


Evaluation of medication error rates in Saudi Arabia

A protocol for systematic review and meta-analysis

Ziyad S. Almalki, PhD^{a,*} , Nasser Alqahtani, PhD^b, Najwa Tayeb Salway, BPharm^a, Mona Marzoq Alharbi, BPharm^a, Abdulhadi Alqahtani, BPharm^a, Nawaf Alotaibi, PhD^c, Tahani M. Alotaibi, BPharm^a, Tahani Alshammari, PharmD^d

Abstract

Introduction: Due to the diversity of reports and on the rates of medications errors (MEs) in Saudi Arabia, we performed the first meta-analysis to determine the rate of medications errors in Saudi Arabia using meta-analysis in the hospital settings.

Methods: We conducted a systematic literature search through August 2019 using PubMed, EMBASE, CINAHL, PsycINFO, and Google Scholar to identify all observational studies conducted in hospital settings in Saudi Arabia that reported the rate of MEs. A random-effects models were used to calculate overall MEs, as well as prescribing, dispensing, and administration error rates. The I^2 statistics were used to analyze heterogeneity.

Results: Sixteen articles were included in this search. The total incidence of MEs in Saudi Arabia hospitals was estimated at 44.4%. Prescribing errors, dispensing errors, and administration errors incidents represent 40.2%, 28.2%, and 34.5% out of the total number of reported MEs, respectively. However, between-study heterogeneity was also generally found to be >90% (I-squared statistic).

Conclusions: This study demonstrates the MEs common in health facilities. Additional efforts in the field are needed to improve medication management systems in order to prevent patient harm incidents.

Abbreviations: CI = confidence interval, ICU = Intensive Care Unit, MEs = medication errors, NCC MERP = National Coordinating Council for Medication Error Reporting and Prevention, NICU = Neonatal Intensive Care Unit, PRISMA = Preferred Reporting Items for Systematic Review and Meta-Analysis.

Keywords: administration error, dispensing error, medication errors, prescribing error, Saudi Arabia

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^a Department of Clinical Pharmacy, College of Pharmacy, Prince Sattam Bin Abdulaziz University, Al-Kharj, ^b Drug & Pharmaceutical Affairs, Riyadh First Health Cluster (C1) at Ministry of Health, Riyadh, ^c College of Pharmacy, Northern Borders University, Arar, Northern Borders, ^d College of Clinical Pharmacy, Almaarefah University, Riyadh, Saudi Arabia.

* Correspondence: Ziyad S. Almalki, Department of Clinical Pharmacy, College of Pharmacy, Prince Sattam Bin Abdulaziz University, Al-Kharj, Riyadh, Saudi Arabia (e-mail: z.almalki@psau.edu.sa).

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1. Introduction

Medication errors (MEs) are major issue in every healthcare system. They are ranked as one of the most common medical errors in the practice, according to the reports of the Joint Commission.^[1] Medication errors have an enormous impact on the health care system, including patients and payers.^[2] They remain the eighth leading cause of amenable and preventable death in the United States of America (USA), causing about 225,000 deaths each year.^[3] According to various studies on drug related hospital admissions, 5% to 6% of all hospitalizations are due to medication-related problems.^[4] It was estimated that MEs causing hospitalization in the UK occur in approximately 10% of inpatients; and nearly 50% of them are preventable.^[5] From the economic standpoint, these may have significant economic repercussions. It has been estimated that the annual cost of MEs in the world is approximately US\$42 billion.^[6]

Medication errors in hospital settings have become a topic of top priority in all nations and represent a significant challenge. There are evidence shows that the transition of care on admission to the hospital and between different units are risk points for MEs.^[7,8] There are many potential reasons for MEs to happen at hospital. Patients commonly receive new drugs or have alternate drugs due to drug formularies limitations which could limit to certain medications during the hospitalization.^[9] In addition, the lack of communication, understanding, and collaboration among

providers is a significant factor in preventable MEs after hospital.^[10]

Disseminating information about the rate of MEs in hospitals is the first step toward tackling this issue. Direct observation has been found to be the most accurate method for defining the real rates of ME.^[11] To date, a considerable number of studies have evaluated the rates of ME in different regions of Saudi Arabia. However, their results significantly vary (41.6%–70%).^[12–15] The reason for the observed variation in ME rates between studies can be explained, at least in part, by the definitions of MEs and the methods used in studies to determine the frequency of MEs. The diversity of methods for determination of MEs and extensive statistics on the rates of ME pushed healthcare planners and policymakers to deal with restrictions on using the results.

Given the above diversity on the rates of ME in Saudi Arabia, it is important to use stringent to combine the previous results of ME rates together to quantify the real prevalence of MEs on national level. Thus, to fill a significant gap in the literature, this research was designed to determine the pooled estimate of ME rates in Saudi Arabia and those occurring at different stages in the hospital setting (i.e., prescribing, dispensing, and drug administration phases) using meta-analysis.

2. Methods

2.1. Information sources and search

In this research, the systematic review was done in accordance with the Preferred Reporting Items for Systematic Review and Meta-Analysis Protocols (PRISMA) guidelines.^[16] Databases including PubMed, EMBASE, CINAHL, PsycINFO, and Google Scholar, which have electronically published studies from January 1966 to August 2019, were searched to find relevant Arabic and English language articles that examined the rate of MEs. We used the following key terms to search a database: *incident, frequency, rate, or percentage, prevalence rates, medication error, drug error, medication mistake, dispensing error, administration error, transcribing error, prescribing error, drug mistake, administration mistake, prescribing mistake, dispensing mistake, transcribing mistake, preparation mistake, Saudi*, and their Arabic equivalents, where above search terms were used in Arabic to search for articles published in Arabic language. We also added the names of cities with *and* and *or* operators in the abstracts and titles of articles and synonyms and other search terms to ensure that we did not overlook relevant studies. The reference lists of previous studies were accessed to find more previous studies if they were impossible to find in databases. The evaluation was done by 2 researchers. Disagreements between the 2 reviewers were brought to a third investigator for resolution.

2.2. Selection of studies

First, we conducted a preliminary examination of the titles on all studies selected from the search to obtain information relevant to our research. Second, we screened for the abstracts and skimmed full text when needed to assess the inclusion of the articles.

