DOI: 10.1111/1475-6773.13094

RESEARCH ARTICLE

HSR Health Services Research

Impact of stratification on the effectiveness of a comprehensive patient-centered strategy for multimorbid patients

Myriam Soto-Gordoa MSc[1,2,3,4] | Esteban de Manuel MD[4] | Ane Fullaondo PhD[4] | Marisa Merino MD, PhD[3,5] | Arantzazu Arrospide PhD[1,2,3] | Juan Ignacio Igartua PhD[6] | Javier Mar MD, PhD[1,2,3,7] | on behalf of the CareWell Group

[1]AP-OSI Research Unit, Alto Deba Integrated Health Care Organization, Mondragon, Spain

[2]Health Services Research on Chronic Patients Network (REDISSEC), Kronikgune Group, Barakaldo, Spain

[3]Biodonostia Health Research Institute, San Sebastian-Donostia, Spain

[4]Kronikgune, Barakaldo, Spain

[5]Tolosaldea Integrated Health Care Organization, Tolosa, Spain

[6]Faculty of Engineering, Mondragon Unibertsitatea, Mondragon, Spain

[7]Clinical Management Unit, Alto Deba Integrated Health Care Organization, Mondragon, Spain

Correspondence
Myriam Soto-Gordoa, MSc, AP-OSI Research Unit, Alto Deba Integrated Health Care Organization, Mondragon 20500, Spain.
Email: myriam.sotoruizdegordoa@osakidetza.eus

Funding information
European Commission within the ICT Policy Support Programme of the Competitiveness and Innovation Framework Programme (CIP), Grant/Award Number: 620983; Beca Asociación Española De Economía de la Salud

Objective: The objective of this work was to assess the effectiveness of a population-level patient-centered intervention for multimorbid patients based on risk stratification for case finding in 2014 compared with the baseline scenario in 2012.

Data Source: Clinical and administrative databases.

Study Design: This was an observational cohort study with an intervention group and a historical control group. A propensity score by a genetic matching approach was used to minimize bias. Generalized linear models were used to analyze relationships among variables.

Data Collection: We included all eligible patients at the beginning of the year and followed them until death or until the follow-up period concluded (end of the year). The control group (2012) totaled 3558 patients, and 4225 patients were in the intervention group (2014).

Principal Finding: A patient-centered strategy based on risk stratification for case finding and the implementation of an integrated program based on new professional roles and an extensive infrastructure of information and communication technologies avoided 9 percent (OR: 0.91, CI: 0.86-0.96) of hospitalizations. However, this effect was not found in nonprioritized groups whose probability of hospitalization increased (OR: 1.19, CI = 1.09-1.30).

Conclusions: In a before-and-after analysis using propensity score matching, a comprehensive, patient-centered, integrated care intervention was associated with a lower risk of hospital admission among prioritized patients, but not among patients who were not prioritized to receive the intervention.

KEYWORDS
identification of target population, integrated care, multimorbidity, primary care, propensity score

1 | INTRODUCTION

A worldwide discussion on the efficiency of primary health care is focused on re-orienting health systems toward proactive, anticipatory, and integrated care.[1-3] Health care systems need to personalize services, put patients at the center of care, and provide services using adequate resources. Yet, the lack of proven efficacy of new interventions represents a problem for health systems globally.[4-7] Smith

et al[8] highlighted that despite the difficulty of improving outcomes in broad populations, integrated interventions focusing on specific populations may be more effective. Therefore, there is a clear need to prioritize integrated care interventions on certain populations according to greatest likelihood of their effectiveness.[9] Risk stratification tools can help to identify complex frail and high-risk patients and to keep these patients on the radar of health systems across the continuum of care.[10-12]

In this context, the Department of Health of the Basque Government launched in 2010 the "Strategy to tackle the challenge of chronicity in the Basque Country",[13] which aimed to re-orient the health system toward an integrated care model and, therefore, toward a patient-centered approach. Twelve Integrated Healthcare Organizations (IHOs) that care for 2.2 million inhabitants comprise the Basque Health Service. The term IHO refers to the delivery of care across primary care and secondary care service areas within a single organization structure. This structure enables patient-centered approaches since it ensures continuum of care. As various chronic conditions often coexist, the Basque Health Service designed a specific integrated care program for patients with multimorbidity. In particular, this patient-centered strategy consisted in a risk stratification for case finding (RSCF) strategy launched in 2011 (available from the late 2012 and onward) by the Department of Health. Its aim was to prioritize complex frail and high-risk patients on the basis of adjusted clinical groups (ACGs).[14] Patient prioritization implied the activation of a specific care pathway. This rationale reflected the hypothesis that empowering primary care (PC) services enables the provision of early treatment that keeps the patient's condition stable longer.[15-17]

The success of chronic-care program interventions depends not only on their intrinsic efficacy and their degree of implementation[18] but also on the selection of target population. However, despite the growing use of risk stratification tools based on predictive models in various health care systems,[19] there is a lack of literature on its impact on health care systems. The measurement of these aspects is critical for their evaluation. The objective of this work was to assess the effectiveness of a population-level patient-centered intervention for multimorbid patients based on risk stratification for case finding.

