Anti-infective medication administration errors by dose omission

Erro de administração de medicamentos anti-infeciosos por omissão de doses

Error de administración de medicamentos antiinfecciosos por omisión de dosis

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Anti-infective agents; Medication errors; Intensive care units; Quality indicators, health care; Patient safety

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Abstract

Objectives: To measure anti-infective medication administration errors by dose omission in an adult intensive care unit.

Methods: A descriptive, cross-sectional, and prospective study, carried out in October and November 2018 in an adult intensive care unit of a teaching hospital in the Federal District, Brazil. The sample was one of convenience. The numbers of prescribed medications and dose omissions were registered on two forms. The medications were classified according to the Anatomical Therapeutic Chemical Code. Data were treated statistically by applying logistic regression and tests for proportions.

Results: Information on about 7,140 prescribed medications was gathered, and 310 dose omissions were identified, which corresponded to a 4.34% error rate in the administration of medications in general. The sample used 711 anti-infective drugs (9.95%), which were associated with 48 dose omissions, yielding a 6.75% error rate. Among the anti-infective medications, the highest number of omissions was in the group of carbapenems (n=13; 27.08%), to be administered intravenously (n=38; 79.16%) and at 8 pm (n=10; 20.83%).

Conclusion: The anti-infective medication administration error rate by dose omission was significant and higher than for the other groups of drugs, showing a higher incidence using the intravenous route and at times approaching changes of shifts. Safety barriers must be implemented, such as dose triple-checking (at the pharmacy, when the medication is received at the intensive care unit, and at the time of administration). Additionally, adequate drug scheduling, continuing education, and training programs for safe use of medications can be useful for preventing these errors.

Resumo

Objetivos: Mensurar a taxa de erro de administração de medicamentos anti-infeciosos por omissão de doses em Unidade de Terapia Intensiva Adulto.

Métodos: Estudo descritivo, transversal e prospectivo, realizado nos meses de outubro e novembro de 2018, em Unidade de Terapia Intensiva adulto de um Hospital de Ensino do Distrito Federal. A amostra foi por conveniência e foram registrados o número de medicamentos prescritos e o número de omissões de doses das prescrições em dois formulários. Os medicamentos foram classificados conforme o *Anatomical Therapeutic Chemical Code*. Realizada análise estatística com regressão logística e testes para proporções.

Resultados: Coletaram-se informações de 7.140 medicamentos prescritos e foram identificadas 310 omissões de doses, correspondendo a 4,34% de taxa de erro na administração de medicamentos em geral. A amostra continha 711 anti-infeciosos (9,95%), e nestes ocorreram 48 omissões de doses, correspondendo a 6,75% de taxa de erro por omissão de doses. Entre os anti-infeciosos, o maior número de omissões foi nos carbapenêmicos (n=13; 27,08%), prescritos para serem ministrados por via intravenosa (n=38; 79,16%) e no horário das 20h (n=10; 20,83%).

Conclusão: A taxa de erro de administração por omissão de dose dos anti-infeciosos foi alta, maior que entre os demais medicamentos, mais frequente pela via intravenosa e nos horários próximos às trocas de turnos. Barreiras de segurança devem ser implementadas, como a tripla checagem das doses – na farmácia, no recebimento na UTI e na administração propriamente dita, além de aprazamento adequado, educação permanente e treinamento em uso seguro de medicamentos.

Resumen

Objetivos: Medir el índice de error de administración de medicamentos antiinfecciosos por omisión de dosis en Unidad de Cuidados Intensivos Adultos.

Métodos: Estudio descriptivo, transversal y prospectivo, realizado en los meses de octubre y noviembre de 2018 en la Unidad de Cuidados Intensivos Adultos de un hospital universitario del Distrito Federal. La muestra fue por conveniencia y se registró la cantidad de medicamentos prescriptos y la cantidad de omisiones de dosis de las prescripciones en dos formularios. Los medicamentos se clasificaron según el *Anatomical Therapeutic Chemical Code*. Se realizó el análisis estadístico con regresión logística y pruebas para proporciones.

Resultados: Se recolectó información de 7.140 medicamentos prescriptos y se identificaron 310 omisiones de dosis, que corresponden al 4,34% de índice de error en la administración de medicamentos en general. La muestra contenía 711 antiinfecciosos (9,95%) y ocurrieron 48 omisiones de dosis de estos medicamentos, que corresponde al 6,75% de índice de error por omisión de dosis. En los antiinfecciosos, la mayor cantidad de omisiones fue en los carbapenémicos (n=13; 27,08%), prescriptos para administrarse por vía intravenosa (n=38; 79,16%) y en el horario de las 20h (n=10; 20,83%).