2.3. Inclusion/exclusion criteria of studies

The inclusion criteria were peer-reviewed observational and interventional studies conducted in hospital settings in Saudi Arabia that reported the rate of MEs in any age groups and in any phase of the pharmaceutical process. We excluded opinion pieces

and letters to the editor, qualitative studies, brief reports, case reports, editorial comments, and review articles. Additionally, we did not make use of studies that reported MEs using voluntary reports. Only studies using direct observation methods by the investigators were included as this method is recognized as effective in identifying MEs that actually occur.^[11] Studies with no data or insufficient data (i.e., total number medications and numbers of ME were not reported) were also excluded. We had no language restrictions to include studies that are not published in English language.

2.4. Definition of medication error

To identify and describe actual or potential MEs, we adopted a universally accepted definition of “medication error” that was approved by the National Coordinating Council for Medication Error Reporting and Prevention (NCC MERP)^[17]: “a medication error is any preventable event that may cause or lead to inappropriate medication use or patient harm while the medication is in the control of the health care professional, patient or consumer.” Several methods are used in classifying MEs. In this study, we used an approach that based the classification on the stages of the medication-use process in hospitals, specifically, prescribing, dispensing, and administration. Definitions of each of the ME categories are well documented in the existing literature.^[18,19]

2.5. Extraction of data

We developed a standardized data extraction instrument for the study that contains a checklist of items that should be included in the studies, that is, the title, year of research, the first author’s name, the sample size of the study, a study place, the frequency of overall occurrence of MEs and distribution across phases of the medication process, the type of methodology and study sampling, and the quality score of the study.

2.6. Quality assessment

To assess the quality of each study included, we used a thirteen-question scoring system (Table 1) utilized by previous studies.^[20–23]

Table 1
A list of quality assessment questions.

No.	Assessment question	Score	
		Yes = 1	No = 0
1	Are the research questions clearly stated?		
2	Is the definition of what constitutes a medication error clearly stated?		
3	Are the error categories clearly specified?		
4	Are the error categories clearly defined?		
5	Is the sampling method and calculation of sample size described clearly?		
6	Is the denominator clearly defined?		
7	Is the data collection method described clearly?		
8	Are the measures used reliable?		
9	Is the setting in which study conducted described?		
10	Are the measures in place to ensure that results valid?		
11	Is the limitations of study listed?		
12	Are any assumptions made mentioned?		
13	Ethical approval was obtained		

A score of 1 was assigned to each question if the study met the requirements of the quality assessment question, and a score of 0 was assigned if the study did not satisfy such a requirement. Criteria were graded *no score* if the requirement was unclear or not reported. The total score for all studies obtained from 13 questions was calculated by collecting the obtained scores.

2.7. Data synthesis and statistical analysis

A random-effects meta-analysis approach was employed to estimate the overall ME rates as well as the error rates of prescribing, dispensing, and administration. The entire analyses involved in this study were conducted using Comprehensive Meta-Analysis software (Biostat, Englewood, NJ). Event rates were noted from articles, and 95% confidence intervals (95% CI) were calculated. For the purpose of this study, we performed 4 group analyses according to the type of errors. Most studies were analyzed in more than 1 group. By using this measure (numerator/denominator) for each study, we were able to calculate the integrated indicators for every one of these groups. The first group specifically included errors regarding medication orders. Errors in MEs were defined as numerators and MEs as denominators. The second group included errors in the prescribing (numerator) of total MEs (denominator). The third group included errors in dispensing (numerators) and total MEs (denominator). Finally, the fourth group included administration

errors as numerators and total MEs as denominators. In cases where the numerator equals the denominator, the study was excluded from the specific group analysis to avoid any imprecise estimate.

We also assessed the statistical heterogeneity scores using the I^2 statistic test (in which a value of >75% was regarded as “large heterogeneity” and a value of <40% was regarded as “heterogeneity force is not important”). In this paper, we assessed the possibility of publication bias in meta-analyses across the selected studies using the funnel plot and Kendall’s tau and Egger bias test. As another way to address publication bias, a fail-safe N was calculated to determine the number of non-significant studies (i.e., with an error rate of zero) that would be necessary to reduce the overall error rate to zero. If we needed a large number of studies, there would be less reason for concern about publication bias.^[24] All significance testing was 2-sided, and the results were considered statistically significant at $P < .05$. In this study, we assessed the rates of the ME in Saudi Arabia based on the completed and published data from previous studies; thus, this study did not need to obtain Institutional Review Board approval.

3. Results

Figure 1 shows a flow diagram of the study selection, based on the inclusion and exclusion criteria. As of date, 16 studies were