2 | METHODS

We carried out a retrospective observational cohort study with an intervention group and a historical control group. Data were obtained from the clinical and administrative databases of the Basque Health Service. The patient-level data on these databases were managed in an anonymized manner. 2012 and 2014 risk stratification for case finding data were only available for the authors. Data from 2012 comprised a historical comparator group that had been included in a chronic-care program. Despite the fact that the integrated care program for multimorbid patients was available from the late 2012, taking into account the complexity of the program, we cannot assume that the program was operational during 2013. Data from 2014 comprised the intervention group. As the intervention's aim was to empower PC services to allow reduced use of hospital inpatient services, the change in resource consumption in PC services was taken into account as a proxy indicator of implementation. In contrast, effectiveness of the intervention was measured by use of hospital services, since this is a relevant indicator both from the clinicians and managers.[20]

2.1 | Study population and variables

The study included all individuals with multimorbidity in the Basque Country more than 65 years old. The prevalence of multimorbidity doubles for individuals aged 65-84 in comparison with those aged 45-64.[21] Therefore, considering individuals older than 65 is a widespread threshold.[22] Multimorbidity was defined as having at least two of three chronic diseases (diabetes mellitus [DM], heart failure [HF], and chronic obstructive pulmonary disease [COPD]). We used the following codes according to "The International Classification of Diseases, 9th Revision, Clinical Modification": 250.* for DM, 428.* for HF; and 491.2* and 518.81 for COPD. The Basque Health Service targeted these pathologies because they are the most prevalent in their local context. Clinical and administrative databases of the Basque Health Service collect all the information related to the medical diagnoses of the population to which they provide health services. Thus, individuals with any of the recently mentioned diagnoses were extracted from those databases. Subsequently, those that were subject only to one of the pathologies and were under 65 years were eliminated.

The Basque Department of Health prioritized those who were more likely to benefit from the integrated intervention. The criteria for prioritization were as follows: having had a hospitalization in the previous year and being in the 5 percent apex of the pyramid of stratification. The process of stratification was based on the ACG system,[23] which measures the morbidity burden of patient populations on the basis of disease patterns, age, and gender. This tool relied on the diagnostic and pharmaceutical information in administrative databases to assign to each individual a risk score predicting resource consumption during the next year, compared with the total population stratification. Higher risk predicted greater costs for the health care system. The process of obtaining the risk score is explained extensively elsewhere.[14] However, the stratification was carried out in a specific moment and was based on data collected during a specific time range, while the evolution of the population was dynamic. Therefore, GPs were urged to continuously update the target population and prioritize more patients who met the established criteria. Exclusion criteria included the presence of neoplasia or receipt of dialysis or transplant. The target population of this study were the prioritized group. Nonetheless, we used the nonprioritized group as a falsification test in order to consider secular trends. The target population of the intervention, the prioritized group, comprised 4225 patients in the intervention group for 2014 and 3558 patients in the control group for 2012. Even though the intervention would probably be implemented in

the prioritized group, it was not limited to that group. Therefore, for more in-depth analysis, the entire multimorbid population was considered for evaluation, and a subgroup analysis was carried out to ascertain differences among the not prioritized and prioritized groups.

We included all eligible patients at the beginning of the year and followed them until death or until the follow-up period concluded (end of the year). Hospital admissions were an indicator of effectiveness.[20] The change in resource consumption in PC services was an indicator of implementation,[17] since the intervention's aim was to empower PC services to allow reduced use of hospital inpatient services.

To adjust our analysis by population characteristics, we collected the following variables: gender, existence of DM, HF or COPD, death at the end of the follow-up, and type of prioritization.

2.2 | Usual care

Usual care of multimorbid patients consisted of receipt of both PC and in-hospitalization services at the patient's request. Patients in the control group had no access to prevention programs such as Osarean, BetiOn or Active Patient, described in the intervention section. In addition, the illnesses were not approached holistically, but rather were treated independently by different specialists. Thus, there was no care coordination among the different specialists. Moreover, as the electronic health record (EHR) was not available for the control group, professionals had partial information of the patient.

