ORIGINAL ARTICLE

Quality Improvement Project to Reduce Prescription Errors in Patients Hospitalized due to Cardiovascular Diseases

Proyecto de mejora de calidad para reducir errores de prescripción en pacientes internados por patologías cardiovasculares

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ABSTRACT

Background: Prescription errors are a common problem which threatens hospitalized patients' safety, particularly in critical care areas.
Objective: The aim of the study was to evaluate the effectiveness of a quality improvement project to reduce prescription errors in patients hospitalized due to cardiovascular diseases.
Methods: A quality improvement project was implemented to reduce in-hospital prescription errors. The three main components of the project were: mandatory supervision of indications, use of a software program that organizes physicians' indications by biological systems, and implementation of a rule with universal format for the prescription of medications, including a dictionary of abbreviations and normalized dilutions. Before the implementation of these changes, the number of weakly prescription errors was assessed, stratified by hospitalization area. The impact of the project was analyzed by dividing the samples into four consecutive 9-week periods (one period before the intervention and three periods after the intervention), comparing the number of errors detected in each period. The indications of 180 patients were randomly evaluated in each period.
Results: A total of 720 prescriptions were analyzed. The implementation of an improvement project reduced the number of errors rapidly and consistently over time (median of 85 before the intervention, IQR 70-95, and 26 after the intervention, IQR 21-37; p=0.0004).
Conclusion: The quality improvement project produced a significant reduction in the number of prescription errors in patients hospitalized due to cardiovascular diseases.

Key words: Medication Errors - Medical Prescription - Patient Safety - Quality

RESUMEN

Introducción: Los errores de prescripción son un problema frecuente que amenaza la seguridad de los pacientes internados, especialmente en áreas de cuidados críticos.
Objetivo: Evaluar la efectividad de un proyecto de mejora de la calidad para reducir errores de prescripción en pacientes internados por patologías de origen cardiovascular.
Material y métodos: Se implementó un proyecto de mejora de la calidad destinado a reducir errores de prescripción intrahospitalaria. Los tres componentes principales del proyecto fueron: supervisión obligatoria de las indicaciones, utilización de un software que ordena las indicaciones por sistemas biológicos e implementación de una norma de formato universal de prescripción de medicamentos, que incluyó un diccionario de abreviaturas y de diluciones normalizadas. Con anterioridad a la implementación de estos cambios se midió la cantidad de errores de prescripción semanales, estratificados por área de internación. Se analizó el impacto del proyecto dividiendo las muestras en cuatro períodos consecutivos de 9 semanas cada uno (un período preintervención y tres posintervención) y se comparó luego la cantidad de errores detectados en cada uno de ellos. En cada período se evaluaron de manera aleatoria las indicaciones de 180 pacientes.
Resultados: Se analizaron en total 720 prescripciones. La implementación del proyecto de mejora logró reducir la cantidad de errores de manera rápida y sostenida en el tiempo (mediana preintervención de 85, RIC 70-95 y mediana final de 26, RIC 21-37; p = 0,0004).
Conclusión: El proyecto de mejora de la calidad implementado permitió reducir significativamente la cantidad de errores de prescripción en pacientes internados por patologías cardiovasculares.

Palabras clave: Errores de medicación - Prescripción médica - Seguridad del paciente - Calidad

Abbreviations

ME	Medication errors	**IQR**	Interquartile range

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INTRODUCTION

Administering medications is a basic component of medical practice that should not be underestimated. In fact, this activity is extremely dangerous and constitutes the most common cause of preventable injury to patients exposed to the health care system. (1-3) The process of administering medications is specially subject to error, as several activities should be accomplished before a patient takes a certain medication. These activities are conducted by different members of the health care team, and can be categorized in five stages: acquisition, indication, prescription, preparation and administration. (4) Different technological initiatives, as the use of computerized physician order entry, have been proposed to reduce medication errors (ME). (5-9) Other non-technological initiatives include the use of rules or the incorporation of pharmacists to detect incorrect prescriptions. (10-13) However, the evidence currently available is not clear in determining which of the initiatives proposed are more effective to reduce ME.

The aim of the present study was to analyze the usefulness of a quality improvement project to reduce ME in patients hospitalized due to cardiovascular diseases. The three main components of the project were: mandatory supervision of indications, implementation of a rule with a correct format and the use of a software program that organizes physicians' indications by biological systems.