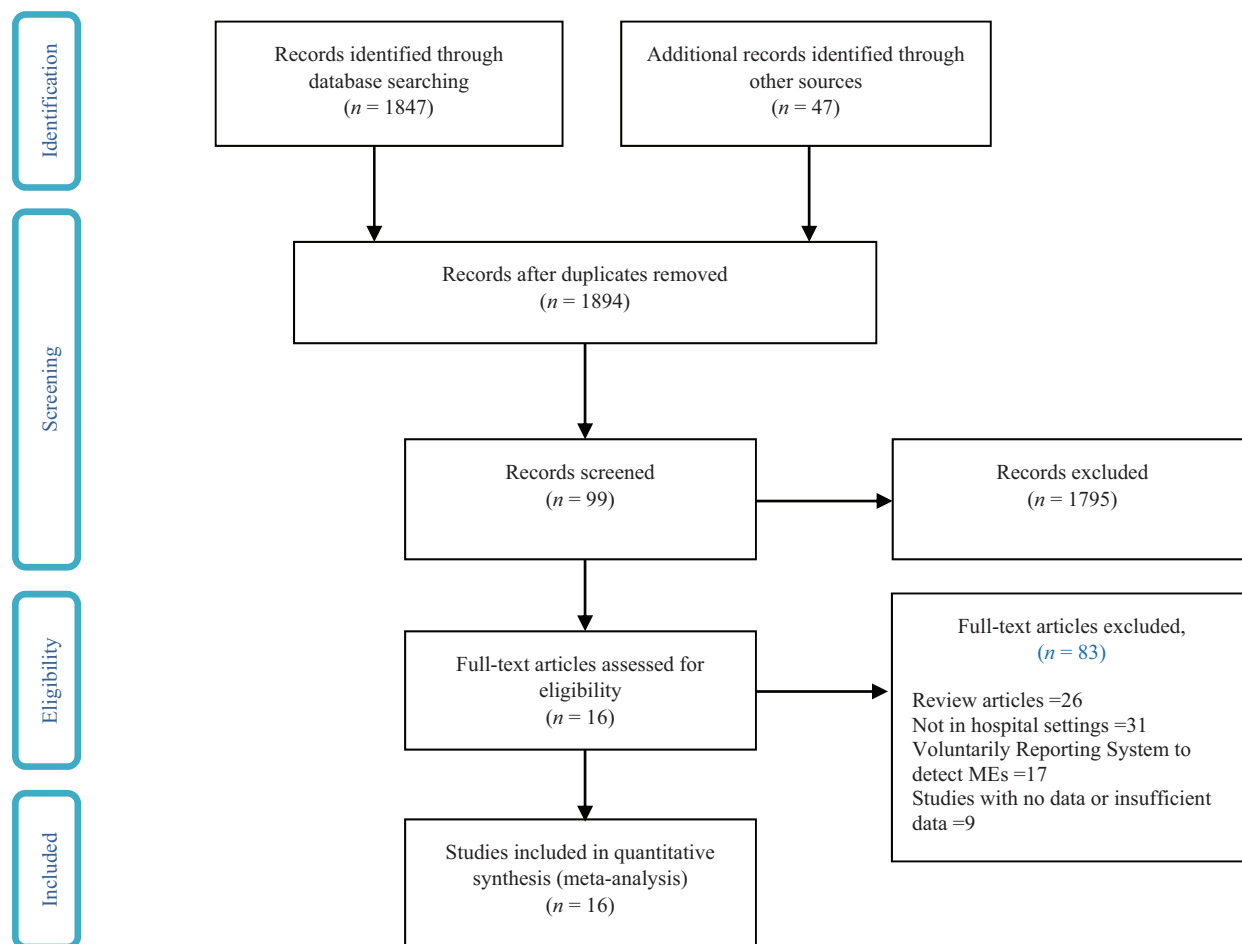
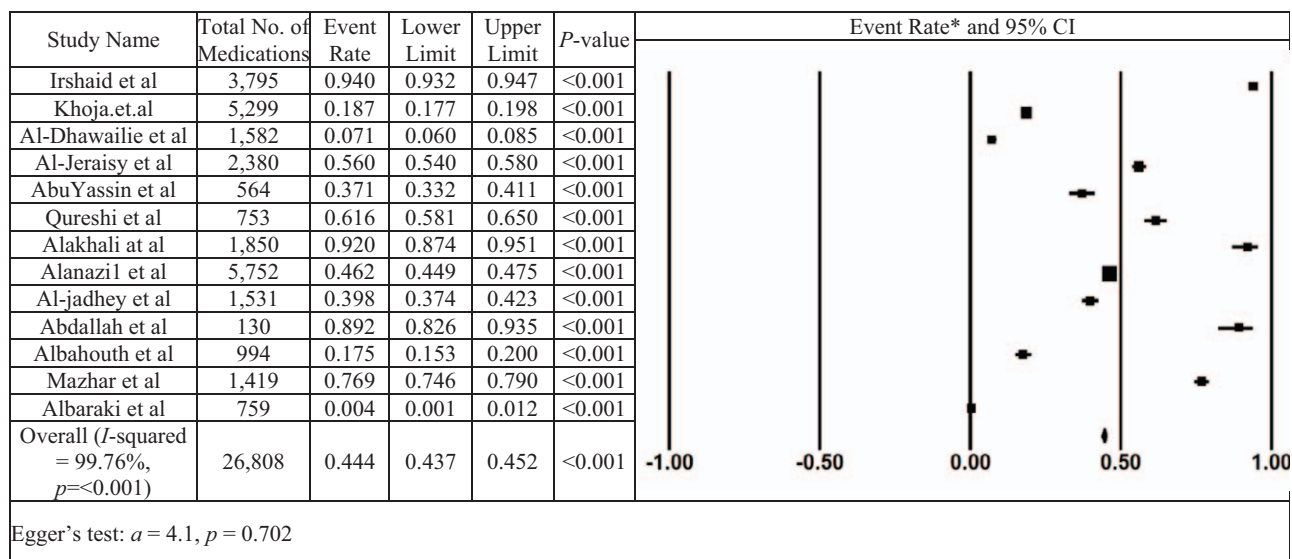


Figure 1. Search flow diagram.

Table 2
Selected articles about medication errors.

