Knowledge of Food and Drug Interactions among Nurses: Assessment Strategy for Continuing Education

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Abstract

The effect of medication errors on patient quality care and safety is a critical ongoing concern requiring solutions. Although medication safety has been a concern of all healthcare professions, registered nurses play an important role in medication safety as patients' advocates. A cross sectional study with structured questionnaire on common FDI found in the medical journal was used in this study. The questionnaire consisted of 37 questions (dichotomous and multiple choice questions). A convenience sample of 271 nurses from different inpatient community nursing units (60 medical surgical, 60 telemetry, 29 Intensive care (ICU), 21 emergency, and 101 'others') across the DC-MD-VA metropolitan areas were recruited for this study. The data was subjected to descriptive analysis. The study protocol was approved by the Office of Regulatory, Research Compliance, Howard University. The result, showed no significant differences in the knowledge of FDI among the 5 groups of registered nurses. The authors propose continuing education for all nurses to update dosage calculation, follow drug administration protocol and enhance knowledge of pharmacology as avenues to reduce medication error. The authors also recommend that future studies focus on a larger sample size, inclusion of more associated FDI variables and use of high level statistical analysis.

Keywords: Food and drug interactions (FDI), Registered Nurses, Medical Surgical, Telemetry, Emergency, Intensive Care (ICU), Units

1. Introduction

The Institute of Medicine (IOM) reported that as many as 98,000 deaths occur annually from medical errors (Committee on Quality of Health Care in America, IOM, 1999). In the United States, the cost of managing drug-related morbidity and mortality is about $37.6 billion annually (IOM, 2010, Qing-ping, et al., 2014). About half of the cost, is associated to preventable errors (AHRQ, 2007, 2010). Nurses practice in a wide-range of specialty areas. These include emergency, trauma, intensive care (ICU), medical surgical units etc. Each unit demands some key skills in order to effectively carry out patient care. American Nurses Association demands that nurses are floated to a unit they have the appropriate competency (ANA 2001). Studies suggest that a better patient outcome is linked to higher nursing competency (ANA 2001). Accurate dosage calculation, following drug administration protocols and sound knowledge of pharmacology are some of the active ways to reduce medication error.

Food and Drug Interaction (FDI), an adverse drug reaction, is one of the sources of medication errors (Bushra et al., 2011). Adverse Drug Reactions (ADRs), pose a significant public health problem requiring solutions. Medication errors occur due to active failures and latent conditions (Frith et al., 2012). Latent conditions include inadequate staffing, time pressures, unit environment and fatigue (Frith et al., 2012). Equally important are active conditions that contribute to errors. Active failures include wrong dosage calculation, failure to follow drug administration protocols and lack of pharmacology knowledge. Although, many strategies such as computerized physician entry, bar code administration systems, medication reconciliation (Frith *et al.,* 2012), are in place to reduce medication errors, the incidence of medication errors remains an issue. Health personnel are key in the management of medication errors. Registered Nurses, play an important role in patient safety (IOM, 2010). Hence, the Joint Commission on the Accreditation of Healthcare Organizations (JCAHO) requires that a thorough drug history be taken during hospital admission and adequate drug reconciliation during discharge (Unroe *et al.,* 2010). Studies suggest that a better patient outcome is linked to higher nursing competency (ANA 2001). Nurses act as the final barrier between a patient and medication error (Frith et al., 2012). The authors suggested that increasing the number of RN (Registered Nurse) hours and decreasing or eliminating LPN hours can be a strategy to reduce medication errors. It has been recommended that nurses should be watchful in monitoring for possible FDI and in counseling patients on food and beverages to avoid when taking certain medications. It is then imperative that nurses be current on potential FDI of medications to ensure that they function properly as patient advocates. Studies on the knowledge of FDI among nurses working in different specialty units are lacking.

FDI occur when specific nutrients in foods interact with drugs if ingested concomitantly. FDI can result in changes in the bioavailability, pharmacokinetics, pharmacodynamics and therapeutic efficacy of the medication. For example, dietary sources of vitamin K, such as spinach or broccoli, have been shown to cause a pharmacodynamic antagonism of warfarin thereby causing a need to increase the dosage requirement for warfarin. Grapefruit juice contains a bioflavonoid that inhibits CYP3A, an enzyme that is involved in the metabolism of many drugs (Andrade, 2014; Hanley, *et al*., 2011). Concomitant administration of grapefruit with drugs that are metabolized by CYP3A enzymes can cause a 5-fold increase in the bioavailability of such drugs (Mason, 2010). This is true with the administration of grape juice with felodipine, an antihypertensive drug that is metabolized by CYP3A enzymes (Hanley *et al.*, 2011). Patients at high risk for FDI include elderly patients taking three or more medications (polypharmacy) for chronic conditions such as diabetes, hypertension, depression, high blood cholesterol, or congestive heart failure. Patients on polypharmacy, should be assessed regularly for possible food and drug interactions (Mouly *et al.,* 2015).

