

The Outcome of IPAS and eMARS - Experience in NUH, Singapore

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Our Goal :

To Eliminate Medication Errors in NUH Wards

- To eradicate inpatient medication errors arising from prescribing, transcription, dispensing and administration, the following system enhancements should be put in place:

Redesign of Work Process (Where Appropriate - Facilitated by IT Enablers)

- Electronic prescription facilitated by Electronic inpatient medication records (eIMR)
- Bar-coded unit doses facilitated by (a) human interventions or (b) Inpatient Pharmacy Automation System (IPAS)
- Bar-code scanning during drug administration facilitated by Inpatient Electronic Medication Administration Records System (eMARS)

Job re-design for Nurses, Pharmacists & Pharmacy Technicians and wrt picking, packing and administration

COMPARISON OF 2 OPTIONS OF DELIVERING THE SAME LEVEL OF MEDICATION SAFETY TO INPATIENTS THROUGH UNIT-DOSES & BAR-CODING:

Human Manual System

Pros:

- Less start up cost
- flexible – can multitask staff
- Not difficult to train staff to pick, pack and label

IPAS

Pros:

- Automated, proven packaging & dispensing system
- - reduce errors of picking, packing, labeling and enables bedside verification
- - Reduces lost charges due to accurate real time billing upon supply
- - saves inventory (reduce stockholding)
- - reduce write-offs due to expired drugs
- - facilitate 24 hour review of orders and supply
- - Can multitask – cartfill, 24/7 real time stat dose production, packaging, returns
- - Can generate reports
- - Can pack for other facilities and generate income

COMPARISON OF 2 OPTIONS OF DELIVERING THE SAME LEVEL OF MEDICATION SAFETY TO INPATIENTS THROUGH UNIT-DOSES & BAR-CODING:

Human Manual System

Cons:

- Labour intensive
- Speed of picking , packing , labeling is dependent staff experience and processing time may be long
- Continuous service not possible
- Inconsistent, depends heavily on competency and adherence to Std Operating Procedure
- Errors are still possible due to human factors

IPAS

Cons:

- Expensive to buy and maintain.
- Still need minimal manpower to run

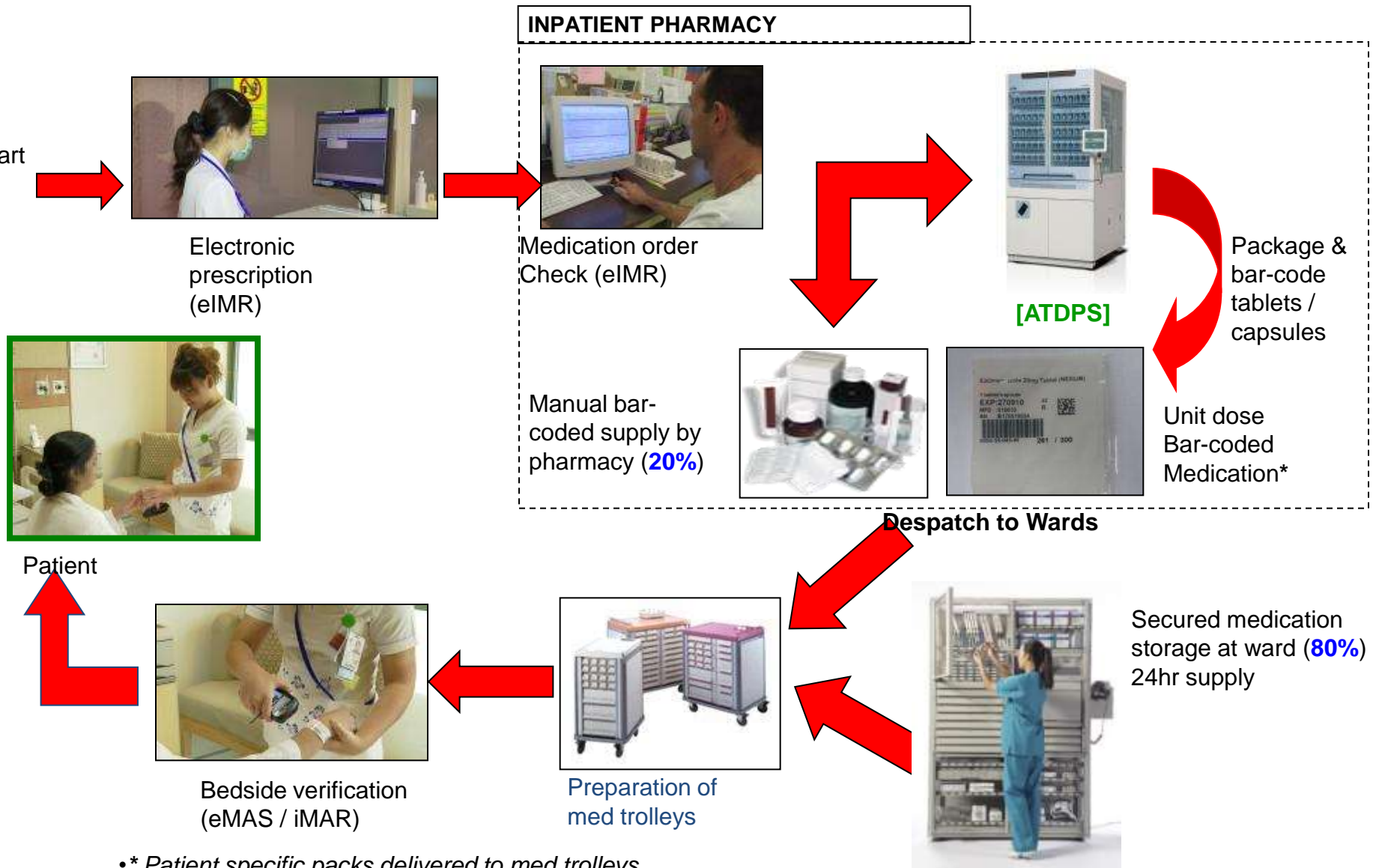
Inpatient Pharmacy Automation(IPAS)

- Consists of: a) automated tablet dispensing and packaging system (ATDPS) which package tablets and capsules into barcoded unit doses, b) automated dispensing cabinets(ADCs) which stores ward stock medications in the wards
- Working in synergy with other IT enablers e.g. eIMR , and eMARS (drug admin) as a total closed loop solution will eliminate/reduce inpatient medication errors. The technology is proven and tested

Inpatient Pharmacy Automation(IPAS)

- Summary of patient-centric benefits arising from IPAS:
 - Total automated closed loop solution, in synergy with other IT enablers to eliminate/reduce inpatient medication errors
 - Facilitates job redesign for pharmacists, pharmacy assistants and nurses
 - Cost savings (both tangible and intangible)
 - Cost avoidance (reduced med errors, compared to manual system to make bar-coded unit doses)
 - i.e. Seamless IT enabled, fully automated and integrated inpatient medication prescription, unit-dose bar coding, checking, picking & packing system

NUH Closed Loop Medication Management System



- * Patient specific packs delivered to med trolleys.
- Non-patient specific topped up in Omnicell units

iPAS – Inpatient Pharmacy Automation System

✓ Nurses not allowed to pick if drugs are discontinued or not prescribed.

