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Relevance of clinical judgement and risk stratification in the success of integrated care for multimorbid patients*

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Este paper ha recibido el premio al mejor artículo presentado en las XXXVII Jornadas de Economía de la Salud por un investigador joven, patrocinado por la Cátedra Fedea – CaixaBank de Economía de la Salud y Hábitos de Vida

fedea

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El reto de la cronicidad está modificando el modelo de prestación de servicios sanitarios y sociales y el rol que pueden desempeñar sus diferentes agentes para asegurar la sostenibilidad del sistema y mejorar así la atención a los pacientes crónicos. Existe un amplio consenso que esto se debe realizar a través de modelos de atención integrada, ya que se asume que el empoderamiento de los pacientes y la atención proactiva de los profesionales mejoran los resultados funcionales y clínicos. No obstante, debido a la alta prevalencia de patologías crónicas, es inviable la monitorización de todos estos pacientes. Así, la identificación de la población diana juega un papel clave en el éxito de los programas integrados. En el País Vasco se han utilizado dos estrategias de identificación de pacientes pluripatológicos. Por una parte, el departamento puso en marcha una estrategia de estratificación basada en algoritmos matemáticos. Y por otro lado, permitía a los clínicos que incluyeran a aquellos pacientes que ellos consideraban susceptibles de beneficiarse del programa. Se ha demostrado que el programa es efectivo cuando los identifica el médico, independientemente si son captados también a través de la estrategia de estratificación; pero que no ocurre lo mismo cuando son identificados únicamente a través de la estrategia de estratificación. Esto se debe a que los pacientes identificados por la vía de la estratificación están sujetos a mayor riesgo y que, a pesar de aumentar considerablemente la probabilidad de ser atendidos al menos una vez en atención primaria, la intensidad de la intervención disminuye en este grupo. No obstante, la estratificación es de gran importancia porque presumiblemente juega el rol de catalizador.

Working-paper

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PATIENT INVOLVEMENT STATEMENT

Patients were not involved in the research.

ABSTRACT

OBJECTIVE

To assess the impact of the inclusion criteria for the integrated-care model for multimorbid patients on the effectiveness of a population-level intervention carried out in the Basque Country (Spain).

DATA SOURCE

Clinical and administrative databases

STUDY DESIGN

Observational study with an historical control group. The change in resource consumption in primary care and hospital care were considered as an indicator of implementation and effectiveness. A propensity score by a genetic matching approach was used to minimize bias. Generalized linear models were used to analyse relationships among variables.

DATA COLLECTION

We included all eligible patients at the beginning of the year and followed them either until they died or until the follow-up period concluded (end of the year). The control group (2012) totalled 8,239 patients, and 8,364 patients were in the intervention group (2014).

PRINCIPAL FINDING

In cases in which the general practitioner's clinical judgement agreed with the risk stratification for case finding, the patients' primary care contacts were increased and in-hospitalizations were reduced.

CONCLUSION

The intervention achieved its objective in those multimorbid patients that could benefit from increased assistance but did not require palliative care.

KEY WORDS

Integrated care, multimorbidity, propensity score, primary care, identification of target population

INTRODUCTION

In order to face the challenge of managing disease chronicity, wide consensus exists to orient health organizations towards a patient-centred continuum-of-care approach through integrated health interventions (MacAdam 2008). Yet, evidence supporting specific interventions for multimorbid patients is scarce (Coulter 1995; Kodner and Spreeuwenberg 2002; Vondeling 2004). Evaluation of integrated care interventions is challenging, since they are characterized by their complexity. They are developed from a number of components, which may act both independently and interdependently and involve behavioural change in those either delivering or receiving the intervention (Campbell et al. 2007; Craig et al. 2008). So, the main challenge in evaluating complex interventions arises because the success of the intervention depends not only on the intrinsic effectiveness of the intervention but also on its implementation (Campbell et al. 2000). When individuals are required to adopt a new professional role as part of an intervention (Greenhalgh et al. 2004; Rogers 2010), success of the implementation is related to the characteristics of the organization (centralization, formalization, resource availability, etc.). The Medical Research Council encourages studying contextual factors in order to make interventions generalizable (Craig et al. 2008; Glasgow 2008). Moreover, the recent availability of clinical and administrative databases that include both clinical and administrative information makes possible the evaluation of interventions as they are implemented in everyday practice (Garrison et al. 2007; West et al. 2008).

The Department of Health of the Basque Government launched in 2010 the “Strategy to tackle the challenge of chronicity in the Basque Country” (J.F. Orueta et al. 2013), which aimed to re-orient the health system towards an integrated care model and, therefore, towards a patient-centred approach. It is managed by the Basque Health Service through 12 Integrated Healthcare Organizations (IHO) that care for 2.2 million inhabitants. As various chronic conditions often coexist, patients with multimorbidity represented a key target population for this strategy. The patient-centred strategy pivoted around two axes. First, given the high prevalence of chronic conditions, it is not feasible to monitor all patients with chronic diseases. So, identification of a target population plays a key role in the success of integrated programmes. For this purpose, the Department of Health started an initiative in 2011 for risk stratification for case finding in which patients were identified on the basis of Adjusted Clinical Groups (ACGs).