Conclusión: El índice de error de administración por omisión de dosis de los antiinfecciosos fue alta, mayor que entre los demás medicamentos, más frecuente por vía intravenosa y en los horarios cerca de los cambios de turno. Deben implementarse barreras de seguridad, como el triple chequeo de las dosis (en la farmacia, al recibirlo en la UCI y en la administración propiamente dicha), además de la correcta programación, educación permanente y capacitación en el uso seguro de medicamentos.

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Introduction

Anti-infective drugs are the second-most used class of medications in hospitals, and their widespread use significantly affects both the microbiota of patients who take them and of hospitals, which can result in microbial resistance and lead to the emergence of pathogens capable of causing infections for which there are no efficient anti-infective substances.[1,2]

The Global Action Plan on Antimicrobial Resistance was approved during the World Health Assembly in 2015, with the main objective of ensuring, for the longest possible time, the continuity of successful treatments and the prevention of infectious diseases with effective, high-quality, and safe medications, used responsibly and made available to every person who needs them.[1]

The goal of reducing severe and avoidable damage related to the use of medications by 50% in the subsequent five years was set as the third global challenge in 2017, in the scope of the Global Alliance for Patient Safety of the World Health Organization (WHO).[3]

The Brazilian Health Regulatory Agency, aligned with the WHO Global Action Plan and the Brazilian National Program for Prevention and Control of Healthcare-Associated Infections, has encouraged the development of programs for the management of antimicrobial drug use in the country. Also, following the global trend in patient safety, the Brazilian Ministry of Health instituted the Brazilian National Patient Safety Program (PNSP, as per its initialism in Portuguese) in 2013 and created six basic protocols to channel safety actions in health services, including the safety protocol for the prescription, use, and administration of medications.[4,5]

One of the current approaches to fight issues related to the vulnerabilities in the use of anti-infective drugs is the development of management programs to ensure good clinical results when these medications are used, reduce costs for health services, and minimize microbial resistance and the consequences of adverse effects.[5]

In hospitals, intensive care units (ICUs) are the place where patients with severe infections are treated and the setting with the highest frequency of healthcare-associated infections (HAIs) and microbial resistance, because of multiple factors. The severity of the condition of the assisted patients, the application of invasive devices, and the longer hospital stays, among other reasons, make the use of several anti-infective medications in most patients common in ICUs. Consequently, an anti-infective medication management use program must be implemented in intensive care settings to seek improvements in the processes involved, aiming at achieving quality and safety in the provided care to reduce the impact of microbial resistance.[1,2,5]

Studies on the magnitude and occurrence of incidents resulting from errors in the prescription, dispensation, and administration of medications are increasingly frequent in the literature. Analyses of the involved risk factors and their causes point to systemic and individual failures, but especially to the lack of computerization in health systems and of investments in communication technologies, combined with the increasing complexity of therapeutic procedures.[6-8]

Once medication errors can be considered preventable, it is important to understand them. Consequently, the whole process must be the object of a risk management system that allows one to know the details of every step and activity in which systemic or individual failures can happen, aiming at establishing the best organization and highest safety level in the process in order to guarantee the correct use of medications.[6-10]

The processes that involve the use of medications can be monitored using quality and patient safety indicators, for instance, the medication administration error rate. This indicator is understood as an analyzed piece of data that allows one to monitor and evaluate the results of work processes up to the point of the quality of the care delivered to patients. This indicator has been defined by the Brazilian Ministry of Health for mandatory monitoring of health services. The Institute for Safe Medication Practices in Brazil suggests a standardized methodology to collect data and calculate the indicator.[11,12]

In this context, the following research question emerges: what is the anti-infective medication administration error rate related to dose omission in adult ICUs? The objective of the present study was to measure the medication administration error rate associated with dose omission in this type of setting.

Methods

A descriptive, cross-sectional, and prospective study, with a quantitative approach, was carried out in the adult ICU of a teaching hospital of the Federal District, Brazil. The ICU had 19 beds, with ten general beds for clinical and surgical patients and nine beds for the coronary unit.

The sample was determined by convenience, given that it depended on the number of prescribed medications and dose omissions that occurred during the data collection dates chosen for analysis. Consequently, the rate was obtained by prevalence.

