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Research Article

A Prospective Observational Studies on Drug Utilization Evaluation and Rational Use of Corticosteroids in Tertiary Care Hospital

Syeda Masarrath Unissa, Sana Kareem, Sumaiya Faheem Ahmed, Syed Imran Ul Haq, S Ahmedullah Hussaini Quadri

Dept. of Pharmacy Practice, MESCO College of Pharmacy, Hyderabad, Telangana, India

ABSTRACT

Background: Corticosteroids are widely prescribed Drugs in Hospitals, forming a part of standard treatment of modern medicine for a wide range of diseases, associated with inflammation and immune activation. Apart from beneficial effects they also produce number of adverse effects. In the present study, Prospective Observational studies on DUE (Drug utilization evaluation) and rationality of Corticosteroids has been Performed.

Objectives: To Investigate the Drug utilization evaluation, Prescription pattern and Rationality of corticosteroids in various department of tertiary care teaching hospital.

Methodology: A prospective observational study was conducted on 100 patients receiving corticosteroids in the various departments of Osmania general Hospital, Hyderabad. Patients prescribed corticosteroids therapy was included in the study. Exclusion of those patients with age less than 18, psychiatric disease, pregnant women and patients not willing to sign on consent form.

Result: This study included 100 Patients out of which 68 were Male and 32 were female. In Age wise distribution, 15 Patients prescribed with corticosteroid in age group 18-28 years, 20 patients in 29- 38 years, 12 in 32-48 years, 16 in 49-58 years, 22 in 59-68 years, 11 in 69-78 years and 4 in above 80 years. This data showed that commonly male populations are more prone to diseases. As per the demographic data our finding shows that Budesonide was the most frequent prescribed corticosteroid (31.75%) followed by Hydrocortisone (26.19%), Dexamethasone (15.08%), Prednisolone 13.49%, Betamethasone (7.94%), Methyl prednisolone (5.56%).

Out of 100 prescriptions total 10 ADRs and 25 Drug interactions were detected in this study. The majority of drug interactions were minor 24 followed by major 1.

Conclusion: The Prescription pattern of corticosteroids was found to be rational as there is no Major drug interaction. Commonly geriatric population was more prone to diseases, for which steroids were used. Hence close observation is required to ensure safety, effectiveness and well-balanced therapeutic management with corticosteroids, both patients and prescribers should be more aware of the appropriate dose, dosage regimen, Drug - Drug interactions, ADRs and overall guidelines for corticosteroids prescribing.

Keywords: Corticosteroids, Drug utilization evaluation, Prescription pattern.

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*Address for Correspondence:

Syed Imran Ul Haq, Dept of Pharmacy Practice, Mesco College of Pharmacy, Hyderabad, Telangana, India

INTRODUCTION

The clinical practice of assessing specific drugs at appropriate and equal intervals to evaluate the drug concentration in the bloodstream through the course of therapy is therapeutic drug monitoring. This also helps in formulating an individual dosage regimen in patients with concomitant drug therapy which enhances the treatment outcome of the patients. ¹

Most of the drugs don't require monitoring but drugs with narrow therapeutic windows, drugs that elicit pharmacokinetic variability and drugs that have a higher probability to cause adverse effects at therapeutic doses show a necessity to be monitored.¹

TDM is based on the belief that there is a significant relationship between the dose and plasma concentration of the drug and also between the concentration of the drug and its therapeutic effect. ²

The main aim of TDM is to monitor drugs that show high variability in patients with different diseased conditions and drugs with narrow therapeutic windows so as to personalize the drug therapy accordingly. With the combined knowledge of pharmacology, pharmacokinetics and pharmacodynamics, the efficacy and the safety of a drug in diverse medical conditions can be appropriately assessed.¹

TDM has been increasingly proposed for many of the therapeutic drugs nowadays, e.g. antibiotics, tyrosine kinase inhibitors along with other targeted anticancer agents, TNF inhibitors, antifungal agents, antiretroviral agents that are used in HIV infection and also for psychiatric drugs³

The following are some examples of drugs that are widely analyzed for therapeutic drug monitoring:⁴

- Aminoglycoside antibiotics (gentamicin)
- Mood stabilisers,
- Antiepileptics (carbamazepine, phenytoin, valproic acid)
- Antipsychotics (pimozone, clozapine)
- Cardiac glycosides (digoxin)
- Cyclosporin, tacrolimus used in organ transplant receiving patients.