Study's names	Publication year	Study design	Type of hospital	Setting	Method of quantification	Sample size	Total no. of prescriptions during the study period	Prevalence of total medication error	Type of error	Duration	Error rate	Quality
Ishaid et al ^[25]	2005	Retrospective cross-sectional	Asir Central Hospital	Outpatient Departments	Direct observational of medication orders	NA	3796	3567	Overall medication errors	12 mo	Overall medication errors = 0.94	8
Dibbi et al ^[26]	2006	Retrospective cross-sectional	Hera General Hospital	NA	Direct observational of medical records	2627	2627	2627	Prescribing errors, dispensing errors, administration errors	24 mo	Prescribing errors = 0.47, dispensing errors = 0.34, administration errors = 0.19	9
Khoja et al ^[27]	2011	Retrospective Cross-Sectional	Primary Health Care Clinics	Public and Private Clinics	Direct observational of Prescribed medication	81	5299	990	Overall medication errors	1 Working Day	Overall medication errors = 0.18	7
Al-Dhawali et al ^[28]	2011	Prospective observational study	Tertiary university teaching hospital	Inpatient pharmacy	Direct observational of inpatient medication orders for medical ward	113	1582	113	Overall medication errors	1 mo	Overall medication errors = 0.07	10
Al-Jeraysi et al ^[13]	2011	Retrospective cohort	King Abdulaziz Medical City	General pediatric wards and the pediatric intensive care unit	Direct observational of physician medication orders and patients' files	44.5	2380	1333	Overall medication errors	5 wk	Overall medication errors = 0.56	10
Abuyassin et al ^[29]	2011	Prospective observational study	Tertiary Hospital	Hospital Departments	Direct observational of prescribed medication	60	564	209	Overall medication errors	Over 2 mo	Overall medication errors = 0.37	12
Qureshi et al ^[30]	2011	Prospective cohort	Three government-funded primary health care (PHC) centres	Outpatient setting	Direct observational of Prescribed medication	100	1182	753	Overall medication errors	12 mo	Overall medication errors = 0.61	9
Alakhalil et al ^[31]	2014	Retrospective cross-sectional	Hospital in Abha	Outpatient	Direct observational of prescribed medication histories	NA	1850	201	Overall medication errors, prescribing errors, dispensing errors, administration errors	2 mo	Overall medication errors = 0.92, prescribing errors = 0.93, dispensing errors = 0.03, administration errors = 0.04	7
Alanazi et al ^[32]	2015	Retrospective cross-sectional	King Abdulaziz Medical City	Emergency Department	Direct observational of medical charts	5752	5752	2657	Overall medication errors	3 mo	Overall medication errors = 0.46	8
Al-Jadhay et al ^[33]	2015	Prospective cohort	Four tertiary hospitals	Surgical and Intensive Care Units (ICUs)	Direct observational of prescribed medication	3985	4041	1676	Overall medication errors	Over 4 mo	Overall medication errors = 0.39	12
Abdallah et al ^[34]	2016	Retrospective cross-sectional	King Saud Medical City	ICU sections	Direct observational of medical records	114	130	116	Overall medication errors	1 mo	Overall medication errors = 0.89	11
Alomi et al ^[35]	2017	Prospective observational study	King Salman Hospital,	Inpatient	Direct observational of documented medication errors forms	805	NA	3089	Prescribing errors, dispensing errors, administration errors	9 mo	Prescribing errors = 0.44, dispensing errors = 0.02, administration errors = 0.34	5
Albahouth et al ^[36]	2018	Prospective observational study	Ten primary care hospital	Internal Medicine Department	Direct observational of prescribed medication	70	994	174	Overall medication errors	2 mo	Overall medication errors = 0.17	10
Abdulghani et al ^[37]	2018	Prospective cross-sectional study	Tertiary care hospital	Hospital ward	Direct observational of prescribed medication	286	3085	537	Prescribing errors	3 mo	Prescribing errors = 0.17	11
Mazhar et al ^[38]	2018	Prospective observational study	Tertiary care teaching hospital	Internal medicine ward.	Direct observational of prescribed medication	375	409	226	Overall medication errors	3 mo	Overall medication errors = 0.76	11
Albaraki et al ^[39]	2018	Retrospective Pilot	Seven military hospitals	Stock Control Departments'	Direct observational of prescribed medication histories	NA	759	3	Overall medication errors	6 mo	Overall medication errors = 0.004	6

ICU = Intensive Care Unit.



Note; Squares represent study weighting, and the horizontal line represents the 95% confidence interval. The diamond at the bottom represents the pooled event rate and its 95% CI.

* Event rate: the rate of MEs per total number of medication orders

Figure 2. The rate of medication errors in Saudi Arabia in study and overall estimation.

eligible to be included in this meta-analysis (Table 2). Two reviewers independently conducted the quality assessment on all studies using a 13-question scoring system. The quality assessment showed that only 1 study had a cumulative quality score of 5; 1 study had a cumulative quality score of 6; 2 studies (12.5%) scored 7; 2 studies (12.5%) scored 8; 2 studies (12.5%) scored 9; 3 studies (18.7%) scored 10; and the remaining studies (31.2%) scored >10.

As shown in Table 2, a total of 16 studies involve the cross-sectional, cohort, and pilot study, and the study hospital setting included a hospital ward; internal medicine ward; outpatient and inpatient setting; tertiary care and primary care; public and private clinics; Intensive Care Unit (ICU) and Neonatal Intensive Care Unit (NICU) sections; surgical, medical and cardiac intensive care units; department of children and obstetrics; gynecology; emergency department; and the stock control departments. Of the 16 selected studies, 7 articles were published between 2005 and 2011, and the remaining 9 articles were published between 2014 and 2018. All articles were published in English.

3.1. Statistical results

3.1.1. Medication error rate. Figure 2 shows the forest plot of the overall ME rate. In this analysis, out of 16 studies, 13 studies met the criteria and had enough information to be included in the meta-analysis (i.e., denominator data were reported, and the numerator does not equal the denominator). There was broad variation among studies in the rate of overall MEs. In a total of 26,808 medication orders from these studies, ME rates ranged from 0.04% to 94%. The lowest reported rate of MEs was found in the Albaraki et al study.^[39] According to the result of the random-effect model, the overall hospital ME rate per medication was calculated as 0.444, with 95% CI: 0.435 to 0.452, which was statistically significant at 5% level. The number of missing studies that would be needed to nullify the significance of the estimate

(classic fail-safe *N*) of the meta-analysis was 185. There is no indication of publication bias according to visual inspection of the funnel plot (Fig. 3) or Kendall's tau statistic ($P=.714$) or Egger's test (intercept $a=4.1; P=.702$). The main analysis indicated a significant amount of heterogeneity (I^2 statistic [$I^2 = 99.973\%$ and $P < .001$]).

3.1.2. Prescribing-error rate. Four studies were used to estimate the prescribing-error rate. The prescribing-error rates reported across these studies varied from 5.26% to 36.26%. The results, reported in Figure 4, showed that the prescribing-error rate is 0.402, with a 95% CI of 0.392 to 0.412 and a value of $P < .001$. Thus, the random-effect rate was 40.2%. The number of missing studies that would be needed to nullify the significance of the estimate of the meta-analysis was 248. There was no significant publication bias found according to a visual inspection of the funnel plot (Fig. 5) or Kendall's tau statistic ($P=.496$) or Egger's test (intercept $a=2.9; P=.908$). According to the results of the heterogeneous test, there was a high degree of heterogeneity between the studies included in the analysis, depending on the results obtained from the I^2 statistic ($I^2 = 99.973\%$ and $P < .001$).

3.1.3. Dispensing-error rate. The dispensing-error rates for each of the 3 studies and overall estimate are reported in Figure 6. Only 3 studies were used to estimate the dispensing-error rate. The integrated prescribing-error rate was calculated as 0.282, with a 95% CI of 0.269 to 0.295 and a value of $P < .001$. The number of non-significant studies needed to nullify the significance of the estimate was 975. An analysis of publication bias was conducted. There is some asymmetry indicating the possibility of missing studies according to visual inspection of the funnel plot (Fig. 7). However, the asymmetry is not confirmed by either Kendall's tau statistic ($P=.601$) or Egger's test (intercept $a = -10.08; P = .444$). Heterogeneity between included studies did show significance ($I^2 = 99.973\%$ and $P < .001$).