1.1 Aim

This study, examines the knowledge of pharmacology with emphasis on food and drug interaction amongst nurses working in different units in community hospitals in the DC-MD-VA.

2. Methods

2.1 Design

This was a cross-sectional descriptive survey using the modified validated, structured questionnaire of Jyoti *et al*. (2012). The questionnaire is focused on common FDI.

2.2 Selection of Participants

The survey included a convenience sample of 271 nurses, divided into 5 groups (60 med surgical, 60 telemetry, 21 emergency, 29 Intensive care (ICU) and 101 'others') of nurses working in different inpatient care units in community hospitals in the District of Columbia metropolitan (DC-MD-VA) area. The 'other' unit, represents a group of data collected from units whose numbers were low due to insufficient participants. The study was carried out during the period of March – December 2014.

2.3 Ethical Considerations

Informed consent was obtained from all the participants before the distribution of the Food and Drug Interaction questionnaire (FDIQ). Personal identifiers were excluded in the questionnaire.

2.4 Data Collection

The Jyoti *et al*. (2012) FDIQ was adopted for this study. There were 37 questions which included dichotomous and multiple choice questions. The 37 questions, tested participants' knowledge (see questionnaire items). The FDIQ included questions regarding food interactions with antihypertensive, antithyroids, antidepressants, anticoagulants, antiretrovirals, peptic ulcer drugs and analgesics. On average it took 30 minutes for each participant to complete the questionnaire.

2.5 Data Analysis

Statistical analysis was carried out using the Statistical Package for the Social Sciences Statistics (SPSS) Version 22 (IBM-SPSS Inc., Chicago, Illinois). Results were expressed as mean ±SD. Questions scored correct, were given one point while incorrect answers, were given a zero point. The maximum score for knowledge questions on FDI was 37. The Pearson's chi-square test followed by the Mann-Whitney U test, were used to evaluate homogeneity of the data across the groups. One-way Analysis of Variance (ANOVA) was used to compare the total score among the different groups. The level of significance was set at $p < 0.05$.

3. Results

The survey was completed within nine months from the start of the study. The response rate was 100%, and all participants completed the FDIQ within 30 minutes. The overall knowledge of the study participants was assessed based on their responses to the questionnaire (see below).

3.1 Questionnaire Items

Q #. Description

1. Theophylline and Caffeine
2. Tetracycline and Dairy products
3. MAOI and tyramine containing foods (cheese)
4. Caffeine and Diazepam
5. Coumadin and Garlic
6. Antibiotics and Citrus juice
7. Ketoconazole and Fatty acid
8. Digoxin and Wheat bran
9. Levodopa and Protein meal
10. Coumadin and Green vegetables
11. Levothyroxine and Cauliflower
12. Age group at highest risk for FDI