2.3 | Intervention

The specific intervention for multimorbid patients consisted of the deployment of a chronic-care program with multidisciplinary teams that included new roles such as liaison nurse, case manager, nurse with advanced skills, and responsible internist. The latter is the reference professional for multimorbid patients admitted to hospital. It is not just the one who receives referrals, but also the responsible of coordinating care provided by different specialist while the patients is in hospital. Moreover, an extensive infrastructure of information and communications technologies was implemented based on the EHR and electronic prescriptions. Last, other services, such as telehealth and empowerment, were accessible. The most important ones were the telecare service called BetiOn which, among other purposes, served to connect patients with specialized professionals in case of emergency and to send information concerning health programs or reminders about medication;[24] Active Patient, the purpose of which was to address clinical and emotional dimensions by relying on expert training provided by health professionals to the patients or their caregivers;[25] and Osarean, which provided continuum of care to these patients outside working hours.[26] The intervention for multimorbid patients was deployed in late 2012 and throughout 2013.

2.4 | Data cleaning

The data controller verified from a randomly selected sample of 50 individuals which included both intervention and comparison patients that data from administrative and clinical databases were consistent with the information collected in the EHR. The accuracy of data related to social variables, diagnosis, and resource consumption was above 95 percent accurate. However, data related to mortality was not that accurate. In order to undergo that problem, we completed our data with the Spanish Mortality Registry.

2.5 | Statistical analysis

A statistical analysis was carried out to compare the operation of a chronic-care program (an integrated organizational model) in 2014 with a historical comparator representing the scenario in 2012. The statistical analysis was performed in a step-wise manner in *R* (version 3.2.2, https://www.r-project.org/foundation/). First, a univariate analysis was conducted to determine if there were sociodemographic and clinical differences by group. Fisher's exact test was applied for categorical variables and Student's *t* test for mean comparison in the case of age and follow-up. Second, resource consumption rates and costs were analyzed. Since mortality has a great impact on this population, rates were adjusted by follow-up. As the rates lacked a normal distribution and our sample showed a substantial probability mass at zero, standard approaches (mean comparison or test of location of the distribution by the Mann-Whitney *U* test) were not suitable. Therefore, for each service, we analyzed separately the risk for patients having no contact (Fisher's exact test) and the median rates for those who had at least one contact (Mann-Whitney *U* test). This approach was especially useful for interpreting data, because it gave insight into both the coverage of the program and the intensity of the intervention provided by PC to measure the implementation. Mean rates were included as additional information. Effectiveness could be estimated as the number of patients that decompensated and, therefore, were hospitalized at least once and the number of hospitalizations and in-hospital days for those admitted.

Subsequently, a multivariate analysis was carried out, which was preceded by a propensity score procedure to minimize selection bias.[27,28] Propensity score refers to the probability of patients being in the intervention group, depending on the observable covariables.[27] Although propensity score is a widespread technique, how to apply the matching is still controversial, since an inappropriate algorithm may increase the bias. We applied the genetic matching that uses an evolutionary search algorithm developed by Mebane and Sekhon to maximize the balance of observed covariates across matched treated and control units.[28] In our study, the matching was based on the following variables: continuous (age), dichotomous (sex, DM, heart failure, COPD, previous year hospitalization, death at the end of the follow-up, and eligibility through GP's clinical judgment) and categorical (risk score deciles). We identified the region of common support (Figure S1 in the technical appendix) and excluded

observations with a propensity score >0.625. Table S1 and Figure S2 in the technical appendix show the results after applying the propensity score. After that adjustment, the differences between the control and intervention groups regarding the probability of having contact with PC and hospitalization were studied with logistic regression. Then, generalized linear models were used to evaluate the differences in the frequency of PC contacts in those with at least one contact the number of hospitalizations for those admitted to the hospital and total costs.[29] Family and link were chosen according to the Akaike information criterion.[29] In both statistical procedures, sociodemographic and clinical data were included as covariables (gender, age, subjected to HF and COPD, follow-up and death at the end of the follow-up). Ultimately, in order to analyze the effect of the patient-centered strategy, all the interactions among the intervention/control variables and the eligibility (prioritized vs not prioritized) were included in the final regression model.

3 | RESULTS

The features of the population are described in Table 1. The total multimorbid population comprised 8329 patients in the baseline group (2012) and 8364 in the intervention group (2014). Approximately half of the patients (3558 in 2012 and 4225 in 2014) were prioritized by risk stratification and one-third (2704 in 2012 and 2761 in 2014) did not meet inclusion criteria. The rest of the individuals were excluded by the GPs. When we analyzed these results in terms of patient prioritization, we found that there were statistically significant differences for a 5 percent alpha level in the mean age of the groups at the beginning of the follow-up, as well as in the prevalence of the different disease combinations. The 2014 cohort was older, and the prevalence of those individuals who had DM and COPD decreased, while the prevalence of those who had HF and COPD or those who had all the conditions considered increased.