At the same time, a complementary bottom-up approach was applied based on general practitioner's (GPs') clinical judgement. Thus, GPs could also identify and include cases in the multimorbid patients group. Second, in late 2012, a specific intervention for multimorbid patients was developed based on the creation of multidisciplinary teams and new professional roles, as well as an extensive infrastructure of information and communications technology (ICT). This rationale reflected the hypothesis that empowering primary care (PC) services enabled the provision of early treatment that kept the patient's condition stable longer. Consequently, acute decompensation could be avoided, and therefore, the patient's quality of life would be improved, and hospital resources would be released (Fabbricotti 2003; Kodner and Spreeuwenberg 2002; Gill et al. 2006). Additionally, this study emerged in the context of the participation of the Basque Country in the CareWell project, a European project that aimed to determine the best response to the complex needs of multimorbid patients (Carewell group n.d.).

Given the high prevalence of chronic conditions**,** it is not feasible to monitor all patients with chronic diseases. So, the identification of target population plays a key role in the success of integrated programmes. The objective of this work was to assess the impact of the inclusion criteria for the integrated care model for multimorbid patients on the effectiveness of a population-level intervention in 2014 compared with the baseline scenario in 2012.

METHODS

We carried out a retrospective observational study with an historical control group with data from the clinical and administrative databases of the Basque Health Service. These databases contained patient-level data and were managed in an anonymised manner. Data from 2012 comprised a historical comparator group, and data from 2014 comprised the intervention group. The current literature on integrated care measurement points out the important distinction between the measurement of structure and process (i.e., implementation and extent of achieving integration) and the measurement outcomes (i.e., evidence of effectiveness) (Bautista et al. 2016; Soto-Gordoa et al. 2017). As the intervention's aim was to empower PC services to allow release of hospital services, the change in resource consumption in PC services was taken into account as an indicator of implementation. In contrast, effectiveness of the intervention was measured by use of hospital services.

Intervention

The specific intervention for multimorbid patients consisted in the deployment of multidisciplinary teams that included new roles such as the liaison nurse, case manager, advanced skilled nurse, reference internist, and an extensive infrastructure of ICTs based on the electronic health record (EHR) and electronic prescriptions. Additionally, other services, such as telehealth and empowerment were accessible. The most important ones were the telecare service called BetiOn which, among others, serves to connect patients with specialized professionals in case of emergency and to send information concerning health programmes or reminders about medication (Irekia 2011), 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 (Osakidetza n.d.), and Osarean, which provided continuum of care to these patients outside working hours (Bengoa 2013). The intervention for multimorbid patients was developed in late 2012 and 2013.

Study population and variables

The study population was individuals with multimorbidity and complexity over 65 years old in the Basque Country. Multimorbidity was defined as having two or more 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 intervention group was the population identified as multimorbid in 2014 (8,372 patients). The comparator group was the multimorbid patient population in 2012 (8,246 patients). In late 2012 and 2013 the intervention was launched, so from that moment onwards, we considered the intervention to be implemented. We included all eligible patients at the beginning of the year and followed them until they died or until the follow-up period concluded (end of the year). The comparator group was a baseline group, as the intervention had not been deployed yet.

To measure effectiveness, outcomes that were relevant to patients and health services, that is, hospital admission, were assessed (NICE guideline 2016). As the intervention's aim was to empower PC services so that hospital services could be released, the change in resource consumption in PC services was identified as an indicator of implementation (Gill et al. 2006). Accordingly, the contacts with GPs and PC nurses in any of the possible modalities (health

centre, home and telephone) and Accident and Emergency (A&E) department visits and in-hospital stays due to medical causes were recorded.

In order 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 eligibility according to GPs' clinical judgement and according to criteria for risk stratification for case finding (Juan F. Orueta et al. 2013). The risk stratification for case finding was based on the ACG system (Robert Wood Johnson Foundation and Johns Hopkins Bloomerang School of Public Health 2010; Anon n.d.) that measures the morbidity burden of patient populations on the basis of disease patterns, age and gender. It 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 stratified population. Higher risk predicted greater costs for the health care system. The 5% of patients in the apex of the pyramid were eligible for the multimorbid integrated care intervention. The process of obtaining the risk score is explained extensively elsewhere (Juan F. Orueta et al. 2013). At least one hospitalization in the previous year was also part of the inclusion criteria. On the other hand, the GPs could include patients in the programme according to their own clinical judgement, which was considered as a different variable. For more in depth subgroup analysis, four different groups of patients were identified depending on patients' eligibility for the intervention and its origin, namely, the GPs clinical judgement or the risk stratification for case finding: none, one of each of them or both of them considered the patient eligible.