13 -16 Food/ Supplement commonly involved in FDI

17. Pharmacokinetic process commonly involved in FDI

18 – 22: Timings of food and drug intake

18. Omeprazole
19. Glipizide
20. Actos
21. NSAID
22. Levothyroxine

23 – 25: Drugs and alcohol

23. Metronidazole
24. Milk
25. Cimetidine

26 – 28: Drugs and grapefruit juice

26. Sildenafil (Viagra)
27. Diltiazem
28. Amiodarone

29 – 31: Hypertensive management

29. Propranolol with or without food
30. Spironolactone and potassium rich foods
31. Salt and hypertension

32 – 34 : anti-HIV and food timing

32. Lopinavir
33. Didanosine
34. Zidovudine

35 – 37: fruit juices, vitamins

35. Vitamins and medications
36. Cranberry juice

37. Orange juice and alcohol

Table 1 compares the knowledge of FDI among nurses working in different units- Medical Surgical, Telemetry, Emergency, Intensive care (ICU) and ‘others’. The values reported for each question represent the percentage of the correct answers in each of the groups. With respect to if drugs can be taken on an empty stomach or with food (timing-Q19-22), most of the participants were knowledgeable with proton pump inhibitors (PPI e.g. omeprazole), non-steroidal anti-inflammatory drugs (NSAIDs) and thyroid hormones (levothyroxine). Some of the participants were not sure if food will affect the absorption of certain drugs such as antidiabetic drugs (acarbose, glipizide), antacids and drug for tuberculosis (isoniazid) . For NSAIDs (Q21) and levothyroxine (Q22) questions, participants working in ICU scored better than the other groups. Similar response scores were observed on question (Q25) regarding the interaction of cimetidine with alcohol. All the participants scored high in their knowledge of the interaction of theophylline with large amounts of tea, coffee and chocolates (Q1). Medical surgical nurses, scored low on question asking for common food and drug interactions such as consumption of cheese, processed meats, legumes, wine, beer, fava beans and fermented products with MAO inhibitors (Q3), as well as the interaction of drugs with dairy, iron and alcohol (Qs 13, 14 &15). Medical surgical nurses scored higher on the pharmacokinetic process where FDI occurs most (Q17). Emergency unit nurses, scored better than the other groups on the interaction of coumadin and garlic (Q5) and vitamins and medications (Q35).

Table 1. Comparison of the knowledge of FDI in the five groups (Medical Surgical (GP I),Telemetry (GP II), Emergency (GP III), ICU (GP IV) and ‘others’ (GP V), expressed as percentage of respondents with correct answers for each question.

Q #	GP I	GP II	GP III	GP IV	GP V	Pair wise comparison (p value)				
	MS	TELE	EM	ICU	OTHERS	1-II	1-III	I-IV	I-V	II-III
	n=60	n=60	n=21	n=29	n=101					
1	84.4	80.3	81.0	82.8	86.5					
2	59.4	47.5	57.1	37.9	46.2					
3	78.1	88.5	85.7	79.3	81.7					
4	84.4	88.5	85.7	86.2	81.7					
5	43.8	34.4	57.1	37.9	54.8					
6	45.3	49.2	66.7	27.6	56.7					
7	39.1	26.2	42.9	27.6	36.5					
8	32.8	37.7	33.3	27.6	22.1					
9	45.3	36.1	81.0	27.6	37.5					
10	64.1	41	61.9	51.7	62.5	0.010	0.005			
11	25.0	19.7	47.6	24.1	28.8					0.130
12	46.7	45	38.1	58.6	42.6					
13	9.4	26.2	28.6	20.7	23.1	0.014	0.029		0.025	
14	10.9	24.6	23.8	20.7	19.2	0.046				
15	15.6	31.1	28.6	24.1	20.2	0.041				
16	75.0	85.2	90.5	93.1	84.6			0.042		
17	73.4	62.3	61.9	69.0	66.3					
18	62.5	73.8	42.9	75.9	68.3					0.010
19	32.8	24.6	38.1	24.1	38.5					
20	40.6	42.6	90.5	27.6	37.5					
21	68.8	65.6	66.7	82.8	64.4					
22	53.1	82	42.9	55.2	47.1	0.001				0.001
23	87.5	82	100	89.7	92.3					0.038

24	26.6	45.9	14.3	41.4	19.2				0.017	0.010
25	84.4	91.8	90.5	96.6	95.2					
26	81.3	75.4	81	62.1	81.7			0.048		
27	64.1	62.3	61.9	72.4	76					
28	65.6	69.2	57.1	51.7	52.9					
29	73.4	72.1	66.7	89.7	71.2					
30	84.4	75.4	81	89.7	75					
31	87.5	98.4	90.5	96.6	98.1	0.019			0.005	
32	90.6	82	76.2	86.2	83.7					
33	78.1	68.9	76.2	79.3	76.9					
34	85.9	72.1	81.0	89.7	74.0					
35	60.9	52.5	81	44.8	54.8					0.022
36	67.2	62.3	57.1	58.6	70.2					
37	65.6	73.8	71.4	69.0	63.5					

Table 1 cont. Comparison of the knowledge of FDI in the five groups (Medical Surgical (GP I),Telemetry (GP II), Emergency (GP III), ICU (GP IV) and 'others' (GP V), expressed as percentage of respondents with correct answers for each question

Q #	GP I	GP II	GP III	GP IV	GP V	Pair wise comparison (p value)				
	MS	TELE	EM	ICU	OTHERS	II-IV	II-V	III-1V	III-V	IV-V
1	84.4	80.3	81.0	82.8	86.5					
2	59.4	47.5	57.1	37.9	46.2					
3	78.1	88.5	85.7	79.3	81.7					
4	84.4	88.5	85.7	86.2	81.7					
5	43.8	34.4	57.1	37.9	54.8		0.012			
6	45.3	49.2	66.7	27.6	56.7			0.007		0.006
7	39.1	26.2	42.9	27.6	36.5					
8	32.8	37.7	33.3	27.6	22.1		0.032			
9	45.3	36.1	81.0	27.6	37.5					
10	64.1	41	61.9	51.7	62.5		0.008			
11	25.0	19.7	47.6	24.1	28.8					
12	46.7	45	38.1	58.6	42.6					
13	9.4	26.2	28.6	20.7	23.1					
14	10.9	24.6	23.8	20.7	19.2					
15	15.6	31.1	28.6	24.1	20.2					
16	75.0	85.2	90.5	93.1	84.6					
17	73.4	62.3	61.9	69.0	66.3					
18	62.5	73.8	42.9	75.9	68.3			0.019	0.028	
19	32.8	24.6	38.1	24.1	38.5					
20	40.6	42.6	90.5	27.6	37.5					
21	68.8	65.6	66.7	82.8	64.4					