Improved Safety

✓ Guided picking (guided lights)

Improved efficiency

✓ 24 hr supply of 80% of inpatient medication. **Improved efficiency**

✓ Different levels of drawer security
- (locking, sensing, matrix)

Improved Safety

✓ Automated Billing - **Improved efficiency**



eMARS : Electronic Medication Administration System



Barcoded Medication

**Scans Name Tags
&
Medication Rings**

**Pharmacy Intervention
Cannot proceed to serve**

**Pharmacy Intervention
Can proceed to serve**

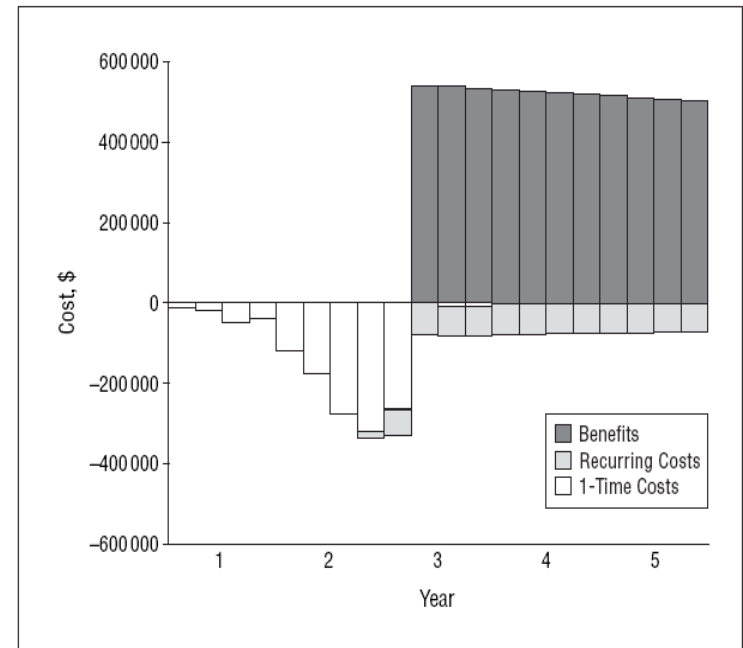
Drug Interaction Flag

The screenshot displays the eMARS application on a mobile device. At the top, it shows patient information for 'X3207136H' and 'NUH EIMR TRAINING PATIENT 02'. Below this, there are sections for medication administration. The first section shows 'Paracetamol Tablet' with a status of 'INTERVENT'. The second section shows 'Glipizide 5mg Tablet' with a status of 'REYCOMM'. The third section shows 'Glipizide 5mg Tablet' with a status of 'Reviewed with comment'. The fourth section shows 'Glipizide 5mg Tablet' with a status of 'Ordered'. The fifth section shows 'Atenolol 50mg Tablet' with a status of 'Ordered'. At the bottom, there is a 'View Comments' button.