Data cleaning

The values were revised to be consistent. A sample of 50 patients was selected, and the data controller verified from the medical records that the data were correct.

Cost calculations

Costs for each patient were calculated as the multiplication of resource use and unit costs. The accounting department in the Basque Health Service headquarters supplied the unit cost for each resource, which is described in the Annex included as supplementary material (Table S1).

Statistical analysis

A statistical analysis was carried out to compare the operation of an integrated organizational model in 2014 with a historical comparator representing the scenario in 2012. The statistical analysis was performed in R (version 3.2.2) in various steps. 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 were analysed. Since mortality has a great impact in 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. Alternatively, for each service, we analysed 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-U Whitney test). This approach was especially useful for interpreting data, because it gave insight into both the coverage of the programme and the intensity of the intervention provided by PC to measure the implementation. Mean rates were included as additional information. In the event of hospitalization, instead of the median and mean rates of contacts, median and mean values for hospital stays were provided. Thus, effectiveness could be estimated as the number of patients that decompensated and, therefore, were hospitalized at least once and the number of 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 (Austin 2011; Diamond and Sekhon 2012). The propensity score refers to the probability of patients being in the intervention group, depending on the observable covariables (Austin 2011). 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 (Diamond and Sekhon 2012). In our study, the matching was based on 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 judgement) and categorical (risk score deciles) variables. After that adjustment, first, the differences between the control and intervention groups in the probability of having contacts with PC and

hospitalization were studied with logistic regression. Second, generalized linear models were used to evaluate the differences in the frequency of PC contacts in those with at least one contact with PC and the stay in days for those admitted to the hospital (Glick et al. 2014). Family and link were chosen according to the Akaike information criterion (Glick et al. 2014). 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). Eligibility and origin of patient recruitment (population based risk algorithm or clinical assessment) were also considered. Last, in order to analyse the effect of the intervention for different subgroups, all the interactions among the intervention/control variables and the origin of the inclusion criteria were included in the final regression model.

RESULTS

The target population comprised 8,239 patients in the baseline group (2012) and 8,364 in the intervention group (2014), and their features are described in Table 1. There were statistically significant differences for a 5% alpha level in the mean age of the groups at the beginning of the follow-up, as well as in the prevalence of COPD and clinical judgement inclusion criteria. The 2014 cohort was older, the prevalence of COPD slightly lower and the inclusion of patients by clinical judgement increased. This table also shows differences in the identification of multimorbid patients between 2012 and 2014. The most outstanding changes were related to the percentage of individuals that were solely identified by risk stratification for case finding. This percentage decreased from 20% to 9%. The percentage of individuals that were identified by both approaches (risk stratification for case finding and clinical judgment) increased from a 35% to a 42%.

The probability of having at least one contact with each of the services, as well as the average and median values of visits these patients had to PC and A&E and the in-hospital stays, are displayed in Table 2. Considering the resource consumption use by identification group, those solely identified by risk stratification for case finding had the lowest probability of having a contact with PC (90%) and that those who were not identified as multimorbid by any the identification strategies had the lowest risk of hospitalization (20%).

After applying the genetic matching (Table S2 and Figure S1 in the supplementary material), we carried out the multivariate analysis. Gamma family and log link were selected for the GLMs

according to the Akaike Information Criteria (Glick et al. 2014).Table 3 shows the adjusted odds ratios (OR) for the probability of a contact with PC and in-hospitalization, as well as frequency of PC visits and hospital stays for patients with at least one contact.

Subgroup analysis provided insight into which inclusion criteria were associated with significant changes between 2012 and 2014. For the same dependent variables than in previous multivariate analysis, Table 4 includes the subgroups analysis according to the eligibility origin. It shows the adjusted OR for 2014 in comparison with the control group in 2012. The full models are shown in table S3 in the supplementary material. Patients who were included in the programme by both eligibility criteria showed changes in agreement with the objectives, as they demonstrated an increase in use of PC resources both in terms of probability of contact (OR: 1.85, CI: 1.68-2.04) and number of contacts (OR: 1.01, CI: 1.00-1.03), with a decrease in the probability of hospitalization in 2014 (OR: 0.85, CI: 0.82-0.88). For those patients that were eligible only in a GP's clinical judgement, the rate of contact increased 21% (OR=1.21, IC=1.17-1.25), while the probability of contact remained stable (OR=0.99, IC=0.78-1.26) and the probability of hospitalization decreased (OR=0.88, IC=0.81-0.95). However, for those that were eligible only according to the risk stratification case finding, the probability of contact in PC increased considerably (OR=2.72, IC=2.28, 3.25), the rates of contact decreased (OR=0.93, IC=0.90-0.96) and the risk of hospitalization increased (OR=1.17, IC=1.11-1.36).