There are many drugs with active metabolites or drugs that are given as prodrugs, where the parent compound has minimal or no pharmacological response. The pharmacological activity of such drugs is elicited by their metabolites. The drugs following the aforementioned mechanism make it difficult to obtain useful information from drug concentration measurements because it is the metabolites that show the therapeutic effect. Hence the active metabolites are assessed separately in these drugs and then monitored for their efficacy.⁵

Where there is a good indicator of drug efficacy, the need to measure drug concentrations is not necessary. For example: measuring the blood pressure during antihypertensive therapy or cholesterol levels in patients being treated with lipid lowering agents. The plasma concentration data for such drugs is very vital during their developmental stages so as to define their pharmacokinetic and pharmacodynamics parameters along with safety and efficacy.⁵

Corticosteroids are used to treat a wide spectrum of inflammatory conditions as they provide rapid symptomatic relief and suppress inappropriate immune system activity. These are highly efficacious drugs and are mostly used to treat various autoimmune, respiratory & dermatological conditions.

Corticosteroids are available in different types: Systemic and Localized.

Localized steroids: these steroids target a specific part of the body, although small amount of these steroids can be absorbed into the body. These can be applied as skin creams, eye drops, ear drops, or inhalers (for lungs).⁶

Systemic steroids: they can be given orally (tablets), through intravenous or intra muscular route (which can be into blood vessel, joints or muscles) to assist more parts of the body through the blood.⁷

Hydrocortisone and cortisone are termed as a naturally occurring corticosteroids released from the adrenal cortex.⁸

Systemic steroids are broadly divided into:

Glucocorticoids: it helps in the breakdown of fats, carbohydrates and proteins. Hence, reduces the inflammation and immunity.

Drugs include:

- Glucocorticoid
- Hydrocortisone
- Cortisone
- Prednisone
- Prednisolone
- Dexamethasone

Mineralocorticoids: Affects sodium, potassium and fluid balance.

Drugs include:

- fludrocortisone⁹

These agents can cause various harmful side effects that are associated with excess dose and prolonged usage.

- Osteoporosis
- Skin atrophy
- Diabetes
- Abdominal obesity
- Glaucoma
- Cataracts
- Hypertension^{10,11}

Corticosteroids are mainly used to treat conditions such as:

- Asthma
- Allergic rhinitis and hay fever
- Urticarial (hives)
- Atopic eczema
- Chronic obstructive pulmonary disease (COPD)
- Painful and inflamed joints, muscles and tendons
- Lupus
- Inflammatory bowel disease (IBD) - including Crohn's disease and ulcerative colitis
- Giant cell arteritis and polymyalgia rheumatica
- Multiple sclerosis (MS)

They also treat Addison's diseases, in which the adrenal glands are unable to produce even the minimum amount of corticosteroids that the body needs.¹²

MATERIALS AND METHOD

The study included all the consecutive patients admitted to the hospital and those visited to hospital for follow up on the weekly or monthly basis with the age group more than 18 years of age.

Study Design: A Prospective Observational Study.

Study Site: General Medicine and Dermatology, Osmania General Hospital, Hyderabad.

Study Period: The study was carried out for a period of 6 Months.

Study Population: All the patients satisfying the inclusion criteria are being selected.

Sample SIZE: sample size is 100

Sources of Data:

- ✓ Case Sheet
- ✓ Patient Interview
- ✓ Past Medication History

Study Criteria:

Table 1: Inclusion and Exclusion Criteria:

Inclusion Criteria	Exclusion Criteria
Patients of Either Sex	Patients Suffering from terminal Illness
Patients of Age Group > 18Yrs	Patients Suffering from Terminal Illness or Cancer
Patients receiving corticosteroids for different indications.	Pregnant and Lactating women

Plan of Work:

Data collection form was designed, than after taking approval ethics committee, patient’s data was collected prospectively by observations. Patient’s progress and prescriptions were observed daily till his availability in the hospital. The data collected was analyzed for usage of corticosteroid along with other drugs in the prescriptions, duration of treatment was noted, the dosage form, the frequency of administration, inappropriate utilization of drug, drug- drug interactions and adverse drug reactions were observed and noted. Rationality of corticosteroids usage was also be analyzed as per standards provided in literature. Results are reported and conclusion is drawn.

- ✓ Getting IEC approval
- ✓ Designing of data collection form
- ✓ Obtaining patients demographic data, previous medication and disease history
- ✓ Recording of patients physical and physiological parameters
- ✓ Recording patients prescribed pharmacotherapy and follow up
- ✓ Analyzing variations in the parameters with different drug therapies
- ✓ Percentage and graphical presentation of the results
- ✓ Discussion
- ✓ Conclusion.

