 screening). No consistent differences in recovery times were observed between clusters for the 10 treatment indicators, where many PCPs had already recovered by 2021.

Cluster characterisation (**Table 1**, **Supplementary Figure 9**) revealed enrichment of rural PCPs among fast and fast for informed clusters (50% each vs. 32% and 23% of *fast for incentivised* and *slow* PCPs, **Supplementary Figure 9A**). Fast recoverers also had smaller assigned populations (avg. 16,230 vs. 20,348 in slow PCPs), fewer professionals (24.8 vs. 28.6 in slow PCPs), and lower 2020 drops (11% vs. 14.7–16% among the rest). These lower drops were mainly attributable to fast-recovering rural practices, with no significant drop differences among urban, least-deprived PCPs (**Supplementary Figure 9B**).

Discussion

Summary

This study adds to evidence on primary care improvement by evaluating how financial incentives and information provision aided quality-of-care recovery after a system shock like COVID-19, which diverted focus toward pandemic control and reduced routine care.[3,38] We analyzed 37 indicators across 287 PCPs: 13 financially incentivised in 2021 and 24 re-incentivised in 2023, enabling comparison between financial incentives and information-only strategies. Early reinstatement of incentives accelerated recovery, with 85% of indicators returning to pre-pandemic levels by December 2024, and doubled the likelihood of early recovery in 2021–2022. Information alone also supported gradual improvements, with 54% of late-incentivised indicators improving before incentives resumed. Indicator type and practice context influenced recovery, highlighting the value of combining and tailoring strategies for resilience.

Strengths and limitations

Strengths include a large sample, over five years of monthly data, and the natural experiment created by phased incentive reintroduction. The broad indicator set enabled exploration of differential responses by type and practice profile, and clustering offered novel insight into recovery patterns. Limitations include the absence of a contemporaneous control group due to system-wide rollout, and possible selection bias, as early-incentivised indicators were likely higher priority. Uneven indicator distribution (e.g., diagnostic, follow-up and vaccination indicators only in the late-incentivised group) limited full comparisons. The Cox model was stratified by indicator type and adjusted for relevant covariates, but baseline hazard for incentives could only be estimated using indicators present in both groups. This and the proportional hazards assumption should be considered when interpreting results. While our findings reflect the structure and incentive framework of Catalonia's public primary care system, their generalisability to other health systems may depend on local organisational contexts, incentive structures, funding models, and recovery strategies. Finally, these findings are framed in a post-pandemic recovery phase, when quality improvement dynamics and provider behaviour may differ from routine periods, and it remains uncertain whether observed improvements can be sustained once incentives are withdrawn.

Comparison with existing literature

Our study adds to the existing literature by providing evidence on the effects of financial incentives and information provision in the context of recovery from an acute system shock (the COVID-19 pandemic), a setting which has been rarely examined in prior research. Our finding that financially incentivised indicators recovered more quickly, with double the likelihood of recovery during 2021–2022, is consistent with prior research showing that incentives can prompt faster behavior change, particularly with low baseline performance.[15,24,25,43] Over half of later-incentivised indicators improved during the information-only period, supporting earlier evidence on the sustained benefits of non-financial interventions.[24,25,36]

Unlike earlier studies, which often examined narrower indicator sets,[15,16,45,46] our analysis covered a broader range, enabling nuanced assessment of recovery patterns by indicator type and practice profile. Not all indicator types responded equally: treatment indicators declined less and recovered faster, likely due to remote prescription renewals,[38] whereas diagnostic indicators lagged, with one-third of practices unrecovered by 2024, highlighting the need to explore barriers to diagnostic care. Differences by practice context mirror reports of greater resilience among rural and smaller practices, potentially due to less disruption in dispersed populations,[38,44] while slower recovery in urban settings suggests a need for targeted incentives and extended recovery periods.

Implications for research and practice

For policymakers, these findings suggest that targeted financial incentives for a reduced set of indicators may support recovery. [47,48] Indicators should be selected based on clinical relevance, low baseline performance,[15,18] and contextual barriers. As improvement is context-dependent, multi-faceted approaches combining financial and non-financial measures may yield better long-term outcomes. Informed indicators also improved—though more slowly—, underscoring the value of transparency and clinician engagement even without direct rewards. Sustained improvement requires regular monitoring, flexible incentive designs, and alignment with meaningful clinical goals and local realities.

Overall, this study examined short- to medium-term effects of financial and informational interventions in a recovery setting. Whether improvements persist without incentives remains unclear, and future research should explore long-term effects and broader generalizability. While our findings align with evidence supporting the effectiveness of financial incentives,[12,43,49,50] debates persist about their overall value and unintended

consequences.[15,16] Continued evaluation across varied contexts is crucial to guide equitable, effective quality improvement policies.