Figure 1 shows the percentage of patients identified through clinical judgement and risk stratification inclusion criteria for each risk score decile group. Both identification criteria strategies identify as eligible for the integrated programme for multimorbid patients a greater percentage of individuals in the higher risk scores. Nonetheless, GPs' clinical judgement considers a range of individuals suitable for the programme in the lowest risk score groups that the risk stratification for case finding does not contemplate. And, on the contrary, GPs do not consider part of the individuals identified by the risk stratification eligible for the intervention.

DISCUSSION

Our work supports the hypothesis that the provision of early treatment in PC avoids hospitalizations in cases of multimorbid patients eligible for the integrated care intervention according to both the GP's clinical judgement and the risk stratification for case finding. However, at the population level the programme did not produce all the expected results.

Implementation of a complex intervention relies on behavioural changes that are often subjected to learning curves (Greenhalgh et al. 2004). Furthermore, the theory of the diffusion process highlights the importance of involving, in addition to innovators and early adopters, the early majority to reach the turning point in change (Rogers 2010). In our situation, a challenging aspect was that the programme involved as many as 1495 GPs and 1495 nurses who took care of the multimorbid patients and needed to adopt their working dynamic (Kilsdonk, Peute, and Jaspers 2017). So, as the follow-up was 2 years, it was too soon to make a conclusive statement regarding the success of the intervention. Nevertheless, in spite of the short intervention period, the integrated programme achieved 15% reduction in the probability of hospital admission in those patients that were eligible according both to clinical judgment and risk stratification. On the one hand, the intervention may be effective in this subgroup of the population because clinicians' engagement is higher in patients that are explicitly identified as multimorbid. And, on the other hand, the success in this subgroup might be related to the patients' intrinsic characteristics (Wagner 2001).

In terms of clinicians' engagement, not only was the probability of contact relevant, but also the number of visits to GPs had to achieve a figure above a certain threshold. Those marked as multimorbid by the risk stratification for case finding approach did not achieve a reduction in the risk of hospitalization (in fact, the risk increased with an OR=1.17, IC=1.08-1.26), even though the probability of being seen by PC professionals increased significantly (OR=2.72, IC=2.28-3.25). This may be because the number of contacts with PC decreased (OR=0.93, 0.90-0.96). In contrast, those patients selected only by the GPs or selected by both GPs and risk stratification for case finding maintained a balance between the probability of contact in PC and the number of visits, which resulted in a decrease in the risk of hospital admission. Taking into account that the probability of contact was far lower in the baseline (OR=0.45, CI=0.42-0.50), another possible explanation is that despite the fact that in 2014 the probability of contact almost tripled (OR=2.72, CI=2.28-3.25) it did not achieve the needed threshold to succeed.

We could expect the programme to be successful in more severely affected patients defined by a higher risk score. Nevertheless, according to Figure 1, GPs did not consider a number of the patients with greater risk of resource use to be eligible. On the contrary, they included a group of low-risk patients into the target population. A possible explanation may be that GPs consider

the most severely ill patients suitable for palliative care, rather than for a monitoring programme (Lanzeta, Mar, and Arrospide 2016).

The transferability of our results relies on the possibility of the intervention to be delivered elsewhere (Bonell et al. 2006) and on the identification of the target population. Therefore, we cannot state that this conclusion is directly generalizable to other countries and settings. However, the approach to boost implementation by engaging health care professionals into a more proactive and intensive care approach looks plausible in other countries with universalized national health systems like the UK. The challenge arises on finding mechanisms that help identifying those could benefit from increased assistance but did not require palliative care.

The definition of the target population is a key issue in the planning of integrated care programmes. According to data of the Organisation for Economic Co-operation and Development, the percentage of elderly people has increased by 11% in the last 10 years, reaching 18% in 2014 in the European Union (OECD Data n.d.). If this trend continues, the prevalence of multimorbid patients will also increase, which may threaten the sustainability of such an approach to care in cases of multimorbidity. Programmes aiming to respond to needs of such big and heterogeneous populations should evolve towards different action plans regarding patients' characteristics. Our work provides evidence that in the subgroup selected by both clinical judgement and risk stratification for case finding the programme can effectively reach its objectives.

Evidence of specific interventions for multimorbid patients is scarce, and examples can hardly be compared, since the criteria and procedures for identification of these patients are diverse (Coulter 1995; Kodner and Spreeuwenberg 2002; Vondeling 2004). Nevertheless, the literature shows that it is difficult to support the hypothesis that empowering PC reduces hospital use (Byford and Sefton 2003; Campbell et al. 2000; Coderch et al. 2016). In line with our results, the systematic review carried out by Smith et al (Smith et al. 2012), found that only 1 of 10 studies showed significant improvement across various measures related to hospital admissions, although numbers of admissions were small in most studies. Authors of three studies reported on visits to a range of health service providers, but none showed significant changes in health service use (36–38). One of four patient-oriented studies demonstrated outcomes for health service utilization and found significant improvements across various measures related to

hospital admissions (Lorig et al. 1999). However, no researchers have carried out a subgroup analysis to narrow the target population who can objectively benefit from the intervention. Transferability of results is only possible if the key features that support the success of the programme are identified.