Data collection was performed in October and November 2018. During this period, three days, selected by convenience, were allocated to analyze all the prescriptions issued in the week for all the inpatients. Six hundred thirteen prescriptions issued in 55 days were evaluated. The examination included prescriptions of medications and anti-infective agents from the first day of the treatment plan. Prescriptions of medications and anti-infective drugs that had been changed or canceled or were illegible were excluded because it was considered that the medication should not be administered in those cases.

Data were obtained by using two forms designed for the present study, in which the numbers of prescribed medications and dose omissions, that is, doses that were prescribed and not checked, were registered. The medication administration errors considered were dose omissions or omissions caused by failures in drug scheduling. The first form had numerical information about the prescription date, bed number, number of prescribed medications, number of dose omissions, number of anti-infective medications prescribed, and number of dose omissions of anti-infective medications. The second form was used to register information about the prescribed medications that had dose omissions, including the medication name, dose, route, and administration time.

The numerator in the fraction of the medication administration error rate indicator proposed by the PNSP is the number of medications prescribed with omission errors, that is, those which were prescribed but not administered (checked), and the denominator is the total number of administered medications (all the medications prescribed over a certain period). The ratio is multiplied by 100 so as to be expressed as a percentage.[11,12] The drugs were classified according to the Anatomical Therapeutic Chemical Classification (ATCC) system.[13]

Two electronic worksheets were designed using Excel 2013® software to create a databank. Statistical analysis was run using R: A Language and Environment for Statistical Computing software.

To investigate whether dose omissions were related to the classification of the medications, the drugs were grouped into anti-infective and non-anti-infective, and logistic regression was applied. Three binary dependent variables were analyzed using this method: dose omissions, when examining the frequency of omissions among anti-infective and non-anti-infective substances; the intravenous route, when analyzing the frequencies associated with the routes for which dose omissions happened; and the closeness of the time to changes of shifts, when examining the times the omissions occurred. Tests for proportions were used to calculate p-values, and the level of significance adopted was 1% for analysis of medication type and administration route and 5% for omission times.

The present study is part of the macroproject entitled *Protocolos de Segurança do Paciente e Seus Indicadores*, approved by the research ethics committee of the Medical School of the University of Brasília as per report no. 1,572,454 on July 2, 2016.

Results

Data on 7,140 prescribed medications were collected, and 310 dose omissions were identified, which

Table 1. Anti-infective medication administration error rate caused by dose omission

Classification	Prescribed medications n (%)	Dose omissions n (%)	Administration error rate (%)	Omission times n (%)	Omission routes n (%)
Anti-infective	711 (9.95)	48 (15.48)	6.75	2h – 2 (4.16) 4h – 5 (10.41) 6h – 5 (10.41) 8h – 5 (10.41) 10h – 1 (2.08) 12h – 3 (6.25) 14h – 5 (10.41) 16h – 2 (4.16) 18h – 3 (6.25) 20h – 10 (20.83) 22h – 2 (4.16) Absent – 5 (10.41)	IV – 38 (79.16) OR – 6 (12.5) PR – 3 (6.26) TR – 1 (2.08)
Non-anti-infective	6,429 (90.04)	262 (84.51)	4.07	2h – 4 (1.52) 4h – 10 (3.81) 6h – 49 (18.70) 8h – 46 (17.55) 10h – 34 (12.97) 12h – 15 (5.72) 14h – 42 (16.03) 16h – 16 (6.10) 18h – 15 (5.72) 20h – 7 (2.67) 22h – 15 (5.72) 24h – 6 (2.29) Absent – 3 (1.14)	PR – 84 (32.06) OR – 84 (32.06) SC – 41 (15.64) IV – 40 (15.26) TR – 11 (4.19) IR – 1 (0.38) RR – 1 (0.38)
Total	7,140 (100)	310 (100)	4.34		

PR – probe route; OR – oral route; SC – subcutaneous route; IV – intravenous route; TR – topical route; IR – inhalation route; RR – rectal route

corresponded to a 4.34% medication administration error rate. The sample had 711 anti-infective drugs, which accounted for 48 dose omissions, yielding a 6.75% anti-infective medication administration error rate (Table 1).

Regarding analysis of the difference in omission rates found for anti-infective and non-anti-infective medications, the result of the logistic regression was 0.53305, with a p-value equal to 0.00102. To interpret this parameter, it was necessary to calculate its exponential value, thus obtaining 1.70412076. Consequently, it was concluded that anti-infective medications have a probability of dose omission 70.04% higher than non-anti-infective drugs.