METHODS

A prospective, experimental study of "before and after" design, implementing a quality improvement project, was used with the aim of reducing prescription errors in patients hospitalized due to cardiovascular diseases.

The following measures were implemented in the attempt to reduce ME:

- Mandatory supervision of indications by another physician: After the indications were made, another physician, either the coordinator of the area or a superior, evaluated and signed the indications.
- Implementation of a rule with universal format for the prescription of medications: Two dictionaries were created to establish prescription rules: one of permitted abbreviations (Figure 1) and another one of normalized dilutions. Therefore, there was only one way of preparing intravenous infusions of inotropic drugs, vasoactive agents, antiarrhythmic drugs, diuretics, antithrombotic agents, muscle relaxants and analgesics. The maximal doses of each of these drugs were determined according to current guidelines, adjusted for weight, renal function and liver function (Figure 2).
- Both dictionaries were printed and delivered to all the physicians responsible for the medical prescription in plastic-coated cards, and were also placed at the nurses' stations of the different units.
- Use of a software program that organizes physicians' indications by biological systems: As medications were ordered using a hybrid system (data were entered into a software and the prescriptions were then printed), an electronic form was designed using Microsoft Access, which automatically organized the indications according to previously defined groups (general measures, digestive, hematologic, cardiologic, respiratory and infectious aspects) (Figure 3). This software allowed a computerized order of the indications after completing mandatory fields: date, patient's name and surname, and prescription of medications (drug, dose, time and route of administration). Figure 3 shows a screenshot of the software; the buttons at the right of the screen have suggestions of medications usually used; after clicking on one button, the indication field was displayed and the indication could be completed with the dose, route of administration and adequate standardized preparation (in case of infusions). Then, once the indication was printed, it appeared organized by biological systems, irrespective of the order it was completed. The aim of this intervention was to facilitate the supervision of the indications already printed. As we have previously mentioned, other advantages of the software is the suggestion of habitual doses of medications commonly used in patients hospitalized to reduce incorrect medication dosing. The subsequent changes of the printed indication were handwritten until the changes were introduced in the software on the following day.

The study was performed at the Instituto Cardiovascular de Buenos Aires (ICBA), between July 1, 2014 and March 10, 2015 (36 weeks).

Before the implementation of the quality improvement project, we started measuring the number of prescription errors in random samples of 20 indications per week, stratified by area of hospitalization (5 in the Cardiovascular Recovery Unit, 5 in the Coronary Care Unit, 5 in the Intermediate Care Unit and 5 in the Cardiology Ward). The number of errors was evaluated using specially designed forms. The forms detected the presence of 11 probable errors in each of the indications: lack of name and surname, wrong date, crossed out text, illegible text, writing in the space that corresponds to nurses' notes, contradictions (e.g. simultaneous prescription of beta blockers and adrenergic agonists), faults in dose selection, wrong infusion, lack of time or signature after modifications, use of inappropriate abbreviations and writing outside the corresponding lines. Errors were measured by residents in cardiology specially trained for this activity who were not rotating in that area so that they were not involved in the prescription process. The indications were randomly evaluated and the physicians were trained to perform the measurements with the aim of implementing the same criterion. Interobserver agreement was evaluated, resulting in a kappa coefficient of 0.67 (95% CI, 0.47-0.87).

The impact of the project was analyzed by dividing the samples into four consecutive 9-week periods, each with 180 indications (determined by sample size): Period 1 (weeks 1 to 9), Period 2 (weeks 10 to18), Period 3 (weeks 19 to 27) and Period 4 (weeks 28 to 36). The quality improvement project started on week 10; thus, period 1 was considered pre-intervention and the remaining three periods, post-intervention.

Statistical analysis

To determine the adequate number of medical prescriptions to analyze, and based on a pilot study with 50 indications, a sample size calculation estimated 180 indications per period, assuming a median error of 65 (IQR 35-95). A power of 90% was defined to detect a difference of 20%, considering an alpha error of 0.05 with Bonferroni adjustment for multiple comparisons of four groups ($p=0.01$), adding 15% to the initial sample size calculated ($n=159$) because a non-parametric test was used (Mann-Whitney U test).