As this is an observational study the internal validity of this study is weaker than in randomized clinical trials. However, this design using data from the administrative and clinical databases take into account the actual health care provision circumstances. It measures the effectiveness of the intervention in a real world situation, not in lab environment. In randomized control trials clinicians take a clearly differentiated attitude toward the patient depending on whether they are in the intervention group or not. Yet, GPs implement integrated programmes according to the specific needs that they identify in each patient which determine 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 (Garrison et al. 2007; Makady et al. 2017). At the same time, the large sample size in this study provided insight into which population subgroup the intervention was most effective. The possible biases associated with the study design were addressed with statistical tools such as genetic matching (Diamond and Sekhon 2012), logistic regression and generalized linear models (Glick et al. 2014). 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 to improve the validity of the results.

CONCLUSIONS

The definition of the target population is a key issue in order to make integrated care programmes successful and sustainable in time. Our work demonstrated that the intervention achieved its objective in those multimorbid patients that could benefit from increased assistance but did not require palliative care. Furthermore, results show that not only the reach of the intervention but also the contact frequency is crucial for attaining the objective.

LIST OF ABBREVIATIONS

ACG Adjusted Clinical Group

A&E Accident and Emergency

COPD Chronic Obstructive Pulmonary Disease

DM Diabetes Mellitus

EHR Electronic Health Record

GP General Practitioner

HF Heart Failure

ICT Information and Communications Technology

IHO Integrated Healthcare Organizations

PC Primary Care

DECLARATIONS

Ethics approval and consent to participate

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

Consent for publication

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

Availability of data and material

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

Competing interests

All authors have completed the ICMJE uniform disclosure form and declare no support from any organisation for the submitted work, no financial relationship with organisations 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.

Authors' 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.

Data sharing statement

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

HIGHLIGHTS

What is already known on this subject.

Ample consensus exists for orienting health organizations towards a patient-centred continuum-of-care approach through integrated health interventions. Yet, evidence supporting specific interventions for multimorbid patients is scarce. Because of the complex nature of these interventions, contextual factors underlie their success. The Medical Research Council encourages studying these factors in order to make interventions generalizable.

What this study adds.

The observational design of this study allowed us to obtain a large sample by which to analyse through subgroup analysis key elements for the success of an integrated intervention for multimorbid patients in real practice. The subgroup analysis revealed an impact in the resource-use profile of those patients identified as suitable for the integrated programme for multimorbid patients both in the clinical judgement of the GP and the risk stratification for case finding. That is, the intervention achieved its objective in those patients that could benefit from increased assistance but did not require palliative care.

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Table 1.- Comparison of demographic and clinical features of multimorbid patients in 2012 (control group) and 2014 (Intervention group)

		2012	2014	p-value
N		8,239	8,364	
Age Mean (SD)		78.90 (7.27)	79.38 (7.36)	<0.01
Follow-up Mean (SD)		0.92 (0.22)	0.92 (0.22)	0.24
N (%)	Male	5,004 (61%)	5,024 (60%)	0.38
	Diabetes	6,900 (84%)	7,068 (85%)	0.18
	Heart Failure	4,683 (57%)	4,814 (58%)	0.35
	COPD	5,744 (70%)	5,682 (68%)	<0.01
	Death	1,108 (13%)	1,164 (14%)	0.39
	CJ, RSCF inclusion criteria			
	CJ=NO, RSCF=NO	3,059 (37%)	3,569 (43%)	<0,01
	CJ=SI, RSCF=NO	696 (8%)	752 (9%)	
	CJ=NO, RSCF=SI	1,622 (20%)	570 (7%)	
	CJ=SI, RSCF=SI	2,862 (35%)	3,473 (42%)	

*SD = standard deviation; COPD = chronic obstructive pulmonary disease; HF = heart failure; CJ= Clinical Judgement; Risk Stratification for Case Finding

Table 2.- Univariate analysis of resource consumption for multimorbid patients.