22	53.1	82	42.9	55.2	47.1	0.008				
23	87.5	82	100	89.7	92.3		0.045			
24	26.6	45.9	14.3	41.4	19.2			0.041		0.014
25	84.4	91.8	90.5	96.6	95.2					
26	81.3	75.4	81	62.1	81.7					0.026
27	64.1	62.3	61.9	72.4	76					
28	65.6	69.2	57.1	51.7	52.9					
29	73.4	72.1	66.7	89.7	71.2					0.042
30	84.4	75.4	81	89.7	75			0.047		
31	87.5	98.4	90.5	96.6	98.1					
32	90.6	82	76.2	86.2	83.7					
33	78.1	68.9	76.2	79.3	76.9					
34	85.9	72.1	81.0	89.7	74.0					
35	60.9	52.5	81	44.8	54.8	0.022		0.011	0.027	
36	67.2	62.3	57.1	58.6	70.2					
37	65.6	73.8	71.4	69.0	63.5					

The five groups scored low on the interaction of digoxin with foods such as wheat bran, rolled oats and sunflower seeds (Q8). The nurses working in the Telemetry unit scored high on the FDI of amiodarone with grapefruit juice (Q28). There was no significant difference among the five groups on their knowledge of FDI between diltiazem and grapefruit juice (Q27). The total scores on the knowledge test as displayed in Table 2 were as follows: Medical Surgical (22.13±4.97), Telemetry (21.78±4.58), Emergency (23.38±3.39), ICU (21.79±4.22) and others (21.96±4.43). Hence, no significant differences in knowledge were found among the five groups.

Limitations of this study are small sample. Future research calls for a larger sample size and to assess FDI knowledge, practice and awareness amongst nurses working in different facilities (hospital, nursing home, college). In addition, higher statistical analysis such as regression, propensity is recommended in future studies for more validated results.

Table 2. Total score, mean difference and the mean score percentage of Attitude of FDI among five groups

Total score	**Med/Surg (n = 60)**	**Telemetry (n = 60)**	**Emergency (n =21)**	**ICU (n = 29)**	**'Other' (n= 101)**
Mean±SD	22.13±4.97	21.78±4.58	23.38±3.39	21.79±4.22	21.96±4.43
Mean difference	-0.3500	-1.5976	-1.2476	-0.3402	-0.1729
Mean score percentage	59.8%	58.9%	63.0%	58.9%	59.3%
p value	0.60	0.60	0.60	0.60	0.60

4. Discussion

The present study was successful in evaluating the knowledge of FDI among nurses working in different nursing units. With respect to knowledge of FDI, there were no significant differences among nurses working in different nursing units. However, there were some significant differences in some individual questions such as interaction of coumadin with garlic (Q5), ketoconazole with garlic (Q7), digoxin with fiber (Q8), milk and alcohol (Q20). This observation in the knowledge of FDI amongst nurses working in different nursing units suggest that the nursing preparation is the same irrespective of the unit they work in. This supports the finding that there is no difference between patient outcome and nursing education (IOM, 2010).

The results also showed that drug interaction does not only occur between two drugs rather, they can occur between drugs and between any kind of foreign substance (xenobiotica), food (e.g. grapefruit juice, broccoli, and barbecue) as well as caffeine and alcohol (Haen, 2014). Warfarin interacts with many foods (Nutescu *et al.*, 2011). Vegetables, such as broccoli, kale, spinach, rich in vitamin K, when consumed in large quantity, will interfere with the effectiveness and safety of warfarin (Bushra, 2011). FDI occur when the presence of a food changes the bioavailability of a drug co-administered together. This variation can result in therapeutic failure especially with orally administered drugs (Mouly *et al.*, 2015) Foods can change drug bioavailability through various mechanisms which include changes in gastric emptying, and changes in the activity of drug metabolizing enzymes (Kersemaekers *et al*., 2015).