RESULTS

This was a prospective observational study was conducted in the Out Patient Department of Osmania General Hospital in the In-patient Department of General Medicine for about 6 months. The results of the observations are reported below.

Gender Distribution

As per demographic data obtained, out of the total 100 patients, 68 % were male and 32% were female. This data showed that commonly male population was more prone to diseases, for which steroids are used.

TABLE 2: DISRIBUTION OF SUBJECTS BASED ON GENDER

Gender	No of Patients	Percentage Of Patients
MALE	68	68.00%
FEMALE	32	32.00%
TOTAL	100	100.00%

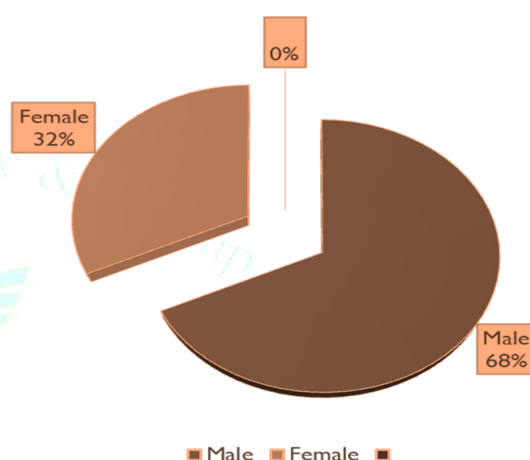


FIGURE-1: PIE CHART SHOWING DISTRIBUTION OF SUBJECTS BASED ON GENDER (%)

Age Distribution:

All the patients were classified as per the age group a maximum of around 22% belongs to the age group of 59-68 and 20% belongs to the age group of 29-38 followed by least no of patients were found between the age group of 78-88 and 89-98 with the percentage of 3% and 1%.

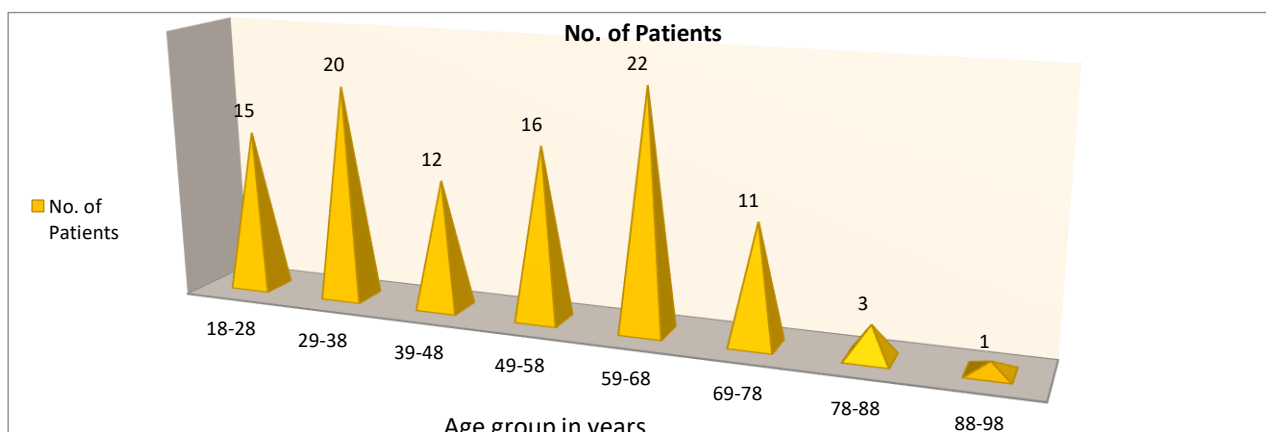


FIGURE-2: Showing distribution of subjects based on age

Distribution of the Subjects on Usage of Steroids in Different Disease Conditions:

Systems involved with the usage of corticosteroid include-respiratory with the percentage of 40%, neurology with the percentage of 15%, cardiology with the percentage of 4%,

nephrology with the percentage of 2%, endocrinology with the percentage of 2%, dermatology with the percentage of 15%, hepatology with the percentage of 1%, skeletal system with the percentage of 2% and others with the percentage of 19%. Among the study population the usage of corticosteroid was most common in respiratory system.