	2012	2014	p-value
N and probability of having at least one contact with each service			
General Practitioner	7,698 (93%)	7,979 (95%)	<0.01
-At the Health Centre	7,542 (92%)	7,740 (93%)	0.02
-At home	2,559 (31%)	2,617 (31%)	0.75
-By telephone	4,101 (50%)	5,238 (63%)	<0.01
Primary Care Nurse	7,495 (91%)	7,710 (92%)	<0.01
-At the Health Centre	7,153 (87%)	7,159 (86%)	0.02
-At home	2,806 (34%)	2,993 (36%)	0.02
-By telephone	3,178 (39%)	3,865 (46%)	<0.01
Primary Care Service by identification group			
CJ=NO, RSCF=NO	2,950 (96%)	3,464 (97%)	0.15
CJ=YES, RSCF=NO	689 (99%)	732 (97%)	0.02
CJ=NO, RSCF=YES	1,453 (90%)	548 (96%)	<0.01
CJ=YES, RSCF=SI	2,737 (96%)	3,373 (97,1)	<0.01
Accident & Emergency department	4,474 (54%)	4,612 (55%)	0.28
In-hospital stays	2,881 (35%)	2,978 (36%)	0,40
In-hospital stays by identification group			
CJ=NO, RSCF=NO	567 (19%)	764 (21%)	<0.01
CJ=YES, RSCF=NO	285 (41%	290 (39%)	0.35
CJ=NO, RSCF=YES	722 (45%)	243 (43%)	0.46
CJ=YES, RSCF=SI	1,307 (46%)	1,681 (48%)	0.03
Number of contacts for each service for those who had at least one contact			
Mean Rate (SD)			
General Practitioner	16.1 (14.8)	17.0 (15.4)	
-At the Health Centre	11.9 (9.5)	11.4 (9.3)	
-At home	5.3 (8.8)	5.6 (8.8)	
-By telephone	5.0 (8.4)	6.3 (9.4)	
Primary Care Nurse	18.7 (23.7)	19.4 (27.8)	
-At the Health Centre	12.0 (15.4)	11.6 (17.1)	
-At home	14.62 (21.3)	14.9 (22.1)	
-By telephone	4.2 (9.5)	5.8 (11.3)	
Accident & Emergency department	3.6 (6.0)	3.4 (4.9)	
In-hospital stays	23.8 (37.4)	22.0 (33.5)	
Median Rate (P25-P75)			
General Practitioner	13.0 (7.0-20.3)	13.0 (7.0-22.1)	<0.01
-At the Health Centre	10.0 (6.0-16.0)	9.0 (5.0-15.0)	0.18
-At home	2.6 (1.0-6.0)	3.0 (1.0-6.3)	<0.01
-By telephone	2.9 (1.0-5.4)	3.0 (1.0-7.0)	<0.01
Primary Care Nurse	11.77 (6.0-22.1)	11.03 (5.0-22.1)	<0.01
-At the Health Centre	8.0 (4.6-15.0)	7.0 (3.0-14.0)	<0.01
-At home	7.0 (2.0-19.0)	7.5 (2.2-18.1)	<0.01
-By telephone	2.0 (1.0-4.2)	2.4 (1.0-6.0)	<0.01
Accident & Emergency department	2.0 (1.0-4.0)	2.0 (1.0-4.0)	<0.01
In-hospital stays	11.3 (6.0-25.9)	11.0 (5.0-24.3)	0.40

SD: standard deviation. P: percentile.

Table 3.- Determinants of the probability of contacts with primary care and hospitalizations and of the number of contacts with primary care and hospital stays

	Probability of contact[1]		Number of contacts/stays[2]	
Primary Care	AOR (IC-95%)	p-value	AOR (IC-95%)	p-value
2014 Group	1,53 (1,44-1,63)	<0,01	1,01 (1,00-1,02)	<0,01
Female	0,70 (0,66-0,75)	<0,01	1,12 (1,11-1,13)	<0,01
Age≥80	0,53 (0,49-0,57)	<0,01	1,13 (1,12-1,14)	<0,01
Subjected to both HF and COPD	0,77 (0,72-0,83)	<0,01	1,11 (1,1-1,12)	<0,01
CJ, RSCF inclusion criteria				
CJ=NO, RSCF=NO	1		1	
CJ=YES, RSCF=NO	1,25 (1,09-1,43)	<0,01	1,49 (1,47-1,52)	<0,01
CJ=NO, RSCF=YES	0,45 (0,42-0,5)	<0,01	1,24 (1,22-1,26)	<0,01
CJ=YES, RSCF=YES	1,25 (1,16-1,35)	<0,01	1,56 (1,54-1,57)	<0,01
Follow-up (months)	1,52 (1,49-1,56)	<0,01	0,95 (0,95-0,95)	<0,01
Death	6,67 (5,39-8,31)	<0,01	1,35 (1,31-1,39)	<0,01
In-hospitalization	AOR (IC-95%)	p-value	AOR (IC-95%)	p-value
2014 Group	0,99 (0,97-1,02)	0,639	0,94 (0,92-0,96)	<0,01
Female	0,98 (0,96-1,01)	0,18	0,98 (0,96-1,01)	0,16
Age≥80	1,10 (1,07-1,13)	<0,01	0,90 (0,88-0,92)	<0,01
Subjected to both HF and COPD	1,43 (1,39-1,47)	<0,01	1,19 (1,16-1,22)	<0,01
GPCJ, RSCF inclusion criteria				
CJ=NO, RSCF=NO	1		1	
CJ=YES, RSCF=NO	2,69 (2,57-2,81)	<0,01	1,16 (1,11-1,21)	<0,01
CJ=NO, RSCF=YES	2,32 (2,22-2,42)	<0,01	1,26 (1,21-1,32)	<0,01
CJ=YES, RSCF=YES	3,38 (3,28-3,48)	<0,01	1,33 (1,29-1,37)	<0,01
Follow-up (months)	1,17 (1,16-1,18)	<0,01	0,86 (0,86-0,87)	<0,01
Death	10,09 (9,32-10,93)	<0,01	1,34 (1,28-1,4)	<0,01