Statements

Data sharing statement

Data from this study will be made accessible upon reasonable request.

Ethics statement

The present study was approved by the Clinical Research Ethics Committee of IDIAP Jordi Gol with reference number 23/160-P.

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Competing interests

All authors have completed the ICMJE uniform disclosure form at http://www.icmje.org/disclosure-of-interest/ and declare: no support from any organisation for the submitted work; no financial relationships with any organisations that might have an interest in the submitted work in the previous three years; no other relationships or activities that could appear to have influenced the submitted work.

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Figure legends

Figure 1 | Summary of year-to-year changes for all the assessed indicators. Heatmap depicting the outcomes of the analysis of the % change from previous year for all indicators (early- and late-incentivised), both in terms of indicator variability (CV, left block) and results (right block) across PCPs. Green cells represent significantly positive changes from the previous year, red cells depict significantly negative changes, and grey cells represent years where no significant change was detected. The right column indicates the type of indicator, as explained in Methods.

Figure 2 | Time to recovery and 2020 result drops for all indicators. Lollipop plot representing the average recovery times (in months since January 2021) of all indicators (left panel, faceted by financial incentive scheme) and the average % drop in results during the pandemic (right panel). Colours represent indicator types, and dot shapes their recovery status (recovered or not 2019 results).

Figure 3 | Percentage of PCPs that recovered and did not recover per indicator. (A) Barplot representing the number of PCPs for each indicator that recovered results (green, with pale green being PCPs that recovered during the only informed period), those that did not recover during the study period (red), and those that had already recovered at the beginning of the follow-up (January 2021) or never dropped results (yellow). Green numbers represent the % of recovered PCPs per indicator. The top panel includes the early-incentivised indicators, and the late-incentivised are at bottom panel. (B) Boxplots comparing the differences in the % of PCPs that dropped results in 2020 and then recovered (left panel), the % of PCPs that did not recover (centre panel) and the % of PCPs recovered before 2021 (right panel). P-values represent the result of Mann-Whitney-Wilcoxon tests.

Figure 4 | Classification of PCPs based on recovery patterns found with unsupervised clustering. Heatmap of scaled recovery times for all indicators among the 4 classes of PCPs that were defined by unsupervised clustering (see Methods). Blue indicates low recovery time values, and red represents high values. Top annotations indicate the PCP rural/urban and MEDEA socioeconomic deprivation index for urban areas (4U to 1U, from most to least deprived). Right annotations represent indicator types and significant differences in indicator recovery times among clusters: columns represent paired comparisons, and the degree of orange is proportional to p-value significance below 0.05 (Dunn's post-hoc test).

Tables

Table 1 | Summary of the associations between recovery profiles and the sociodemographic and organisational characteristics of PCPs.

	Fast	Fast for incentivised	Fast for informed	Slow	p.overall
	N=66	*N=72*	*N=36*	*N=112*	
MEDEA socioeconomic deprivation index					.
1U	4 (6.06%)	10 (13.9%)	3 (8.33%)	27 (24.1%)	
2U	12 (18.2%)	10 (13.9%)	2 (5.56%)	15 (13.4%)	
3U	7 (10.6%)	11 (15.3%)	9 (25%)	21 (18.8%)	
4U	10 (15.2%)	18 (25.0%)	4 (11.1%)	23 (20.5%)	
Rural	33 (50.0%)	23 (31.9%)	18 (50.0%)	26 (23.2%)	
N patients	16,230 (8,163)	17,838 (7,785)	16,840 (8,731)	20,348 (7,755)	**0.005**
Age of patients	49.5 (1.81)	48.8 (1.73)	48.9 (2.24)	48.9 (1.91)	0.177
% female patients	50.2 (1.67)	50.7 (1.58)	50.2 (2.26)	50.9 (2.53)	0.139
% immigrant patients	16.7 (7.24)	18.2 (8.88)	20.3 (8.56)	19.1 (9.76)	0.202
N professionals	24.8 (10.9)	26.3 (9.66)	24.8 (10.6)	28.6 (9.40)	**0.046**
N general practitioners	12.3 (5.46)	13.1 (4.97)	12.4 (5.40)	14.4 (4.77)	**0.035**
N nurses	12.5 (5.53)	13.2 (4.74)	12.4 (5.20)	14.3 (4.68)	0.063
Avg % drop in 2019 results	-11.02 (4.70)	-14.83 (4.24)	-14.74 (3.76)	-16.04 (3.67)	**<0.001**

N represents the number of observations. MEDEA classification stratifies urban PCPs according to the socioeconomic deprivation of the area they serve, ranked from 1U to 4U (from less to more deprived, respectively).