The number of prescription errors in each period was

< Lower than		Intro	Introducer
> Higher then		CRF	Chronic renal failure
To reg	To regular	Int	Intermittent
MKA	Motor kinetic assistance	KCl	Potassium chloride
RKA	Respiratory kinetic assistance	mEq	Milliequivalents
Amp	Ampoules	mg	Milligrams
RMA	Respiratory mechanical assistance	Mg	Magnesium
ATB	Antibiotics	ml	Milliliters
BB	Betablockers	ml/h	Milliliters/hour
CIP	Continuous infusion pump	MOD	Modification
e/	Each	NaCl	Sodium chloride
Ca	Calcium	NA	Nadrenaline
Cc	Cubic centimeters	NBZ	Nebulizations
DCath	Dialysis catheter	SNO	Sodium nitroprusside
CPAP	Continuous positive air pressure device in airway	NTG	Nitroglicerine
CVS	Control of vital signs	O2	Oxygen
BLTD	Breakfast, Lunch, Tea and Dinner	IHP	Intravenous hydration plan
DBT	Diabetes	Sat	Saturation
Dx	Dextrose	SC	Subcutaneous
Spiro	Spironolactonea	PS	Physiological saline solution
IV	Intravenous	NGT	Nassogastric tube
HR	Heart rate	SUSP	Suspension
Vial	Vial	UC	Urinary catheter
Dps	Drops	BP	Blood pressure
Gr	Grams	MAP	Mean arterial pressure/arterial introducer
BC	Blood cultures	UC	Uroculture
HGT	Hemoglucotest	IU	International units
hs	Hours	CVA	Central venous access
ACEI	Angiotensin-convering enzyme inhibitor	NIV	Non-invasive ventilation
NHI	Normal human insulin	PO	Per os

Fig. 1. Dictionary of permitted abbreviations.

considered a continuous quantitative variable, and was expressed as median and interquartile range due to the non-normal distribution, evaluated by the Kolmogorov-Smirnov test. The differences between the different groups were analyzed by the Mann-Whitney U test. A two-tailed p value <0.05 was considered statistically significant. Box plots were used. All the statistical calculations were performed using STATA 13.0 software package.

Ethical considerations

The protocol was approved by the Teaching and Research Committee of the Instituto Cardiovascular de Buenos Aires. Patients were not asked to sign an informed consent form because the study did not use patients' personal data.

RESULTS

During the 36-week period, 720 indications were evaluated. The median number of prescription errors observed in the pre-intervention period was 85 (IQR 70-95). Over time, the implementation of an improvement quality project significantly reduced the number of errors in a rapid and sustained way: 48 (IQR 34-53) in the second period, 30 (IQR 26-36) in the third period and 26 (IQR 21-37) in the fourth period (Figure 4). Compared with the pre-intervention period, the number of errors was significantly lower in the three periods after the intervention; yet, from week 27 onwards, the reduction in the number of errors seemed to have stopped. However, in this last period the number was still significantly lower compared with that of the pre-intervention period ($p=0.0004$).

Ninety-seven percent of the errors were due to incorrect format (lack of complete name and surname, crossed out text, illegible text, writing in the space that corresponds to nurses' notes, lack of time or signature after modifications, use of inappropriate abbreviations and writing outside the corresponding lines) and not due to inadequate medical criterion (contradiction, faults in dose selection or wrong infusion). The lack of time or signatures after modifications was the most common prescription error (45% of the cases) followed by writing outside the corresponding lines (21%).