The probability of these patients having at least one contact with each of the services, as well as the average and median values of their visits to PC and hospitalizations, is displayed in Table 2. The cost of prioritized patients more than doubled the cost of not prioritized patients.

After applying the genetic matching (Table S2 and Figure S1), we carried out the multivariate analysis (Table 3). Subgroup analysis provided insight into eligibility criteria associated with significant changes between 2012 and 2014. Table 4 shows the adjusted odds ratio (OR) for 2014 in comparison with the control group in 2012. The full models are shown in Tables S2-S5. Patients who were prioritized in the program showed an increase in use of PC resources both in terms of probability of contact (OR: 2.10, CI: 1.70-2.39) and number of contacts (OR: 1.07, CI: 1.05-1.10), with a decrease in the probability of hospitalization (OR: 0.91, CI: 0.86-0.96) and in the number of hospitalizations (OR: 0.96, CI: 0.91-1.00) in 2014. For those patients that were not prioritized, the probability of contact with PC increased (OR: 1.64, CI: 1.27-2.39), while the number of contact decreased (OR = 0.95, IC = 0.92-0.97). In this group, the probability of hospitalization increased (OR: 1.19, CI: 1.09-1.30).

4 | DISCUSSION

In a before-and-after analysis using propensity score matching, a comprehensive, patient-centered, integrated care intervention was associated with a 9 percent lower risk of hospital admission among prioritized patients, but not among patients who were not prioritized to receive the intervention. Therefore, the hypothesis that the provision of early treatment in PC avoids hospitalizations was supported. A predictive model can reveal only which patients are at risk of a particular event. It cannot manage patients' care and prevent their deterioration or a hospital admission. Therefore, since a trade-off exists between the target population and the effectiveness of the intervention in preventing unplanned hospital admissions,[2] the

TABLE 1 Comparison of demographic and clinical features of multimorbid patients in 2012 (control group) and 2014 (intervention group)

	Multimorbid patients		Not prioritized multimorbid patients		Prioritized multimorbid patients	
	2012	2014	2012	2014	2012	2014
N	8239	8364	2704	2761	3558	4225
Age mean (SD)	78.90 (7.27)	79.38 (7.36)	77.61 (7.42)	77.89 (7.42)	79.20 (6.93)	80.17 (7.06)
Follow-up mean (SD)	0.92 (0.22)	0.92 (0.22)	0.95 (0.18)	0.95 (0.18)	0.94 (0.19)	0.90 (0.25)
Predictive Index (SD)	7.10 (3.14)	7.02 (2.76)	4.62 (1.47)	4.70 (1.64)	8.02 (2.44)	8.57 (2.41)
N (%)						
Male	5004 (61%)	5024 (60%)	984 (36%)	980 (36%)	2153 (61%)	2491 (59%)
DM&HF	2495 (30%)	2682 (32%)	592 (22%)	686 (25%)	1223 (34%)	1511 (36%)
DM&COPD	3.556 (43%)	3550 (42%)	1806 (67%)	1816 (66%)	1165 (33%)	1144 (27%)
HF&COPD	2188 (27%)	2132 (26%)	306 (11%)	259 (9%)	1170 (33%)	1570 (37%)
DM&HF&COPD	849 (10%)	836 (10%)	89 (3%)	74 (3%)	455 (13%)	677 (16%)
Death	1108 (13%)	1164 (14%)	261 (10%)	237 (9%)	365 (10%)	777 (18%)

COPD, chronic obstructive pulmonary disease; DM, diabetes mellitus; HF, heart failure; SD, standard deviation.

TABLE 2 Univariate analysis of resource consumption by multimorbid patients

	Multimorbid patients		Not prioritized multimorbid patients		Prioritized multimorbid patients	
	2012	2014	2012	2014	2012	2014
N and probability of having at least one contact with each service						
Primary care service	7829 (95%)	8117 (97%)*	2642 (98%)	2718 (98%)	3426 (96%)	4105 (97%)*
Hospitalizations	2881 (35%)	2978 (36%)	492 (18%)	584 (21%)	1592 (45%)	1971 (47%)
Number of contacts for each service for those who had at least one contact						
Mean rate (SD)						
Primary care service	33.7 (31.9)	35.1 (36.9)	26.4 (23.4)	26.4 (29.6)	37.0 (30.8)	43.7 (41.2)
Number of hospitalizations	3.3 (6.2)	3.1 (4.8)	2.6 (3.6)	2.5 (3.3)	2.9 (4.8)	3.3 (5.4)
Median rate (P25-P75)						
Primary care service	25.2 (15.0-42.0)	24.7 (14.0-43.1)	20.0 (13.0-32.0)	18.95 (11.0-31.1)	29.0 (18.0-46.0)	32.1 (18.2-53.2)*
Number of hospitalizations	2.0 (1.0-3.1)	2.0 (1.0-3.3)	1.0 (1.0-3.0)	1.0 (1.0-2.0)	2.0 (1.0-3.0)	2.0 (1.0-4.0)*
Mean total cost	4456.6 (11 047.5)	4259 (10 190.7)	2206.8 (7638.9)	2330.6 (7411.7)	4908.3 (10 375.3)	5892.6 (12 049.2)