TABLE-3: Showing systems involved and usage of steroids

SYSTEMS INVOLVED	No. of patients
RESPIRATORY	40
ASTHMA	7
COPD	21
TB	6
PNEUMONITIS	3
PLEURAL EFFUSION	1
LUNG METASTASIS	1
LEFT RESPIRATORY TRACT INFECTION	1
NEUROLOGY	15
AMS	3
CVA	4
EPILEPSY	2
MENINGITIS	4
OTHERS	2
CARDIOLOGY	4
CAD	3
ANGIOEDEMA	1
NEPHROLOGY	2
AKI	2
ENDOCRINOLOGY	2
GRAVES DISEASE	1
CUSHING SYNDROME	1
DERMATOLOGY	15
EXFOLIATIVE DERMATITIS	1
SLE	2
PSORIATIC ERYTHRODERMA	6
HANSENS DISEASE	4
SJS	1
ALLERGIC CONTACT DERMATITIS	1
HEPATOLOGY	1
CLD	1
SKELETAL SYSTEM	2
MYESTHINIA GRAVIS	1
POLYARTHRITIS	1
OTHERS	19
ANAEMIA, DVT, SNAKE BITE, RADIAL NERVE PALS, IC BLEED WITH VASCULATION, PARAQUIT POISONING, THROMBOCYTOPENIA, PERIODIC PARALYSIS, MCTD WITH VASCULITIS, DSAP, ULCERATIVE COLITIS, CHRONIC URTICARIA, ALOPECIAAREATA, BULLOUS DISORDER, PEMPPHIGUS VULGARIS.BICYTOPENIA, ACUTE FLACID QUADRAPERESIS, ACUTE NEUROLOGICAL ILLNESS.	

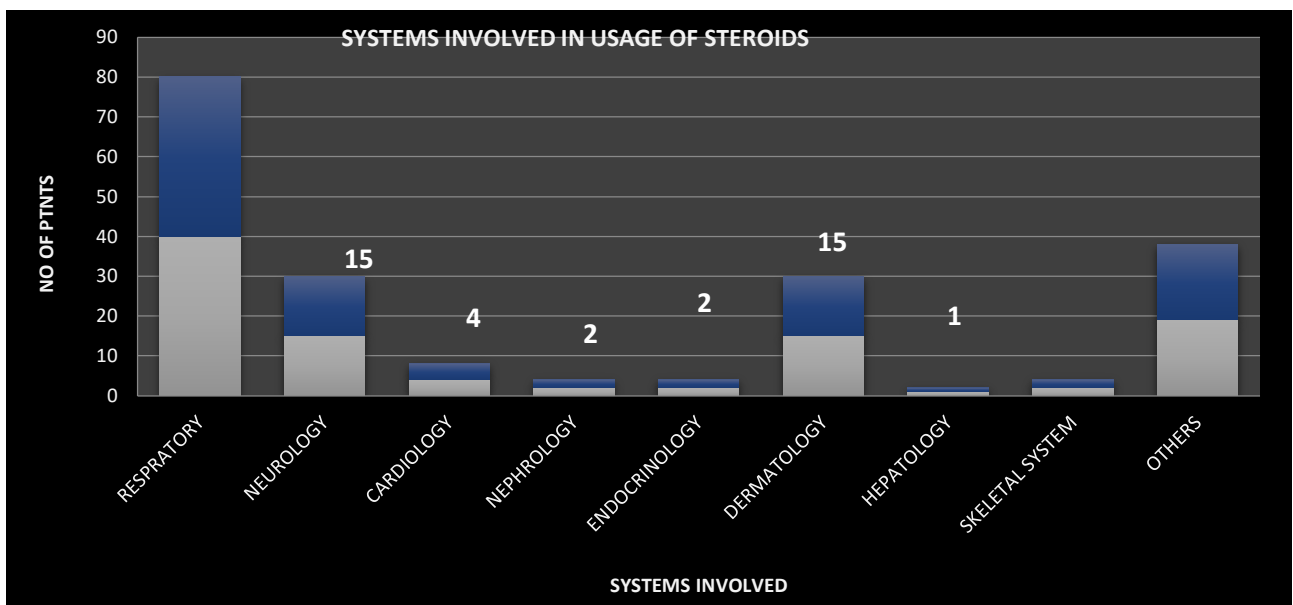


FIGURE-3: Showing systems involved and usage of steroids

Among the study Population the diseases involved include with the systems Include

Respiratory system: It include diseases such as Asthma with the percentage of 7%, COPD with the percentage of 21%, tb with the percentage of 6%, pneumonitis with the percentage of 3%, pleural effusion with the percentage of 1%, lung metastasis with the percentage of 1%, left respiratory tract infection with the percentage of 1%.