Drug	Content	Preparation	Recommended dose
Adrenaline	1 mg	4mg/100 ml	Up to 50 mcg/min
Amiodarone	150 mg	3 or 5 amp/250 ml	10-15 mg/kg/day
Atracurium	50 mg	2 amp/100 ml	5-13 mcg/kg/min
Dexmedetomidine	200 mcg	2 amp/100 ml	0.2-0,7 mcg/kg/h
Diltiazem	25 mg	5 amp/250 ml	Up to 240 mg/day (10 mg/h)
Dobutamine	250 mg	500 mg/250 ml	Up to 15 mcg/kg/min
Dopamine	200 mg	400 mg/250 ml	Up to 15 mcg/kg/min
Phenylephrine	10 mg	40 mg/250 ml	Up to 150-200 mcg/min
Fentanyl	0.25 mg	5 amp/250 ml	Up to 10 mcg/kg/h
Furosemide	20 mg	10 amp/100 ml or 25 amp	Up to 1 g/day
Heparin		20000 IU/250 ml	
Epsilon	2 g	5 amp/100 ml	15 ml/h
Isoprotenerol	1 mg	5 mg/250 ml	0.05-0.5 mcg/kg/min
Labetalol	20 mg	10 amp/160 ml	0.5-2 mg/min
Levosimendan	12.5 mg	12,5 mg/250 ml	0.05-0.2 mcg/kg/min
Lidocaine	400 mg	2 g/250 ml	1-4 mg/min
Midazolam	15 mg	5 amp/250 ml	0.03-0.5 mg/kg/h
Milrinone	10 mg	10 mg/100 ml	0.37-0.75 mcg/kg/min
Morphine	10 mg	3 amp/250 ml	(0125 x weight) ml/h
Noradrenaline	4 mg	16 mg/250 ml	Up to 100 mcg/min
NPS	50 mg	50 mg/250 ml	Up to 6 mcg/kg/min
NTG	25 mg	22 mg/250 ml	Up to 5 mcg/kg/min
Propofol	Al 2% 1 gr>50 ml	1 undiluted vial	Up to 80 mcg/kg/min
Remifentanil	5 mg	2 amp/250 ml	Up to 0.25 mcg/kg/min
Tirofiban	12.5 mg	12,5 mg/250 ml	0.1 mcg/kg/min Up to
Vasopressin	20 IU	20 IU/100 ml	0.04 IU/min (max 12 ml/h)

Fig. 2. Dictionary of normalized dilutions with recommended therapeutic doses.

Interestingly, prescription errors began to decrease even before the evaluations started (between week 1 and 9 of the pre-intervention period, the errors decreased from 125 to 78). Probably, the physicians of each area felt observed when they realized that the quality of medical prescriptions was being measured. Nevertheless, the number of errors was significantly lower in the three periods after the intervention, evidencing the impact of the quality improvement project beyond the initial improvement before the intervention.

DISCUSSION

This study evaluated the impact on the number of prescription errors of three simultaneous initiatives. These interventions, which included mandatory supervision of indications, implementation of a rule with a universal format for the prescription of medications, and the use of a software program that organizes physicians' indications by biological systems, produced a significant reduction of prescription errors that was sustained over time.

In a similar way, Lavalle et al. evaluated the impact of supervision and the use of a protocol for the prescription process in a before and after comparative study and observed a significant reduction of ME. (14) However, that study did not include among the initiatives evaluated a software program that organizes physicians' indications by biological systems.

Several authors have published studies evaluating the usefulness of computerized physician order entry to reduce ME. Bates et al. demonstrated that physician order entry systems reduce ME at the ordering and transcription stages. (6, 7) In their corresponding studies, Shulman, Colpaert, and Garg confirmed the efficacy of computerized physician order entry systems to reduce the rate of ME. (8, 9, 15) The technological intervention evaluated in our study was different from the one used in these publications. In our study we used a hybrid system to order the indications, based on the use of a Microsoft Access electronic form that was then printed in paper and allowed handwritten modifications. We did not find other publications describing the usefulness of this electronic initiative to reduce prescription errors.

Among non-technological measures, Bertshce et al. used protocols to standardize the preparation and administration of medications, improving patients'