*Difference is statistically significant for alpha 95%.

embeddedness of the risk stratification and the definition within a larger strategy were key issues in the success of the intervention. Moreover, our study shows a 5 percent reduction in mean costs among prioritized patients, while not prioritized patients mean cost increased by an 11 percent.

Despite the growing use of risk stratification tools based on predictive models in various health care systems,[19] there is little literature on its impact on health care systems. The accuracy of a predictive model has been debated by the model developers using techniques such as split-sample and bootstrapping.[2] However, what decision makers and clinicians need is evidence that supports the predictive model's use.[30] As discussed earlier, the identification of patients at risk of decompensation cannot by itself reduce hospital admissions, yet it should change professional behavior toward patient assistance. Despite the challenge of the program involving as many as 1495 GPs and 1495 nurses who needed to adapt their working dynamic to take care of the multimorbid patients,[31] the results showed that the risk stratification helped with the implementation of the intervention. In those patients that were prioritized by the risk stratification, the probability of contact with PC services considerably increased (OR = 2.01, CI: 1.70-2.39) and the number of contacts increased by 7 percent (OR = 1.07, CI = 1.05-1.10). In contrast, the probability of contact with PC had a lower increase (OR = 1.64, CI: 1.27-2.13), and the number of contacts decreased by 5 percent (OR = 0.95, CI: 0.92-0.97) in those that were not prioritized.

In terms of effectiveness, evidence for multimorbid patients is scarce, and examples can hardly be compared, since the criteria and procedures for identification of these patients are diverse.[4,16,32] The literature shows that it is difficult to support the hypothesis that empowering PC reduces hospital use.[18,33,34] Similar to our study, the systematic review carried out by Smith et al[8] found five organizational studies that reported outcomes of health services utilization.[35-39] Among those, only two approaches[35,37] were comparable to our study. Sommers et al[37] reported improvements for participants in the intervention group across a variety of measures relating to hospital admissions, whereas Boult et al[35] did not find statistically significant differences. However, Boult et al[35] reveal two main limitations that were addressed in our study. First, they pointed out limitations on the selection of patients who were most likely to benefit from the integrated care. In the Basque Country, this issue was managed by the strategy of RSFC. This process of patient identification is objective and can be transferred to other settings with universalized national systems like the United Kingdom. Second, Boult et al[35]argue that in their study, "there were few penalties or rewards that provided consistent incentives for teams to improve the quality and outcomes of care" disclosing a possible lack of implementation. If we had analyzed only multimorbid patients as a whole, we would not have achieved satisfactory results, since the risk of hospitalization would have remained constant. Yet, the decision to separate our analysis into those patients prioritized by the strategy (and, therefore, more likely to be treated proactively) from those that were not prioritized allowed us to prove that only when the intervention is implemented sufficiently is it likely to be effective. Finally, these approaches seem to be assimilated more readily in more "well-developed" organizations. This is supported by the fact that both Osakidetza and Kaiser-Permanente (the group that seemed more effective in the study by Boult et al[35] have both

TABLE 3 Determinants of the probability and number of contacts with primary care and hospitalizations among the whole multimorbid population sample (16 603 patients; 8239 in the control group and 8364 in the intervention group)

	AOR	
	Probability of contact[a]	Number of contacts[b]
Primary care		
2014 Group	1.87 (1.68-2.08)	0.99 (0.97-1.01)
Female	0.74 (0.67-0.83)	1.07 (1.05-1.09)
Age ≥80	0.53 (0.47-0.59)	1.11 (1.09-1.13)
DM&HF vs those with all three diseases	0.86 (0.72-1.02)	0.86 (0.83-0.88)
DM&COPD vs those with all three diseases	1.03 (0.85-1.23)	0.67 (0.65-0.69)
HF&COPD vs those with all three diseases	0.74 (0.61-0.89)	0.85 (0.82-0.88)
Death	4.21 (2.98-6.04)	1.34 (1.27-1.41)
Follow-up (mo)	1.44 (1.39-1.49)	0.95 (0.94-0.96)
Hospitalization		
2014 Group	0.99 (0.95-1.03)	0.99 (0.97-1.02)
Female	0.97 (0.92-1.01)	0.97 (0.94-1.00)
Age ≥ 80	1.13 (1.08-1.19)	0.91 (0.88-0.93)
DM&HF vs those with all three diseases	0.48 (0.45-0.52)	0.85 (0.82-0.89)
DM&COPD vs those with all three diseases	0.32 (0.30-0.35)	0.79 (0.76-0.82)
HF&COPD vs those with all three diseases	0.66 (0.61-0.71)	0.90 (0.86-0.94)
Death	8.52 (7.40-9.83)	0.96 (0.91-1.01)
Follow-up (mo)	1.14 (1.12-1.16)	0.84 (0.83-0.85)