In addition, improper timing of foods and drugs are contributors to treatment failure (Jyoti et al., 2012). The participants from the five groups scored very low in some questions on the FDIQ such as the timing of foods and drugs such as glipizide, actose, synthroid (thyroid hormone) . To enhance therapeutic effects, drugs such as glipizide, atenolol, and synthroid that interact with foods should be taken on an empty stomach (Manrique *et al.*, 2014; Winstanley *et al.*, 1989). The five groups scored low on their knowledge of alcohol interaction with foods, such as milk. Acute ethanol absorption, inhibits drug metabolism. Chronic alcohol consumption had been shown to affect the bioavailability of drugs consumed orally or by the parenteral route (McCance-Katz et al., 2013).

The five studied groups especially nurses that worked in the intensive care unit (ICU), scored poorly on the interaction of griseofulvin, ketoconazole and albendazole with fatty diets. These drugs have antifungal and anthelmintic properties. Earlier studies have shown that these drugs are poorly absorbed when administered orally. A high systemic concentration is observed when these drugs are coadministered with a fatty food (Omotoso *et al.*, 2013). The maximum plasma concentration of griseofulvin increased by 80% in the presence of high fat content meals. This increase is a result of enhanced solubilization of griseofulvin by fat (Palma *et al.*, 1986). Drugs with a large therapeutic index, produce a harmless effect when they interact with food (Mason, 2010). Griseofulvin has a wide therapeutic index. However, at a high concentration, toxicity is observed because of concentration-dependent liver enzyme induction. Albendazole exhibits similar characteristics as griseofulvin in the presence of a fatty meal. Unlike griseofulvin, a high carbohydrate, low fat meal significantly reduces the plasma concentration of ketoconazole and albendazole (Mannisto *et al.*, 1982). Drugs with low therapeutic index are more likely to produce a significant harmful effect when they interact with food (Omotoso et al., 2013).

The five groups of participants, scored low in the interaction of digoxin with foods such as wheat bran, rolled oats and sunflower seeds. Digoxin is a drug that is commonly used in the management of atrial arrhythmias and congestive heart failure. Agents that affect intestinal motility have been shown to affect the rate and extent of absorption of orally administered digoxin (Hussain 2011). Johnson *et al.* (1987) showed in sixteen healthy volunteers, concurrent administration of digoxin tablets with a meal high in fiber content decreased the extent of absorption of digoxin. Digoxin has a narrow therapeutic index. Therefore, changes in the bioavailability of digoxin will have a significant therapeutic effect. The consequence of a decrease in the plasma concentration of digoxin will lead to therapy failure. Drugs with low therapeutic indices such as phenytoin should be taken at set times with relation to meals (Mason, 2010; de Lima Toccafondo & Huang 2012; Carrillo, 2012).

The groups did poorly on the interaction of levodopa with a meal rich in protein. Levodopa is used in the management of Parkinson's disease. Its absorption from the small intestine is mediated through an unknown large neutral amino acids transport pump (Carmago et al., 2014). The coadministration of Levodopa with dietary amino acids causes an increase in the competition for transport in the small intestine and at the blood-brain barrier, thus decreasing the bioavailability of Levodopa (Carmago *et. al.*, 2014). Question 14 tested participants on the pharmacokinetic process where interactions occur most. All the groups scored below 80 %. Nurses working on the Medical surgical unit, scored better as compared to other groups. Similar scores were noticed on the effect of grapefruit juice on amiodarone . Nurses in ICU scored very low compared to other groups on some questions such as ketoconazole and fatty diet (Q7), digoxin and wheat bran(Q8), levodopa and protein diet, synthroid and the timing of food(Q19), metronidazole and alcohol (Q20).

5. Conclusions

Our studies are in agreement with previous studies (Nazari et al., 2011; Jyoti et al., 2012) that have shown that health care professionals lack knowledge about FDI. This study shows that the level of knowledge of FDI among nurses working in the different units are similar. Suggesting that the nurses are equally prepared in pharmacology. However some units scored lower than others in some individual questions. Some significant differences were observed in certain questions such as interaction of Coumadin with garlic (Q5), digoxin with fiber (Q8), theophylline with caffeine (Q1). There were no significant differences on the total score earned by each group (table 2). There were no significant differences on the total score earned by each group (table 2). The results of this study support the Code of Ethics for Nurses with Interpretive Statements that nurses should not be assigned to a particular unit without first having established the ability to provide professional care in such unit (ANA, 2001). The authors propose continuing education for all nurses to update dosage calculation, follow drug administration protocol and enhance knowledge of pharmacology as avenues to reduce medication error.

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