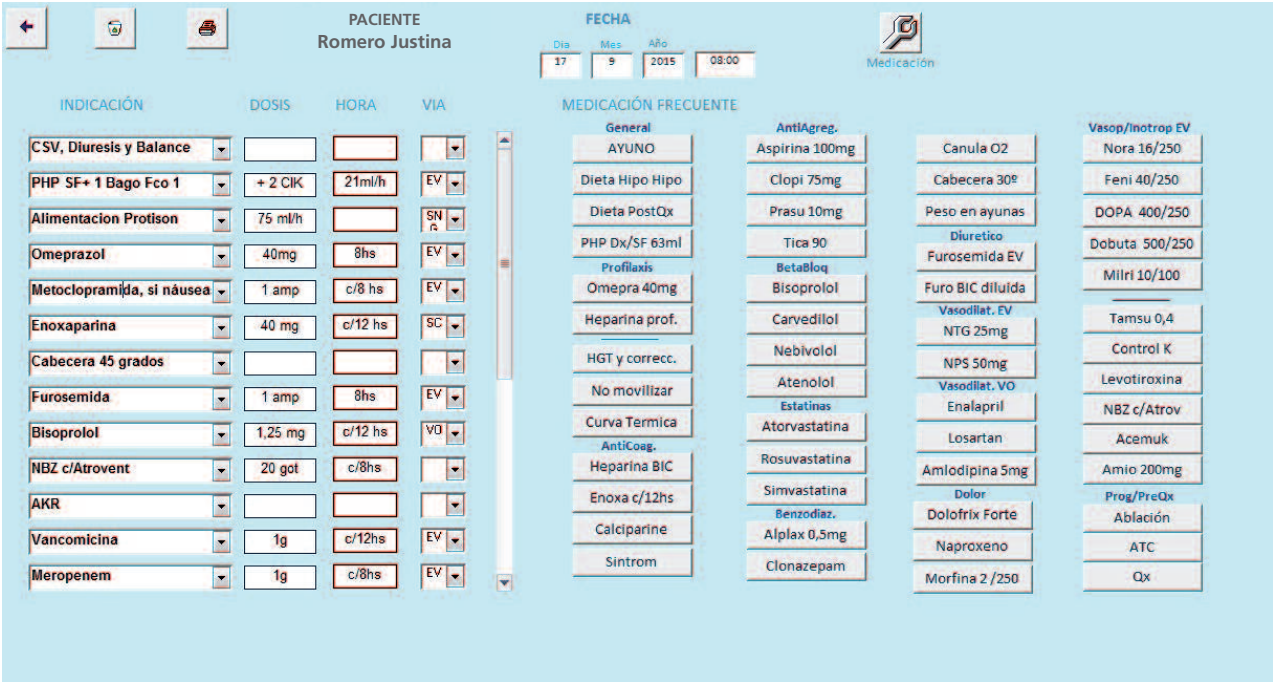

Fig. 3. Software program for prescribing medications, organized by biological systems and with suggested doses.

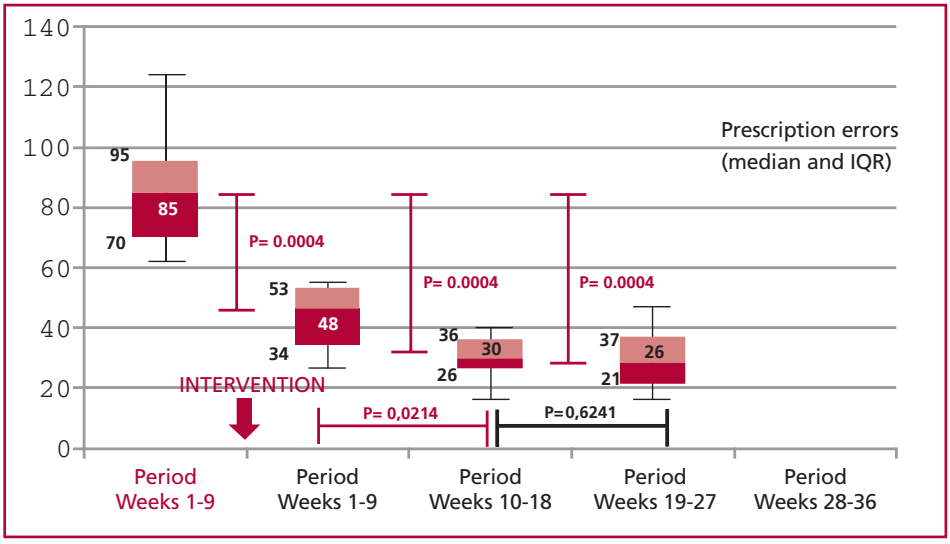

Fig. 4. Number of prescription errors in each of the periods evaluated.

safety. The authors reported 59% error reduction in the infusion of intravenous medications in the intensive care unit (5.8% vs. 2.4%) through the process of standardization. (10) These data suggest that the preparation of standardized intravenous infusions helps to reduce ME.

Supervision of the indications helped to detect errors and to evaluate the legibility of the indications before they were used by the other actors of the medication system.

The early reduction in the rate of prescription errors reported during the pre-intervention period should be remarked. Probably, these findings were due to the fact that physicians improved the quality of indications when they realized that this was being measured. This phenomenon has already been described in other industries and is known as the Hawthorne effect, which means the importance of measuring processes to improve them. (16)

Since a small percentage of ME ends by producing some kind of damage in hospitalized patients, the measures analyzed should provoke a positive impact in clinical outcome. Yet, this assertion cannot be made, as the study was not designed to confirm it.

Limitations

Despite being an experimental study, the lack of randomization and blind assignment is subjected to bias. As the three interventions were simultaneously installed, we cannot know which was the most effective to reduce prescription errors.