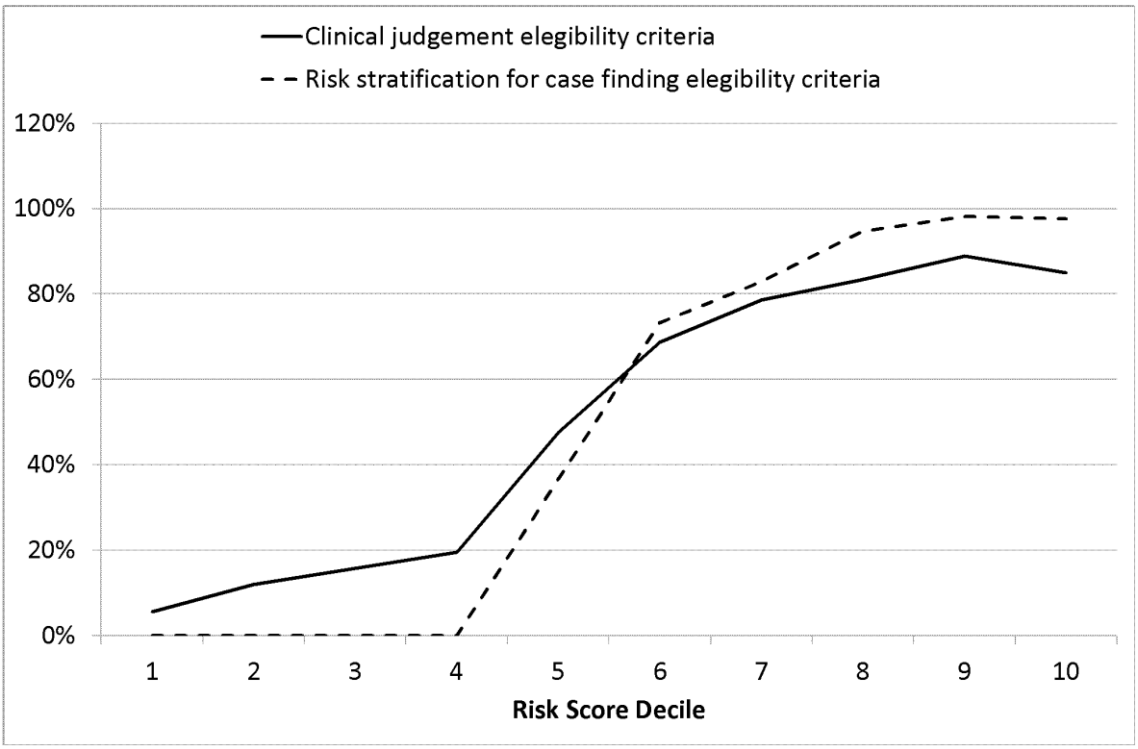
[1]By logistic regression; [2]By generalized linear models;
AOR: Adjusted Odds Ratio; HF: heart failure; COPD: chronic obstructive pulmonary disease; GPCJ: general practitioner clinical judgement; RSCF: risk stratification for case finding.

Table 4.- Subgroup analysis: Difference in resource consumption between intervention (2014) and control (2012) groups depending on interaction among identification groups

2014 vs 2014	AOR (CI)			
	GPCJ=No, RSCF=No	GPCJ=Yes, RSCF=No	GPCJ=No, RSCF=Yes	GPCJ= Yes, RSCF= Yes
Probability of contact in PC[1]	1,06 (0,95-1,17)	0,99 (0,78-1,26)	2,72 (2,28-3,25)	1,85 (1,68-2,04)
Number of contacts in PC[2]	1,00 (0,98-1,01)	1,21 (1,17-1,25)	0,93 (0,90-0,96)	1,01 (1,00-1,03)
Probability of hospitalization[1]	1,27 (1,21-1,33)	0,88 (0,81-0,95)	1,17 (1,08-1,26)	0,85 (0,82-0,88)
Number of hospital stays[2]	1,00 (0,95-1,05)	0,98 (0,91-1,05)	1,06 (0,98-1,13)	0,89 (0,86-0,92)

[1]By logistic regression; [2]By generalized linear models;
GPCJ: general practitioner clinical judgement; RSCF: risk stratification for case finding; PC: primary care; AOR: adjusted odds ratio; CI: confidence intervals.