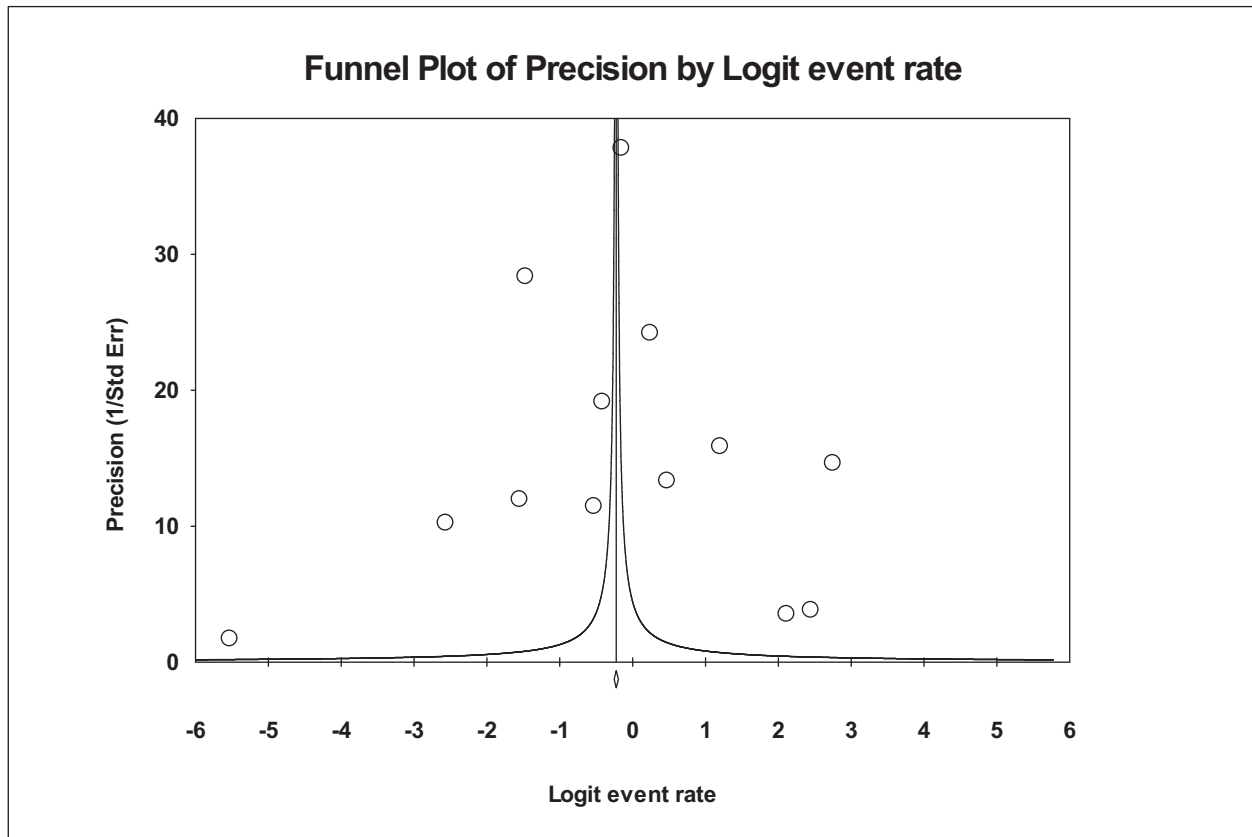


Figure 3. Funnel plot of precision by Logit Event Rate. This is a display of the study’s effect size on a logit scale against its respective precision for each study included in the meta-analysis. Dots represent point estimates plotted over precision measures (1/standard error). The vertical line represents the summary estimate rate using random-effects meta-analysis.

3.1.4. Administration-error rate. Three studies were used for this subgroup analysis to estimate the administration-error rate (Fig. 8). The integrated prescribing-error rate was calculated as 0.282, with a 95% CI of 0.269 to 0.295 and a value of $P < .001$. The number of missing studies that would be needed to change the results of the meta-analysis was 975. A visual inspection of the plot (Fig. 9) indicated some bias; however, the existence of this publication bias could not be confirmed with Kendall’s tau statistic ($P = .601$) or Egger’s test (intercept $a = -10.18$; $P = .777$). There was a high degree of heterogeneity between the studies

included in the analysis, depending on the results obtained from the I^2 statistic ($I^2 = 99.74\%$ and $P < .001$).

4. Discussion

Medication errors cause serious problems for patients and increase the patients’ mortality and hospital cost. In this meta-analysis, we found a significant variation in the reported rates of MEs in different hospitals in Saudi Arabia. The authors were able to use 16 studies in Saudi Arabia to evaluate the rate of MEs in hospitals during the stages of prescribing, dispensing, and

Study Name	Total No. of Medication errors	Event Rate	Lower Limit	Upper Limit	P-value	Event Rate and 95% CI	
						Study Weighting	95% CI
Dibbi et al	3,963	0.470	0.455	0.486	<0.001	0.470	0.455-0.486
Alakhali at al	201	0.920	0.874	0.951	<0.001	0.920	0.874-0.951
Alomi et al	3,089	0.465	0.447	0.482	<0.001	0.465	0.447-0.482
Abdulghani et al	3,085	0.174	0.161	0.188	<0.001	0.174	0.161-0.188
Overall (I^2 -squared = 99.64%, $p < .001$)	10,338	0.402	0.392	0.412	<0.001	0.402	0.392-0.412

Note; Squares represent study weighting, and the horizontal line represents the 95% confidence interval. The diamond at the bottom represents the pooled event rate and its 95% CI.

* Event rate: the rate of prescribing per total number of MEs

Figure 4. The rate of prescribing errors in Saudi Arabia in each paper and the overall estimation.