Neurology: It include diseases such as AMS with the percentage of 3%, CVA with the percentage of 4%, epilepsy with the percentage of 2%, meningitis with the percentage of 4%, others with the percentage of 2%.

Cardiology: It includes diseases such as cad with the percentage of 3%, angioedema with the percentage of 1%.

Nephrology: It includes diseases such as Acute kidney injury with the percentage of 2%.

Endocrinology: It includes diseases such as graves' disease with the percentage of 1%, Cushing syndrome with the percentage of 1%.

Dermatology: It include diseases such as exfoliative dermatitis with the percentage of 1 %, SLE with the percentage of 2%, psoriatic erythroderma with the percentage of 6%, Hansen's disease with the percentage of

4%, SIS with the percentage of 1%, allergic contact dermatitis with the percentage of 1%.

Hepatology: It includes diseases such as CLD with the percentage of 1%.

Skeletal System: It includes diseases such as myasthenia gravis with the percentage of 1%, polyarthritis with the percentage of 1%.

Others: It include diseases such as anaemia, DVT, snake poisoning, radial nerve palsy, TC bleed with vesiculation, paraquat poisoning, thrombocytopenia, periodic paralysis, MCTD with vasculitis, ulcerative colitis, chronic urticaria, alopecia areata, DSAP, bullous disorder, pemphigus vulgaris, bi cytopenia, acute flaccid quadripareisis, acute neurological illness.

Distribution of Different Types of Steroids Prescribed to the Patients:

Among the study population the corticosteroid prescribed to patients include prednisolone, hydrocortisone, methyl prednisolone, budesonide, dexamethasone, betamethasone with the percentages as 13.49%, 26.19%, 5.56%, 31.75%,15.08%, 7.94% among these the mostly prescribed corticosteroid is budesonide with the percentage of 31.75% and the least prescribed corticosteroid is methyl prednisolone with the percentage of 5.56%.

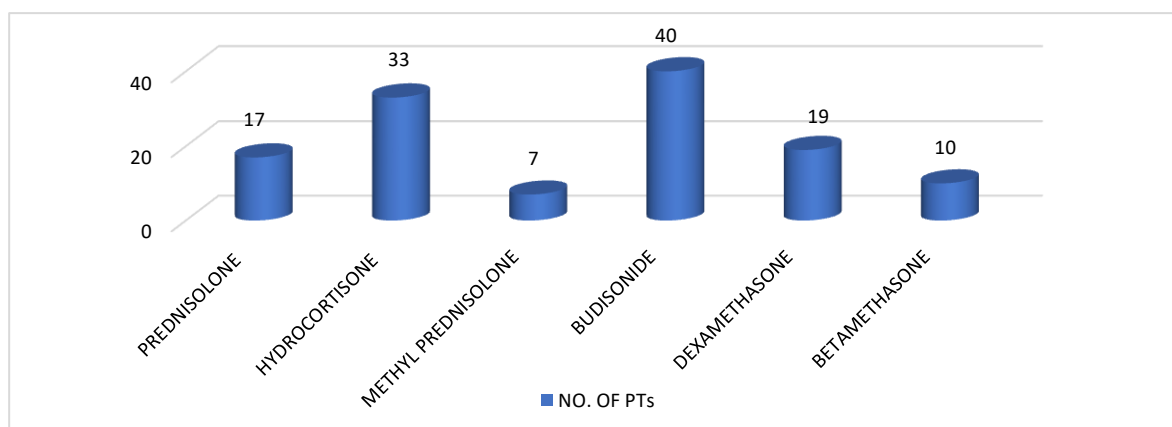


FIGURE-4: Showing distribution of steroids prescribed to subjects.

Steroids Studied For Drug Utilization Review:**Indications, Dose, Dosage of Corticosteroid usage:**

Prednisolone: Prednisolone was prescribed to 17 patients in our study in indications such as anti-inflammatory conditions 5, autoimmune diseases. It was given by the route oral and IV and in dosage of 20mg and 40mg.

Hydrocortisone: Hydrocortisone was prescribed to 33 patients in our study in indications such as community acquired pneumonia. It was given by the route IV and in dosage of 100mg

Methyl prednisolone: Methyl prednisolone was prescribed to 7 patients in our study in indications such as rheumatoid

arthritis and dermatitis. It was given by the route IV and in dosage of 1g in 100ml ns

Budesonide: Budesonide was prescribed to 40 patients in our study in indications such as shortness of breath. It was given by the route intranasal and in dosage of 0.2 mg.