AOR, adjusted odds ratio; COPD, chronic obstructive pulmonary disease; DM, diabetes mellitus; HF, heart failure.
[a]By logistic regression.
[b]By generalized linear models.

TABLE 4 Subgroup analysis: Difference in resource consumption between intervention (2014) and control (2012) groups depending on interaction among prioritization groups

	Not prioritized	Prioritized
N	5465	7783
Probability of contact with PC	1.64 (1.27-2.13)	2.01 (1.70-2.39)
Number of contacts with PC	0.95 (0.92-0.97)	1.07 (1.05-1.10)
Probability of hospitalizations	1.19 (1.09-1.30)	0.91 (0.86-0.96)
Number of hospitalizations	1.02 (0.93-1.11)	0.96 (0.91-1.00)
Total costs	1.11 (1.04-1.18)	0.95 (0.90-1.00)

a sophisticated, interoperable electronic medical record system and a medical center model that includes a variety of health services, which are manifestations of a well-established culture that promotes team care.

As this is an observational study, its internal validity is weaker than in randomized clinical trials. However, this design using data from the administrative and clinical databases takes into account the context of health care provision. It measures the effectiveness of the intervention in a real-world situation, not in a laboratory environment. In randomized control trials, clinicians take a clearly differentiated attitude toward the patients, depending on whether they are in the intervention group. Yet, GPs implement integrated programs according to the identification of the specific needs of each patient, which determines a diffuse deployment of the intervention. Moreover, decision makers involved with establishing guidelines for coverage and payment are developing policies based on information from "real-world" outcomes.[40,41] At the same time, the large sample size in this study provided insight into which intervention was most effective in which population subgroup. The possible biases associated with the study design were addressed with statistical tools such as genetic matching,[28] logistic regression, and generalized linear models.[29] However, our study design solved the heterogeneity in observed variables, and it did not address the unobserved heterogeneity consisting in any difference in unobserved features of the intervention and control group, which could be associated to the hospitalization rate. As the social, economic, and health care access factors did not change meaningfully between 2012 and 2014 and the propensity score achieved a good balance, this actual limitation does not seem to threaten the findings of the study. Other limitation to be underlined is the lack of addressing the effect of attrition. Death was the only event recorded to finish the follow-up. Though it was not included in the propensity score, we could check that it was balanced after it. This way, we lost patients who moved to other regions but we know that migration from the Basque Country to other regions is very rare in the elderly.[42] Now that electronic health records facilitate access to data to assess the operation of the health system, it is even more necessary to highlight the importance of using procedures that will improve the validity of the results.

5 | CONCLUSIONS

A comprehensive, patient-centered, integrated care intervention which included both a stratification strategy and an integrated care intervention was associated with a lower risk of hospital admission among prioritized patients, but not among patients who were not prioritized to receive the intervention.

ACKNOWLEDGMENTS

Joint Acknowledgment/Disclosure Statement: This work has been developed within Carewell project. CareWell project is co-funded by

the European Commission within the ICT Policy Support Programme of the Competitiveness and Innovation Framework Programme (CIP). Grant Agreement No.: 620983. The study was also supported by the Spanish Health Economic Association Grant.

We would like to acknowledge support provided by Stephen O'Neill regarding Genetic Matching. We would like to acknowledge the English-language editorial assistance provided by Sally Ebeling and the comments provided by Jesus Millas, Mariluz Jauregui, Ricardo San Vicente, and Patxi Urbe.

CONFLICT OF INTEREST

All authors have completed the ICMJE uniform disclosure form and declare no support from any organization for the submitted work, no financial relationship with organizations that might have an interest in the submitted work in the previous three years, and no other relationship or activities that could appear to have influenced the submitted work.

AUTHOR CONTRIBUTIONS

MSG designed the study, with the assistance of JM and AA. MSG and AA performed the statistical analysis and wrote the initial draft, with the assistance of JM. EM and AF, and MM participated in the design, reviewed all the clinical and epidemiological data, and drafted the introduction and conclusion. All authors had full access to all of the data (including statistical reports and tables) in the study and take responsibility for the integrity of the data and the accuracy of the data analysis.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

The protocol was approved by the Basque Ethics Committee (Ref PI2014200).