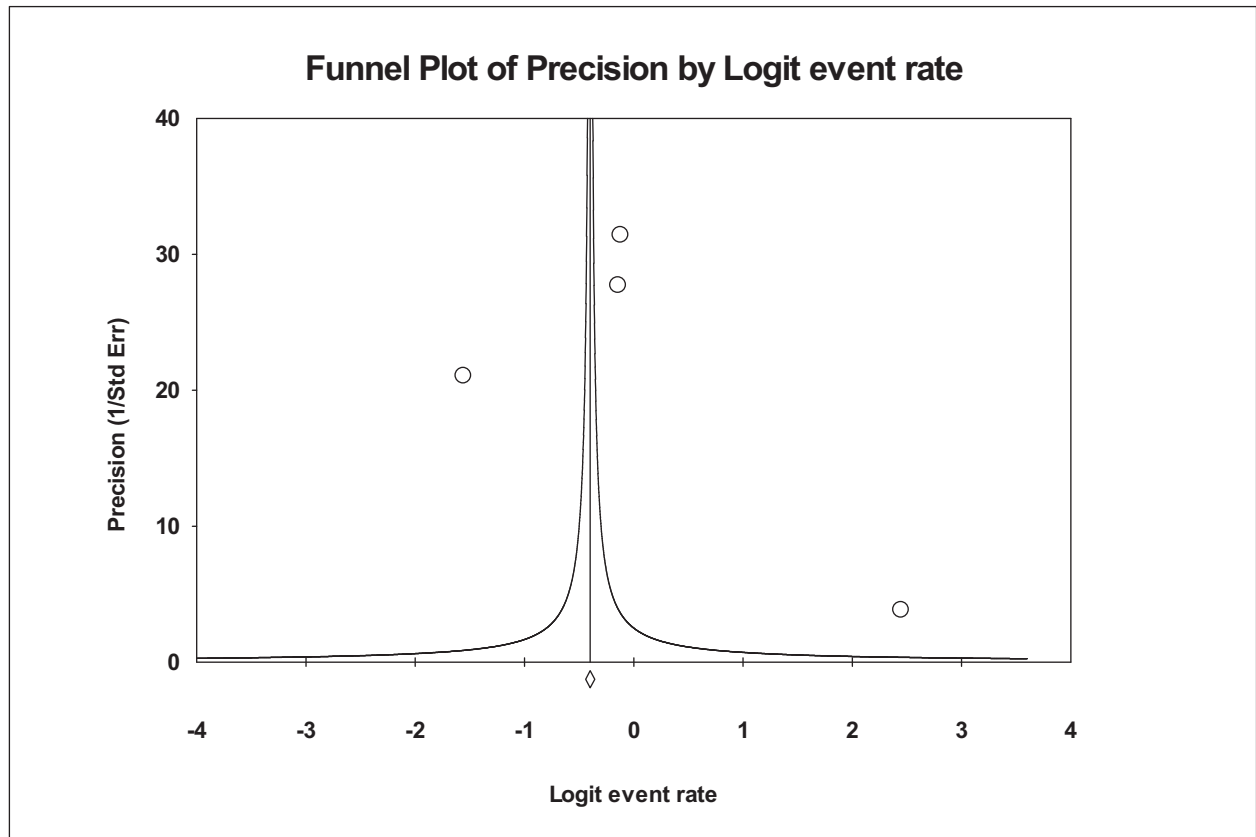


Figure 5. Funnel plot of precision by Logit Event Rate.

administration. The integrated ME rate in Saudi hospitals was estimated to be 44.4%, higher than those reported by the only meta-analyses published in relation to MEs in hospital.^[40] In the review of Taghizadeh et al,^[40] they included 33 out of 323 articles in hospital settings. The pooled rate of MEs in Iranian hospitals was 31.8%. These findings called to attention the high rates of MEs, which warrants serious concern about patient safety in the healthcare system in Saudi Arabia.

This study highlighted the most frequently reported category of MEs according to medication-use process stages. We observed a high rate of MEs in the medication-prescribing stage. This

estimate is higher than those reported by previous studies.^[41–45] The high rate of prescribing errors among physicians in Saudi Arabia is a serious threat to patients and Saudi’s health care system. Unfortunately, prescribing errors that occur in hospital settings have been a major issue for decades.

The future prevention of prescribing errors should focus on their root causes. Previous studies have recognized several important causes of this type of ME. The leading causes for prescribing errors were inadequate drug knowledge and experience, insufficient staff, increased patient load, time pressures and distractions while prescribing, incomplete supervision, miscom-

Study Name	Total No. of Medication errors	Event Rate	Lower Limit	Upper Limit	P-value	Event Rate and 95% CI	
						Study Weighting	95% CI
Dibbi et al	3,963	0.340	0.325	0.355	<0.001	0.340	0.325-0.355
Alakhali at al	201	0.035	0.017	0.071	<0.001	0.035	0.017-0.071
Alomi et al	3,089	0.029	0.024	0.036	<0.001	0.029	0.024-0.036
Overall (<i>I</i> -squared = 99.71%, <i>p</i> <0.001)	10,338	0.0282	0.269	0.295	<0.001	0.0282	0.269-0.295

Egger’s test: $a = -18.08, p = 0.444$

Note: Squares represent study weighting, and the horizontal line represents the 95% confidence interval. The diamond at the bottom represents the pooled event rate and its 95% CI.

* Event rate: the rate of dispensing per total number of MEs

Figure 6. The rate of dispensing errors in Saudi Arabia in each paper and the overall estimation.