Dexamethasone: Dexamethasone was prescribed to 19 patients in our study in indications such as anti-inflammatory conditions. It was given by the route oral, IV and in dosage of 8 mg

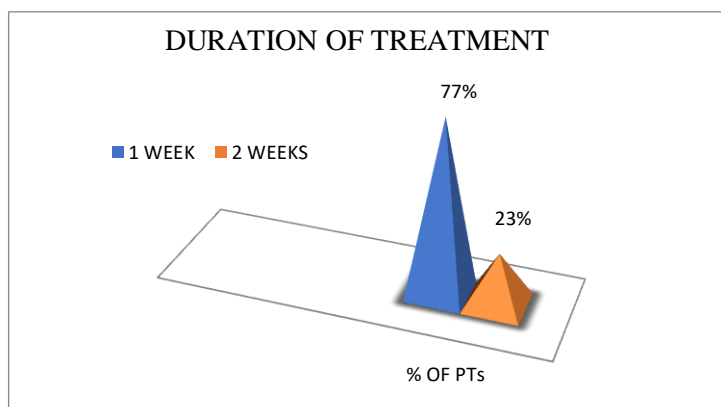
Betamethasone: Betamethasone was prescribed to 10 patients in our study in indications such as dermatitis. It was given by topical route.

Table 4: Indications, Dose, Dosage of Corticosteroid Usage:

SNO	NAME OF THE DRUG	INDICATION	DOSAGE FORM	DOSE USED
1	Prednisolone	INFLAMMATORY CONDITIONS, AUTOIMMUNE DISEASES	PO AND IV	20,40MG
		Prednisolone was prescribed to 17 patients .5 as anti-inflammatory ,12 for autoimmune diseases		
2	Hydrocortisone	CAP	IV	100MG
		Hydrocortisone was prescribed to 33 patients.3 for CAP and 30to treat breathing problems		
3	Methyl Prednisolone	DERMATITIS	IV	1G in 100ml NS
		Methyl prednisolone was prescribed to 7patients.2 for blood disorders and 5 to treat allergic reactions		
4	Budesonide	SOB	IN	0.2 MG
		Budesonide was prescribed to 40 patients to treat SOB		
5	Dexamethasone	ANTI INFLAMMATORY	PO & IV	8MG
		Dexamethasone was prescribed to 19 patients as anti-inflammatory agent		
6	Betamethasone	DERMATITIS	TOPICAL	LOCAL APPLICATION
		Betamethasone was prescribed to 10 patients for skin diseases		

Duration of Treatment

The study was conducted on subjects for the treatment duration of 1 week followed by 2 week 77% subjects were treated for the duration of 1 week, & 23% subjects were treated for the duration of 2 weeks.

**FIGURE-5:** Showing duration of treatment of subjects

Drug-Drug Interaction in Study Population:

The study was conducted on a study population of 100 subjects and drug-drug interactions were checked on software Micromedex & out of 100 subjects 1 drug-drug

interaction were found to be severe this 1 interaction were noted & 24 minor interactions were noted in the department general medicine & 0 interaction were noted in the department of dermatology.

Table 5: Showing drug-drug interaction in a study population

DRUG DRUG INTERACTION		
	MAJOR	MINOR
GENERAL MEDICINE	1	24
DERMATOLOGY	0	0

Drug-Drug Interaction Found:**Table 6:** Severe drug-drug interaction found in the study

Rifampicin (Antitubercular) + Dexamethasone	Rifampicin will decrease the level or effect of dexamethasone by affecting hepatic or intestinal enzyme CYP3A4 metabolism. Possible serious or life-threatening interaction. Monitor closely. Use alternatives if available. Also, rifampin will decrease the level or effect of dexamethasone by P-glycoprotein efflux transporter. Significant interaction possible, monitor closely.
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Adverse Drug Reactions with Corticosteroid Usage:

In this study Adverse drug reactions were reported by patients for ten instances that account for six different types of adverse effects as mentioned below in table, noted mainly by three corticosteroids were found to be the cause of adverse drug reaction. Prednisolone caused headache in 2 patients, facial mooning in 2 patients, osteoarthritis in 1 patient. Dexamethasone caused headache in 1 patient, hypertension in 1 patient, hyperglycaemia in 1 patient, hydrocortisone caused hypertension in 2 patients.