CONSENT FOR PUBLICATION

Anonymized patient-level data were used so that patients were unidentifiable, and thus, consent for publication was not needed.

AVAILABILITY OF DATA AND MATERIAL

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

DATA SHARING STATEMENT

We have included supplementary material that includes more detailed results and the RECORD checklist.

PATIENT INVOLVEMENT STATEMENT

Patients were not involved in the research.

ORCID

Myriam Soto-Gordoa http://orcid.org/0000-0002-3582-4283

REFERENCES

1. World Health Organization (WHO). The World Health Report 2008 – primary Health Care (Now more than ever). 2008. http://www.who.int/whr/2008/en/. Accessed June 10, 2017.
2. Lewis G, Curry N, Bardsley M. Choosing a predictive risk model: a guide for commissioners in England. November 2011. https://www.nuffieldtrust.org.uk/resource/choosing-a-predictive-risk-model-a-guide-for-commissioners-in-england. Accessed June 10, 2017.
3. MacAdam M. Frameworks of integrated care for the elderly: a systematic review. 2008. http://www.integrationresources.ca/wordpress/wp-content/uploads/2013/08/Frameworks-of-Integrated-Care-for-the-Elderly.pdf. Accessed January 16, 2017.
4. Vondeling H. Economic evaluation of integrated care: an introduction. *Int J Integr Care*. 2004;4:e20.
5. Mora J, Iturralde MD, Prieto L, et al. Key aspects related to implementation of risk stratification in health care systems-the ASSEHS study. *BMC Health Serv Res*. 2017;17(1):331.
6. Nolte E, Pitchforth E. What is the evidence on the economic impacts of integrated care? 2014.
7. Nuño-Solinís R. Revisiting organisational learning in integrated care. *Int J Integr Care*. 2017;17(4):4.
8. Smith SM, Wallace E, O'Dowd T, Fortin M. Interventions for improving outcomes in patients with multimorbidity in primary care and community settings. *Cochrane Libr*. 2016.
9. Bowen DJ, Kreuter M, Spring B. How we design feasibility studies. *Am J Prev Med*. 2009;36:452-457.
10. de Manuel Keenoy E, David M, Mora J, et al. Activation of Stratification Strategies and Results of the interventions on frail patients of Healthcare Services (ASSEHS) DG Sanco Project No. 2013 12 04. *Eur Geriatr Med*. 2014;5(5):342-346.
11. Dorfman R, Khayat Z, Sieminowski T, Golden B, Lyons R. Application of personalized medicine to chronic disease: a feasibility assessment. *Clin Transl Med*. 2013;2(1):16.
12. Kansagara D, Englander H, Salanitro A, et al. Risk prediction models for hospital readmission: a systematic review. *JAMA*. 2011;306(15):1688-1698.
13. Orueta J, Aldasoro E, Nuño-Solinis R, Alday-Jurado A, Gutiérrez-Fraile E, García-Álvarez A. Prevalencia de cronicidad y multimorbilidad en la población cubierta por el servicio público de teleasistencia de Euskadi: impacto en costes y calidad de la atención. *An Sist Sanit Navar*. 2013;36:429-440.
14. Orueta J, Nuño-Solinis R, Mateos M, Vergara I, Grandes G, Esnaola S. Predictive risk modelling in the Spanish population: a cross-sectional study. *BMC Health Serv Res*. 2013;13(1):269.
15. Fabbricotti I. Integrated care in Europe: description and comparison of integrated care in six EU countries. *Int J Integr Care*. 2003;3:e05.
16. Kodner DL, Spreeuwenberg C. Integrated care: meaning, logic, applications, and implications – A discussion paper. *Int J Integr Care*. 2002;2:e12.
17. Gill TM, Gahbauer EA, Allore HG, Han L. Transitions between frailty states among community-living older persons. *Arch Intern Med*. 2006;166(4):418-423.
18. Campbell M, Fitzpatrick R, Haines A, et al. Framework for design and evaluation of complex interventions to improve health. *BMJ*. 2000;321(7262):694.
19. Nuño-Solinís R, Contel Segura J, Orueta Mendia J, García Alvarez A, Lewis G. Development and implementation of risk stratification