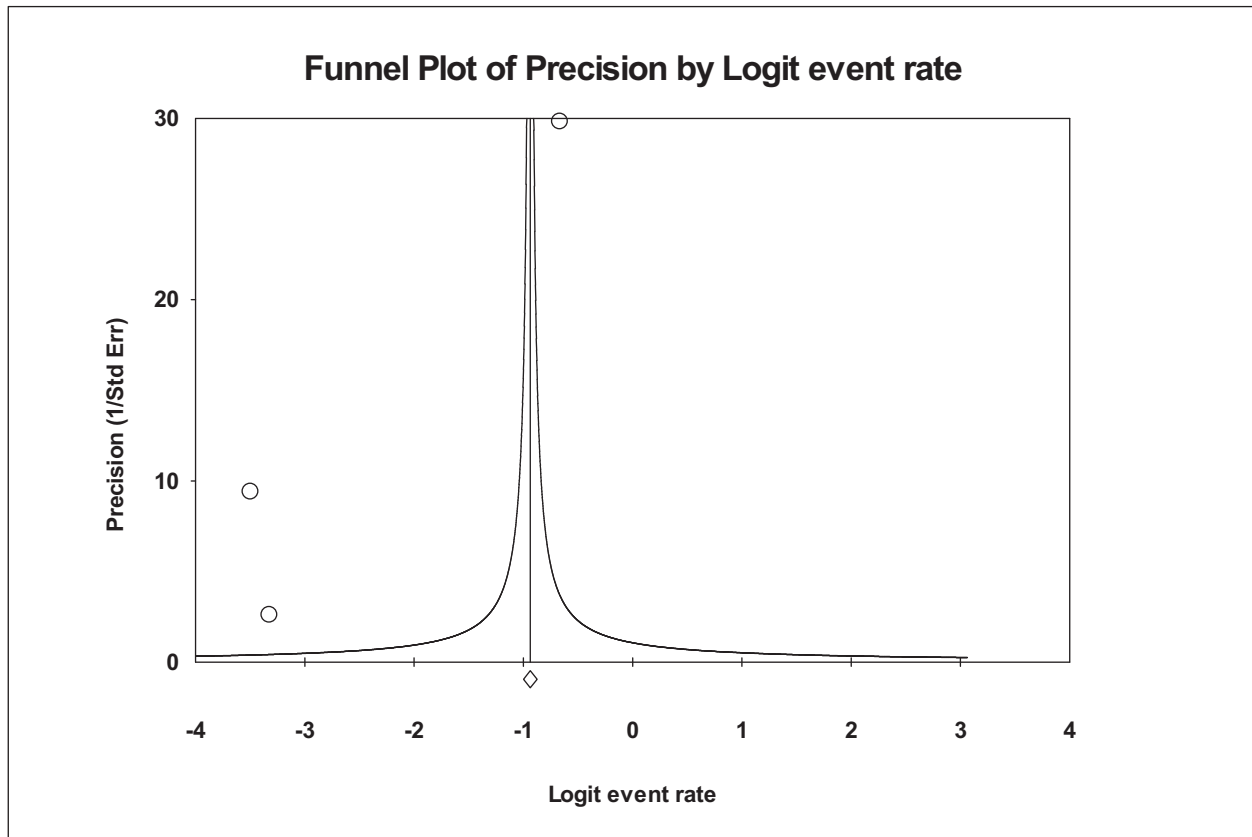


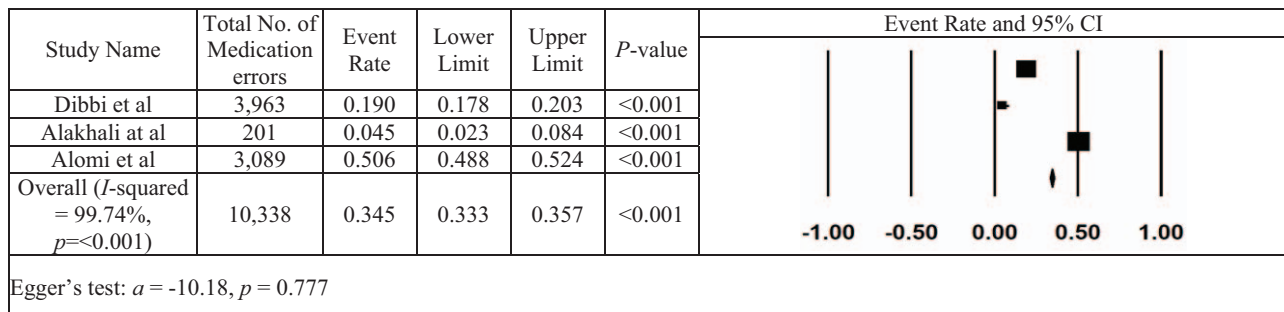
Figure 7. Funnel plot of precision by Logit Event Rate.

munication of prescribing decisions, increased reliance on pharmacists and nurses to identify and correct prescribing errors, and finally the lack of protocol/policy in how certain drugs are prescribed.^[44–49]

To reduce prescribing error in Saudi Arabia, several recommendations can be proposed. First, there is a need to raise awareness about prescribing errors and promote safety culture among prescribers. Secondly, improvement must be made to the system of reporting ME by providing specific on-the-job training in the prescribing error reporting system and encourage prescribers to promptly report such errors. Thirdly, health care

organizations should offer guidelines for clear and effective communication among health care providers. Finally, more appropriate policies and procedures should be put in place to reduce prescribing errors in Saudi Arabia.

Errors in administration, the final step in the medication pathway, remain a serious safety problem. In our study, administration errors were the second most frequently reported types of errors at 34.5% of drug MEs. This observation was found to be higher than those reported by a previous study.^[50] According to a study done by Lan et al, insufficient knowledge of pharmacology was found to be the most significant difficulty



Note: Squares represent study weighting, and the horizontal line represents the 95% confidence interval. The diamond at the bottom represents the pooled event rate and its 95% CI.

* Event rate: the rate of administration per total number of MEs

Figure 8. The rate of administration errors in Saudi Arabia in each paper and the overall estimation.