Table 7: adverse drug reaction found in the study

Drug	ADR observed	NO. of cases
Prednisolone	Headache	2
	Facial mooning	2
	osteoarthritis	1
Dexamethasone	Headache	1
	Hypertension	1
	Hyperglycemia	1
Hydrocortisone	Hypertension	2

DISCUSSION

- In this study 100 Patients were included with different Morbidity who were admitted and prescribed Corticosteroids in various inpatient department of Osmania General Hospital. Demography, route of administration, corticosteroid used, dose and dose frequency, condition for use, drug interactions and ADRs subsequent to use of corticosteroids were studied.
- This study included 100 Patients out of which 68 (68%) were Male and 32 (32%) were female. This data showed that commonly male population are more prone to diseases, for which steroids are used. It shows that corticosteroids are mainly used between the age group of 22 (22%) 59-68 years. As this Age group consider to be mostly affected with many Inflammatory

and chronic diseases. We observed that as the age group increased the prescribing of corticosteroids has also been more frequent.

- As per the demographic data our finding shows that Budesonide was the most frequent prescribed corticosteroid (31.75%) followed by Hydrocortisone (26.19%), Dexamethasone (15.08%), Prednisolone 13.49%, Betamethasone (7.94%), Methyl prednisolone (5.56%). Here Budesonide was mostly used steroid.
- System Associated with the use of Corticosteroids are Respiratory, Neurological, Dermatological with a percentage of 36%, 21%, 18% respectively.
- In our study Prednisolone is used for the treatment of Inflammatory conditions and Auto Immune diseases, route of administration is oral and IV with the dosage 20, 40mg. Hydrocortisone for CAP, route (IV), Dose 100mg. Methylprednisolone for RA and Dermatitis, route (IV), dose 10mg. Budesonide for SOB, route Inhalation (IN), dose 0.2mg. Dexamethasone for Anti-Inflammatory conditions, route (oral and IV), dose 8mg.
- A Drug-Drug Interaction (Rifampicin + Dexamethasone) is noted in two patients. The patients lied in the age group of 60-70 Years, probably due to co-morbidities and more corticosteroids usage to have broad beneficial effect in older age population.
- In 100 prescriptions total 25 interactions were found out of which 24 were minor, 1 were major. Mostly minor interactions were found in the study which was consistent with the study Imran, et al.who found that 24% of the interactions were minor, 1%were major were contraindicated interactions subsequent the use of corticosteroids in his study.
- Ten ADRs were found in this study due to corticosteroids use. Facial mooning was detected in 2, headache in 3, hyperglycaemia in 1, hypertension in 3 (25%) and osteoporosis in 1 (12.50%). Our study was consistent with the study of Treadwell.B, et al 12. WHO found that corticosteroid causes hypertension, facial mooning, osteoporosis in the subjects who were on corticosteroid therapy, Also Clore J, et al.13 in his study

found that Glucocorticoid-induced hyperglycaemia is common in patients with and without diabetes

CONCLUSION:

Corticosteroids are widely prescribed Drugs in Hospitals, forming a part of standard treatment of modern medicine for a wide range of diseases, which associated with inflammation and immune activation. Apart from beneficial effects they also produce number of adverse effects.

In the present study, Prospective Observational studies on DUE and rationality of Corticosteroids has been performed. Out of 100 prescriptions total 10 ADRs and 25 Drug interactions were detected in this study. The majority of drug interactions were minor 24 (24%) followed by major 1 (1%).

Most of the prescription were found to be rational some of them were found to be irrational as there were significant drug interactions. Commonly a patient between the age group of 59-68 years was more prone to diseases, for which steroids were used. Hence close observation is required.

To ensure safety, effectiveness and well-balanced therapeutic management with corticosteroids, both patients and prescribers should be more aware of the appropriate dose, dosage regimen, with careful monitoring of ADRs and Drug - drug interactions.

Hence, the clinical pharmacist can perform potential role in health care system in assisting physician in altering the number of medications taken, the number of doses taken, improving the patient medication adherence, preventing the adverse drug reactions, Drug - Drug interactions, in patient counselling, improve the health-related quality of life and decreasing the health care cost of the patient.

Till now, effective treatment guidelines for corticosteroids are not available. Even though we can't completely eliminate the occurrence of ADRs, definitely we can minimize it. Further studies are needed for implementing standard Guidelines in corticosteroid therapy and all hospitals should implement steroid treatment card to improve the quality of life of the patients.