To analyze the frequency of omissions that occurred at various scheduled times for the medications, the times were grouped into those close to changes of shift (6 am, 8 am, 12 noon, 2 pm, 6 pm, and 8 pm) and other times (2 am, 4 am, 10 am, 4 pm, 10 pm, and 12 midnight). The test for proportion was applied, in which the alternative hypothesis was the omission proportion in the changes of shift is higher than 50%, and the null hypothesis was the proportion is equal to 50%. The latter was rejected, with the adopted level of significance equal to 0.1% for non-anti-infective medications and 5% for anti-infective medications. With this setting, the omission proportion was higher at times approaching changes of shifts.

An analysis of administration routes associated with dose omissions demonstrated that the probe route showed the highest omission proportion, with a statistical difference between the values found using this route and those obtained for other routes. It was concluded that, for a level of significance equal to 1%, the medications administered using the intravenous route had an 82.79% lower probability of being the object of dose omission than those administered via probes; drugs administered subcutaneously had a 53.26% lower chance of being the object of dose omission than those administered using probes; medications to be taken orally had a 40.06% lower probability of being the object of dose omission than those administered via probes; and drugs administered using other routes had a 70.92% lower chance of being the object of dose omission than those administered using probes.

Among the anti-infective drugs, the highest number of dose omissions was obtained for carbapenems (n=13), administered intravenously (n=38) and at 8 pm (n=10), as shown in detail in tables 1 and 2. It was not possible to detect a difference in the chance of dose omission in patients who received medicines intravenously or through other routes.

Table 2. Dose omissions of anti-infective medications

ATCC classification	Medication name	Number of dose omissions n (%)
J01DH02	Meropenem, 500 mg or Meropenem, 1,000 mg	13 (27.08)
J01XB02	Polymyxin B, 500,000 IU	6 (12.5)
J01EE01	Sulfamethoxazole + trimethoprim 400+80 mg or Sulfamethoxazole + trimethoprim 80+16 mg/ml	6 (12.5)
G01AF01	Metronidazole, 5 mg/ml	4 (8.33)
J01GB06	Amikacin, 250 mg/ml	3 (6.25)
G01AA01	Nystatin, 100,000 IU/ml	3 (6.25)
J01CG02	Piperacillin + tazobactam 4+0.5 mg	2 (4.16)
J01DB01	Cephalexin, 500 mg	2 (4.16)
J01GB03	Gentamicin, 40 mg/ml	2 (4.16)
J01MA02	Ciprofloxacin, 400 mg	2 (4.16)
J01CA01	Ampicillin, 500 mg	1 (2.08)
J01MA06	Norfloxacin, 400 mg	1 (2.08)
J01XA01	Vancomycin, 500 mg	1 (2.08)
J06BA02	Immunoglobulin, 5g/100 ml	1 (2.08)
D01AA01	Nystatin, 2,500 IU/g	1 (2.08)

Discussion

The main limitation of the present study is related to the method used to identify, in the nursing records, the doses of non-checked medications for which no reason for not administering them was pointed out and which showed failures in drug scheduling that resulted in non-administered doses. However, even when the medication dose was not checked during prescription, the administration may have occurred, and in this case the failure is characterized as a record failure rather than dose omission.

The investigation found a medication administration error rate caused by dose omission that can be considered high, with the rate for anti-infective agents only being very high, taking into account that all the examined doses of prescribed medications should have been administered in critical care situations, especially those of anti-infective drugs intended for patients with severe infections, because of the risk of microbial resistance and/or treatment inefficacy. The literature shows different methods to calculate error or adverse events rates, according to the studies described next.

When analyzing medication errors informed by notifiers and registered on medical forms, researchers found that 28.3% of the notifications were related to non-administered medications, with the level of harm to patients classified as none (53.1%), mild (25.7%), intermediate (14.1%), or severe (7.1%).[14] Another investigation, in which researchers reviewed ICU patients' medical forms and calculated the prevalence of incidents among the inpatients and the number of hospital admissions, reported an estimated 97.4% of incidents were associated with medications, and lack of checking administered medications was the most frequent type of notifiable circumstance (47.9%), followed by absence of notes about medication administration (21.1%).[15]

Another study focusing on reviewing medical forms, internal data from health surveillance sectors, and notifications obtained from an incident record system regarding 138 medical forms of ICU patients revealed the occurrence of 152 adverse events, namely: dose omission–type medication errors (29.6%), pressure injuries (21.0%), unplanned extubation (17.0%), HAIs (15.13%), and detachment of probes (9.90%).[16]

Observational studies that monitored the preparation and administration of medications identified higher dose omission rates. A study found that 69.6% of the errors occurred during medication administration, and there were dose omissions in 9.5% of the medications. This error category accounted for 85.9% of the total errors. There was more than one error in 34.5% of the doses, and no errors were detected in only 14% of the examined doses.[17]