CONCLUSION

The quality improvement project produced a significant reduction in the number of prescription errors in patients hospitalized due to cardiovascular diseases.

Conflicts of interest

None declared. (See authors' conflicts of interest forms on the website/Supplementary material).

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ICMJE Form for Disclosure of Potential Conflicts of Interest

Section 1. Identifying Information

1. Given Name (First Name): Mariano
2. Surname (Last Name): Benzadón
3. Date: 14-March-2017

4. Are you the corresponding author? [✓] Yes [ ] No

5. Manuscript Title: Proyecto de mejora de calidad para reducir errores de prescripción en pacientes internados por patologías cardiovasculares

6. Manuscript Identifying Number (if you know it):

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Are there any relevant conflicts of interest? [ ] Yes [✓] No

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Are there any relevant conflicts of interest? [ ] Yes [✓] No

Section 4. Intellectual Property -- Patents & Copyrights

Do you have any patents, whether planned, pending or issued, broadly relevant to the work? [ ] Yes [✓] No

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Dr. Benzadón has nothing to disclose.

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ICMJE Form for Disclosure of Potential Conflicts of Interest

Section 1. Identifying Information

1. Given Name (First Name): Gustavo
2. Surname (Last Name): Daquarti
3. Date: 14-March-2017

4. Are you the corresponding author? [✓] Yes [ ] No

5. Manuscript Title
Proyecto de mejora de calidad para reducir errores de prescripción en pacientes internados por patologías cardiovasculares

6. Manuscript Identifying Number (if you know it)

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ICMJE Form for Disclosure of Potential Conflicts of Interest

Section 1. Identifying Information

1. Given Name (First Name): Soledad
2. Surname (Last Name): Mitrione
3. Date: 14-March-2017

4. Are you the corresponding author? ☑ Yes ☐ No

5. Manuscript Title: Proyecto de mejora de calidad para reducir errores de prescripción en pacientes internados por patologías cardiovasculares

6. Manuscript Identifying Number (if you know it):

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Are there any relevant conflicts of interest? ☐ Yes ☑ No

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Are there any relevant conflicts of interest? ☐ Yes ☑ No

Section 4. Intellectual Property -- Patents & Copyrights

Do you have any patents, whether planned, pending or issued, broadly relevant to the work? ☐ Yes ☑ No

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ICMJE Form for Disclosure of Potential Conflicts of Interest

Section 1. Identifying Information

1. Given Name (First Name): Nicolás
2. Surname (Last Name): Vecchio
3. Date: 14-March-2017

4. Are you the corresponding author? ☑ Yes ☐ No

5. Manuscript Title: Proyecto de mejora de calidad para reducir errores de prescripción en pacientes internados por patologías cardiovasculares

6. Manuscript Identifying Number (if you know it):

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Are there any relevant conflicts of interest? ☐ Yes ☑ No

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Do you have any patents, whether planned, pending or issued, broadly relevant to the work? ☐ Yes ☑ No

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ICMJE Form for Disclosure of Potential Conflicts of Interest

Section 1. Identifying Information

1. Given Name (First Name): Clara
2. Surname (Last Name): Ametrano
3. Date: 14-March-2017

4. Are you the corresponding author? ☑ Yes ☐ No

5. Manuscript Title
Proyecto de mejora de calidad para reducir errores de prescripción en pacientes internados por patologías cardiovasculares

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Dr. Ametrano has nothing to disclose.

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2. Surname (Last Name): Furmento
3. Date: 14-March-2017

4. Are you the corresponding author? [✓] Yes [ ] No

5. Manuscript Title: Proyecto de mejora de calidad para reducir errores de prescripción en pacientes internados por patologías cardiovasculares

6. Manuscript Identifying Number (if you know it):

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1. Given Name (First Name): Diego
2. Surname (Last Name): Conde
3. Date: 14-March-2017

4. Are you the corresponding author? [✓] Yes [ ] No

5. Manuscript Title: Proyecto de mejora de calidad para reducir errores de prescripción en pacientes internados por patologías cardiovasculares

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1. Given Name (First Name): Alberto
2. Surname (Last Name): Alves de Lima
3. Date: 14-March-2017

4. Are you the corresponding author? [✓] Yes [ ] No

5. Manuscript Title: Proyecto de mejora de calidad para reducir errores de prescripción en pacientes internados por patologías cardiovasculares

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