ABBREVIATIONS

ADR	Adverse drug reaction
COPD	Chronic obstructive pulmonary disease
CYP3A4	Cytochrome P450 Enzyme
DNA	Deoxyribose Nucleic Acid
DVT	Deep vein thrombosis
DUE	Drug utilization evaluation
HIV	Human immune deficiency virus
IBD	Inflammatory bowel disease
IV	Intra venous
IN	Inhalation
MS	Multiple sclerosis
TNF	Tumor necrosis factor

REFERENCES

- Kang, J.-S., & Lee, M.-H. Overview of Therapeutic Drug Monitoring. *The Korean Journal of Internal Medicine*, 2009; 24(1):1. doi:10.3904/kjim.2009.24.1.1
- Gross AS, Blackwell Science Ltd Br J Clin Pharmacol, 2001; 52:5S-10S
- Schoretsanitis G et al. (April 2018). "TDM in psychiatry and neurology: A comprehensive summary of the consensus guidelines for therapeutic drug monitoring in neuropsychopharmacology, update 2017; a tool for clinicians". *World Journal of Biological Psychiatry*. 19 (3): 162-174.
- Marshall WJ, Bangert SK. *Clinical Chemistry*, 6th Edition. Edinburgh, London: Mosby Elsevier. 2008. ISBN 978-0723434559
- Hallworth M, in *Clinical Biochemistry: Metabolic and Clinical Aspects (Third Edition)*, 2014, Pages 767-786
- Ramamoorthy S, Cidlowski JA, *Corticosteroids-Mechanisms of Action in Health and Disease Rheum Dis Clin North Am*. 2016; 42(1): 15-31
- William Ericson-Neilsen, MD, Alan David Kaye, MD, PhD *Steroids: Pharmacology, Complications, and Practice Delivery Issues*. Academic Division of Ochsner Clinic Foundation the Ochsner Journal 2014; 14:203-207.
- Safiya Shaikh et al., *Applications of Steroid in Clinical Practice: A Review*. International Scholarly Research Network ISRN Anaesthesiology 2012, Article ID 985495, 11 pages.
- Liu et al A practical guide to the monitoring and management of the complications of systemic corticosteroid therapy, *Allergy, Asthma & Clinical Immunology* 2013, 9:30
- National Institute for Health and Clinical Excellence (NICE): *Clinical Knowledge Summaries: Corticosteroids - Oral*. NICE; 2012. [http://www.cks.nhs.uk/corticosteroids_oral], Accessed February 20, 2013.
- Singh N, Rieder MJ, Tucker MJ: Mechanisms of glucocorticoid-mediated antiinflammatory and immunosuppressive action. *Paed Perinatal Drug Ther* 2004, 6:107-115.
- Newton R, Leigh R, Giembycz MA: Pharmacological strategies for improving the efficacy and therapeutic ratio of glucocorticoids in inflammatory lung diseases. *Pharmacol Ther* 2010, 125:286-327.
- Coutinho AE, Chapman KE: The anti-inflammatory and immunosuppressive effects of glucocorticoids, recent developments and mechanistic insights. *Mol Cell Endocrinol* 2011, 335:2-13.
- Croxtall JD, van Hal PT, Choudhury Q, Gilroy DW, Flower RJ: Different glucocorticoids vary in their genomic and non-genomic mechanism of action in A549 cells. *Br J Pharmacol* 2002, 135:511-519.
- Smoak KA, Cidlowski JA: Mechanisms of glucocorticoid receptor signaling during inflammation. *Mech Ageing Dev* 2004, 125:697-706.
- Stellato C: Post-transcriptional and nongenomic effects of glucocorticoids. *Proc Am Thorac Soc* 2004, 1:255-263.
- Furst DE, Saag KG: Determinants of glucocorticoid dosing. *Up To Date* 2012; 2013. http://www.uptodate.com/contents/determinants-of-glucocorticoiddosing?source=search_result&search=glucocorticoid&selectedTitle=4~150.
- Deshmukh CT: Minimizing side effects of systemic corticosteroids in children. *Indian J Dermatol Venereol Leprol* 2007, 73:218-221.
- Da Silva JA, Jacobs JW, Kirwan JR, Boers M, Saag KG, Inês LB, de Koning EJ, Buttgereit F, Cutolo M, Capell H, Rau R, Bijlsma JW: Safety of low dose glucocorticoid treatment in rheumatoid arthritis: published evidence and prospective trial data. *Ann Rheum Dis* 2006, 65:285-293.
- Weinstein RS, Jilka RL, Parfitt AM, Manolagas SC: Inhibition of osteoblastogenesis and promotion of apoptosis of osteoblasts and osteocytes by glucocorticoids. Potential mechanisms of their deleterious effects on bone. *J Clin Invest* 1998, 102:274-282.