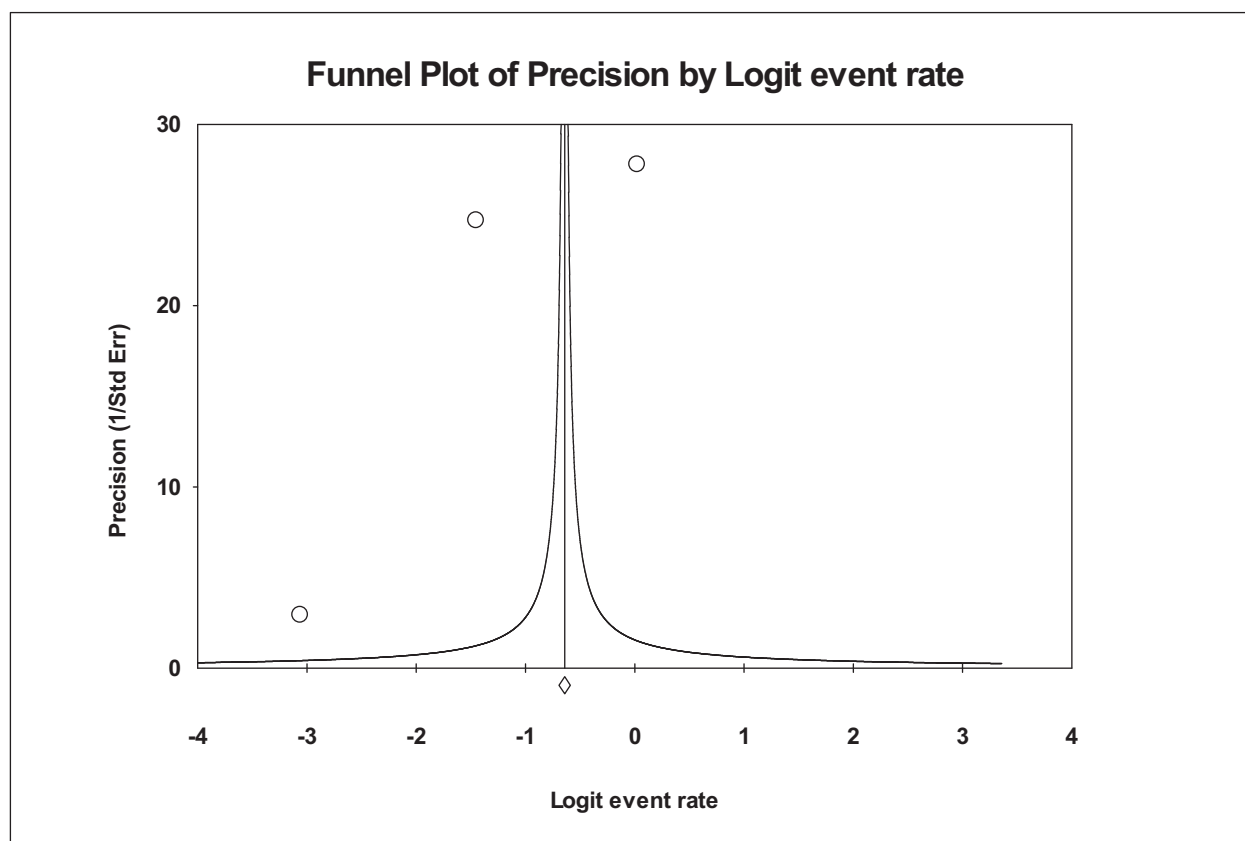


Figure 9. Funnel plot of precision by Logit Event Rate.

nurses encountered when administering medications.^[51] Thus, in the clinical environment, it is an institution's role to improve nurses' working procedures and knowledge by implementing an educational training program about drugs and potential MEs.^[52]

Although there has been a real increase in the adoption of new technologies such as automated dispensing systems,^[53] dispensing errors accounted for 28.2% of the total MEs in Saudi hospitals; the results are significantly higher than studies performed previously in health institutions in different countries.^[44,45,54] High workload, distractions, and working environment were both subjectively and objectively reported as contributing to dispensing errors.^[55,56] It is crucial that the medication dispensing system that involves preventing and detecting MEs offers the possibility of connecting all the steps of care of the patient, in addition to preventing dispensing errors.

Currently, MEs in hospital settings are of a greater degree in comparison to those in other healthcare settings.^[57] Our results demonstrate that Saudi healthcare settings share much of the challenges in medication safety observed in most countries around the world. While we did not evaluate it in the current research, we feel it is important to call for additional studies to elucidate the nature and define the causal factors of these MEs that, when eliminated, would prevent recurrence of these errors. Clearly, additional focus is needed on prescribing-error prevention strategies in the hospital settings in Saudi Arabia. Probably, computerizing the medication process system in hospital settings and pharmacological education of prescribers and nurses could help to reduce MEs.

To explore the potential source of heterogeneity across studies, sensitivity analyzes were performed by excluding studies one at a time to determine whether heterogeneity was substantially modified. When these studies were excluded from the analysis, the heterogeneity among studies was essentially unchanged. Thus, we cannot rule out that the bias and imprecision of I^2 when only a low number of studies in some analyses were used.^[58]

This analysis has its own limitations, and these should be noted before the implications of the current findings are considered. First, as noted previously, a significant heterogeneity across the selected studies points to caution in the interpretation of our findings. However, the heterogeneity may emanate from the variety of the studies' characteristics, initially, the different study durations and settings that complicated the studies' grouping. For example, studies with longer duration of data collection and conducted at outpatient and emergency departments represented higher medication error rates compared to other settings. Second, although the funnel plots assume a bias among the studies being examined in some group analyses, the bias was not evident by the Kendall's and Egger's tests. In addition, fail-safe numbers showed that publication bias is unlikely to be a problem. Finally, the meta-analysis included a few studies that make it difficult to generalize the results.

5. Conclusions

Understanding the MEs that occur in hospitals is an essential step toward improving the safety of patients. The results of this study

provide data on the rates and types of MEs in hospitals in Saudi Arabia. Through this meta-analysis, we learned that the most common errors were prescribing errors, followed by administration errors. Because of this concern, there is an urgent need for additional work in the field to improve medication management systems in order to prevent patient harm due to MEs. This information can be used to prioritize the future studies to identify the causes of errors occurring at different stages in the hospital setting as well as to develop intervention directed at reducing the risk to patients from MEs.

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Author contributions

Conceptualization: Ziyad S Almalki, Nasser Alqahtani, Abdulhadi Alqahtani, Nawaf Alotaibi.

Data curation: Ziyad S Almalki, Najwa Tayeb Salway, Mona Marzoq Alharbi, Abdulhadi Alqahtani, Tahani Alshammari.

Formal analysis: Ziyad S Almalki, Nasser Alqahtani, Najwa Tayeb Salway, Mona Marzoq Alharbi.

Funding acquisition: Ziyad S Almalki.

Investigation: Najwa Tayeb Salway, Abdulhadi Alqahtani.

Methodology: Ziyad S Almalki, Nasser Alqahtani, Najwa Tayeb Salway, Mona Marzoq Alharbi, Abdulhadi Alqahtani, Tahani M Alotaibi.

Project administration: Ziyad S Almalki, Tahani M Alotaibi.

Resources: Abdulhadi Alqahtani.

Software: Ziyad S Almalki, Tahani M Alotaibi, Tahani Alshammari.

Supervision: Najwa Tayeb Salway.

Validation: Mona Marzoq Alharbi.

Writing – original draft: Ziyad S Almalki, Nasser Alqahtani, Najwa Tayeb Salway, Mona Marzoq Alharbi, Nawaf Alotaibi, Tahani Alshammari.

Writing – review & editing: Ziyad S Almalki, Nasser Alqahtani, Najwa Tayeb Salway, Abdulhadi Alqahtani, Nawaf Alotaibi, Tahani Alshammari.

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