tools: Practical tools to identify patients with complex needs. *O Berri Work Pap*. 2013;1.
20. National Institute for Clinical Excellence – NICE. NICE guideline: Multimorbidity: clinical assessment and management. https://www.nice.org.uk/guidance/ng56/resources/multimorbidity-clinical-assessment-and-management-pdf-1837516654789. Published September 21, 2016. Accessed July 5, 2017.
21. Barnett K, Mercer SW, Norbury M, Watt G, Wyke S, Guthrie B. Epidemiology of multimorbidity and implications for health care, research, and medical education: a cross-sectional study. *Lancet*. 2012;380:37-43.
22. Marengoni A, Angleman S, Melis R, et al. Aging with multimorbidity: a systematic review of the literature. *Ageing Res Rev*. 2011;10(4):430-439.
23. Robert Wood Johnson Foundation, Johns Hopkins Bloomerang School of Public Health. Chronic care: making the case for ongoing care. 2010. http://www.rwjf.org/content/dam/farm/reports/reports/2010/rwjf54583. Accessed June 3, 2017.
24. Irekia. ¿Quieres conocer el servicio de teleasistencia BetiOn? http://www.irekia.euskadi.eus/es/news/8419. Published December 6, 2011. Accessed August 9, 2016.
25. Osakidetza. ¿Qué es el Programa Paciente Activo? https://www.osakidetza.euskadi.eus/pacienteactivo/. Published October 14, 2013. Accessed September 17, 2015.
26. Bengoa M. Proyecto Osarean "Osakidetza no presencial." http://www.socinfo.es/contenido/seminarios/1327vasco5/MartinBegona.pdf. Published 2013. Accessed September 7, 2016.
27. Austin PC. An Introduction to propensity score methods for reducing the effects of confounding in observational studies. *Multivar Behav Res*. 2011;46(3):399-424.
28. Diamond A, Sekhon JS. Genetic matching for estimating causal effects: a general multivariate matching method for achieving balance in observational studies. *Rev Econ Stat*. 2012;95(3):932-945.
29. Glick HA, Doshi JA, Sonnad SS, Polsky D. *Economic Evaluation in Clinical Trials*, 2nd edn. Oxford, UK: Oxford University Press; 2014.
30. Sauto Arce R, Saenz De Ormijana A, Orueta JF, Gagnon M-P, Nuño-Solinís R. A qualitative study on clinicians' perceptions about the implementation of a population risk stratification tool in primary care practice of the Basque Health Service. *BMC Fam Pract*. 2014;15(1):150.
31. Kilsdonk E, Peute LW, Jaspers MWM. Factors influencing implementation success of guideline-based clinical decision support systems: a systematic review and gaps analysis. *Int J Med Inf*. 2017;98:56-64.
32. Coulter A. Shifting the balance from secondary to primary care. *BMJ*. 1995;311(7018):1447.
33. Byford S, Sefton T. Economic evaluation of complex health and social care interventions. *Natl Inst Econ Rev*. 2003;186(1):98-108.
34. Coderch J, Pérez-Berruezo X, Sánchez-Pérez I, et al. Evaluación de la efectividad de un programa de atención integrada y proactiva a pacientes crónicos complejos. *Gac Sanit*. 2018;32:18-26.
35. Boult C, Reider L, Leff B, et al. The effect of guided care teams on the use of health services: results from a cluster-randomized controlled trial. *Arch Intern Med*. 2011;171(5):460-466.
36. Hogg W, Lemelin J, Dahrouge S, et al. Randomized controlled trial of anticipatory and preventive multidisciplinary team care. *Can Fam Physician*. 2009;55(12):e76-e85.
37. Sommers LS, Marton KI, Barbaccia JC, Randolph J. Physician, nurse, and social worker collaboration in primary care for chronically ill seniors. *Arch Intern Med*. 2000;160(12):1825-1833.
38. Katon W, Russo J, Lin EH, et al. Cost-effectiveness of a multicondition collaborative care intervention: a randomized controlled trial. *Arch Gen Psychiatry*. 2012;69(5):506-514.
39. Krska J, Cromarty JA, Arris F, et al. Pharmacist-led medication review in patients over 65: a randomized, controlled trial in primary care. *Age Ageing*. 2001;30(3):205-211.
40. Garrison LPJ, Neumann PJ, Erickson P, Marshall D, Mullins CD. Using real-world data for coverage and payment decisions: the ISPOR Real-World Data Task Force report. *Value Health*. 2007;10(5):326-335.
41. Makady A, Ham RT, de Boer A, Hillege H, Klungel O, Goettsch W. Policies for use of real-world data in health technology assessment (HTA): a comparative study of six HTA agencies. *Value Health*. 2017;20(4):520-532.
42. Eustat. Euskal Estatistika Erakundea. *Panorama Demográfico 2014*. http://www.eustat.eus/elementos/ele0012200/Panorama_demografico_2014/inf0012240_c.pdf. Accessed September 3, 2018.

SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of the article.

How to cite this article: Soto-Gordoa M, de Manuel E, Fullaondo A, et al. Impact of stratification on the effectiveness of a comprehensive patient-centered strategy for multimorbid patients. *Health Serv Res*. 2019;54:466–473. https://doi.org/10.1111/1475-6773.13094