Figure 1.- Percentage of clinical judgement and risk stratification for case finding inclusion criteria by risk score decile group in 2014



TECHNICAL APPENDIX OF *"Relevance of clinical judgment and risk stratification in the success of integrated care for multimorbid patients"*

Table S1.- Unit costs of primary care and hospital care for the Basque Health System at the year 2015

	Unit cost (€)
General Practitioner	
At the Health Centre	26.75
At home	107.01
By telephone	13.38
PC-Nurse	
At the Health Centre	7.42
At home	29.70
By telephone	3.71
Accident&Emergency department	150.70
In-hospital stays	430.48

Table S2.- Genetic matching in dichotomic variables

	Before matching	After matching
Sex	0,38	0,83
Identified by physician	<0,01	1,00
Previous year hospitalization	0,86	1,00
Death	0,38	1,00

Table S3.- Results of the raw multivariate analysis with interactions between Group (2014 vs 2012) and physician identification to explain the probability of contacts with primary care and hospitalizations, the number of contacts with primary care or hospital stays, and costs

	Probability of contact[1]		Number of contacts/stays[2]	
Primary Care	AOR (IC-95%)	p-value	AOR (IC-95%)	p-value
2014 Group	1.06 (0.95-1.17)	0.30	1.00 (0.98-1.01)	0.51
Female	0.71 (0.66-0.75)	<0.01	1.12 (1.11-1.13)	<0.01
Age≥80	0.53 (0.50-0.57)	<0.01	1.13 (1.12-1.14)	<0.01
Subjected to both HF and COPD	0.76 (0.71-0.81)	<0.01	1.11 (1.10-1.12)	<0.01
GPCJ=SI, RSCF=NO	1.29 (1.07-1.57)	<0.01	1.34 (1.31-1.37)	<0.01
GPCJ=NO, RSCF=SI	0.33 (0.30-0.37)	<0.01	1.27 (1.24-1.30)	<0.01
GPCJ=SI, RSCF=SI	0.97 (0.87-1.07)	0.51	1.54 (1.52-1.56)	<0.01
Follow-up (months)	1.53 (1.49-1.56)	<0.01	0.95 (0.95-0.95)	<0.01
Death	6.72 (5.44-8.36)	<0.01	1.35 (1.32-1.39)	<0.01
2014 Group & GPCJ=SI, RSCF=NO	0.94 (0.72-1.22)	0.63	1.22 (1.18-1.26)	<0.01
2014 Group & GPCJ=NO, RSCF=SI	2.57 (2.10-3.16)	<0.01	0.93 (0.90-0.96)	<0.01
2014 Group & GPCJ=SI, RSCF=SI	1.75 (1.52-2.02)	<0.01	1.02 (1.00-1.04)	0.07
In-hospitalization	AOR (IC-95%)	p-value	AOR (IC-95%)	p-value
2014 Group	1.27 (1.21-1.33)	<0.01	1.00 (0.95-1.05)	0.99
Female	0.98 (0.96-1.01)	0.16	0.98 (0.96-1.01)	0.13
Age≥80	1.10 (1.07-1.13)	<0.01	0.90 (0.88-0.92)	<0.01
Subjected to both HF and COPD	1.43 (1.39-1.47)	<0.01	1.19 (1.16-1.22)	<0.01
GPCJ=SI, RSCF=NO	3.28 (3.06-3.50)	<0.01	1.18 (1.11-1.26)	<0.01
GPCJ=NO, RSCF=SI	2.50 (2.36-2.65)	<0.01	1.25 (1.18-1.32)	<0.01
GPCJ=SI, RSCF=SI	4.18 (4.00-4.36)	<0.01	1.42 (1.36-1.48)	<0.01
Follow-up (months)	1.17 (1.15-1.18)	<0.01	0.86 (0.86-0.87)	<0.01
Death	10.00 (9.24-10.84)	<0.01	1.34 (1.28-1.40)	<0.01
2014 Group & GPCJ=SI, RSCF=NO	0.69 (0.63-0.76)	<0.01	0.98 (0.89-1.15)	0.58
2014 Group & GPCJ=NO, RSCF=SI	0.92 (0.84-1.01)	0.08	1.06 (0.97-1.15)	0.21
2014 Group & GPCJ=SI, RSCF=SI	0.67 (0.63-0.71)	<0.01	0.89 (0.84-0.94)	

[1]By logistic regression; [2]By generalized linear models;
AOR=Adjusted Odds Ratio
GPCJ: general practitioner clinical judgment; RSCF: risk stratification for case finding

Figure S1: Q-Q plot comparing Age distribution in the control and treatment group before and after matching.