An observational study involving care evaluation and classification according to Carter's positivity index in 557 doses of prepared and administered medications classified as safe care the items' correct route (85.7%) and correct way (100%), and as tolerable care the items' correct patient (33.3%), correct medication (66.67%), correct dose (50%), correct record (33.33%), correct guidance (0%), and correct time (50%). The authors concluded that the set of practices could be categorized as tolerable care, given that six out of eight evaluated items showed low adherence, and these weaknesses compromised the whole medication administration process.[18]

Corroborating the higher medication administration error rate found for anti-infective drugs in the present study, a pilot investigation that analyzed the proportion of medication errors related to anti-infective agents and their consumption reported a total of 2,164 medication errors, including 301

(14%) related to anti-infective drugs. Most (95%) of the medication errors related to anti-infective substances did not have consequences for patients. Dose omission (26%) and administration of wrong doses were the two most frequently reported events, and 80% (n=242/301) of the medication errors occurred during the administration step, whereas 8% (n = 24/301) happened during the prescription stage. Three anti-infective medications had the highest medication error rate: linezolid, doxycycline, and acyclovir.[19]

The same study showed a ratio of 65.4 medication errors/10,000 defined daily doses of anti-infective medications and a proportion of 41.9 medication errors/10,000 days of therapy of the same class of medications. The authors concluded that the study puts the focus on monitoring anti-infective medications and improving the risk management system associated with this class of medications, and that anti-infective management programs must also take into account proportions of medication errors for these anti-infective drugs to increase patient safety and optimize medication use.[19]

Just like the present study, an investigation carried out in Brazil had the objective of identifying the classes of drugs involved in medication errors in ICUs. Three hundred and five events were detected, with a mean value of 6.9 occurrences per patient. The involved medications belonged to 33 classes, with the most frequent ones being antibiotics (25.2%), reducers of gastric acidity (19.0%), and antihypertensives (9.2%).[20] The study did not identify reasons for the higher frequency of omissions for anti-infective drugs of the carbapenem type (Meropenem) and among the different medication administration routes.

It is important to emphasize that dose omissions were more frequent at times close to changes of nursing team shifts, which may be related to the high number of activities at these moments, including both the significant number of doses scheduled at those times and other tasks involved in the change-of-shift process. The highest number of errors occurred in the processes of medication preparation and administration during the morning shift, as was also reported in another investigation.[17]

In addition to the WHO's recommendations and several publications in the literature about safety in the use of medications, a recent handbook with clinical practice guidelines on the safe use of medications in ICUs associates known strategies with their respective evidence categories. The document points out that hospitals and ICUs must become high-reliability institutions. An ideal patient safety culture in an ICU environment has to incorporate multiple strategies to prevent medication errors in all the steps of the process (prescription, dispensation, administration, and monitoring). Some strategies seem promising in getting around errors and improving results, such as the use of technology, including the introduction of computerized prescriptions, systems supporting clinical decision-making, medication administration systems with bar codes, and smart infusion pumps.[10]

Still, according to the handbook, the incorporation of new strategies, such as harmonization of medications and standardized practices for preparing intravenous medications, is a potential option to reduce the occurrence of errors. An active patient safety surveillance system can identify possible medication-related events to prevent injuries in real time or similar events in future patients. Other approaches include clinical pharmaceutical participation in the care of patients admitted to ICUs, as well as guaranteeing adequate amounts of human resources for all healthcare professionals. Errors and adverse events in ICUs remain a problem, despite the increase in awareness, regulatory mandates, and technological progresses. Given the complexity of critical patients' conditions at every care level and the limitation of hospital resources, each institution must evaluate possible strategies and implement them in their ICUs.[10]

Conclusion

The medication administration error rate by dose omission for anti-infective drugs in the analyzed ICU was significant, higher than the value found for other medications, and more frequent for the intravenous route and at times close to nursing

team changes of shifts. Safety barriers and strategies to prevent failures must be implemented to decrease potential risks and the occurrence of these errors. For instance, dose triple-checking (at the pharmacy, when the medication is received in the ICU, and when the administration itself is performed), as described in standard operational procedures, could be a useful action, as could be proper drug scheduling (avoiding times close to changes of shift) and continuing education and training on the safe use of medications.

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Collaborations

Castro AF, Oliveira JP, and Rodrigues MCS declare that they contributed to the study conception, data analysis and interpretation, writing of the manuscript, critical review of its intellectual content, and final approval of the version.

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