**Drug allergies and alerts
On CMIS**

ROI : Benefits of Bar Coding project

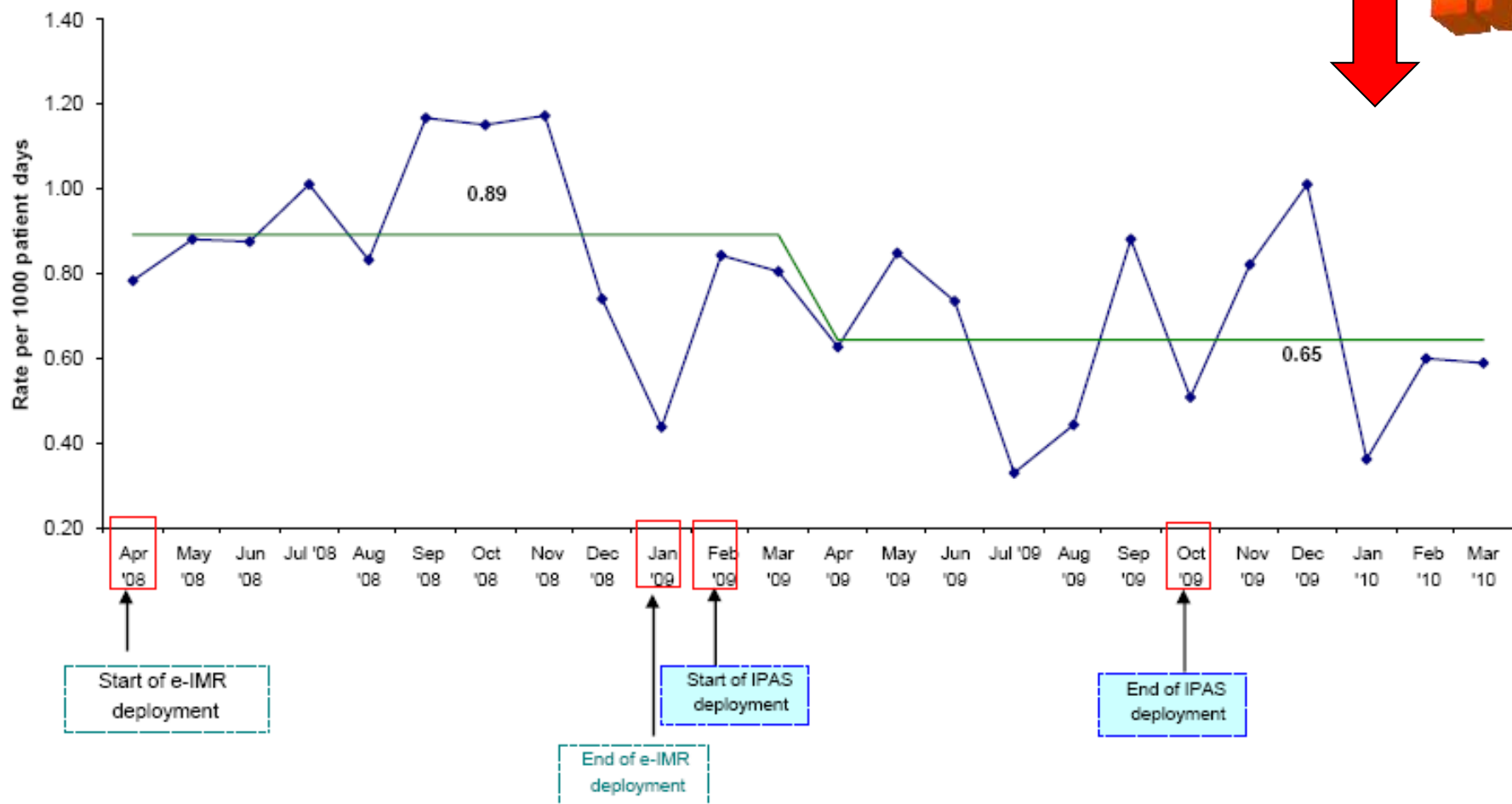
Monte Carlo Input Variable	Mean (SD)	Source
Doses affected by bar coding, %	84.0 (1.5)	Poon et al ¹³
Pre-bar coding potential ADE rate, %	0.19 (0.013)	Cina et al ¹⁵
Post-bar coding potential ADE rate, %	0.07 (0.005)	Poon et al ¹³
Rate of interception of potential ADEs, %	34.0 (7.6)	Leape et al ¹¹
Potential ADEs resulting in actual ADEs, %	13.4 (5.9)	Bates et al ³
Cost per preventable ADE, \$	4600 (2067)	Bates et al ⁶
Prospective payment rate, %	72.5 (0.2)	2003 BWH billing data
Repackaged doses per month, No.	402 655 (2799)	Measured
Cost per repackaged dose, \$	0.07†	Per contract
Carousel leasing cost, per dose, \$	0.03†	Per contract
Pre-bar coding fill rate, doses per hour	161†	Measured
Post-bar coding fill rate, doses per hour	192†	Measured



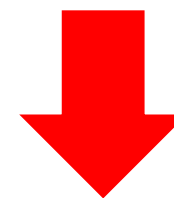
Maviglia, ARCH INTERN MED/VOL 167, APR 23, 2007

Reported Medication Related Error Rates in NUHS 2008-2010

Medication Error Rate (per 1000 patient days) for Inpatient Wards

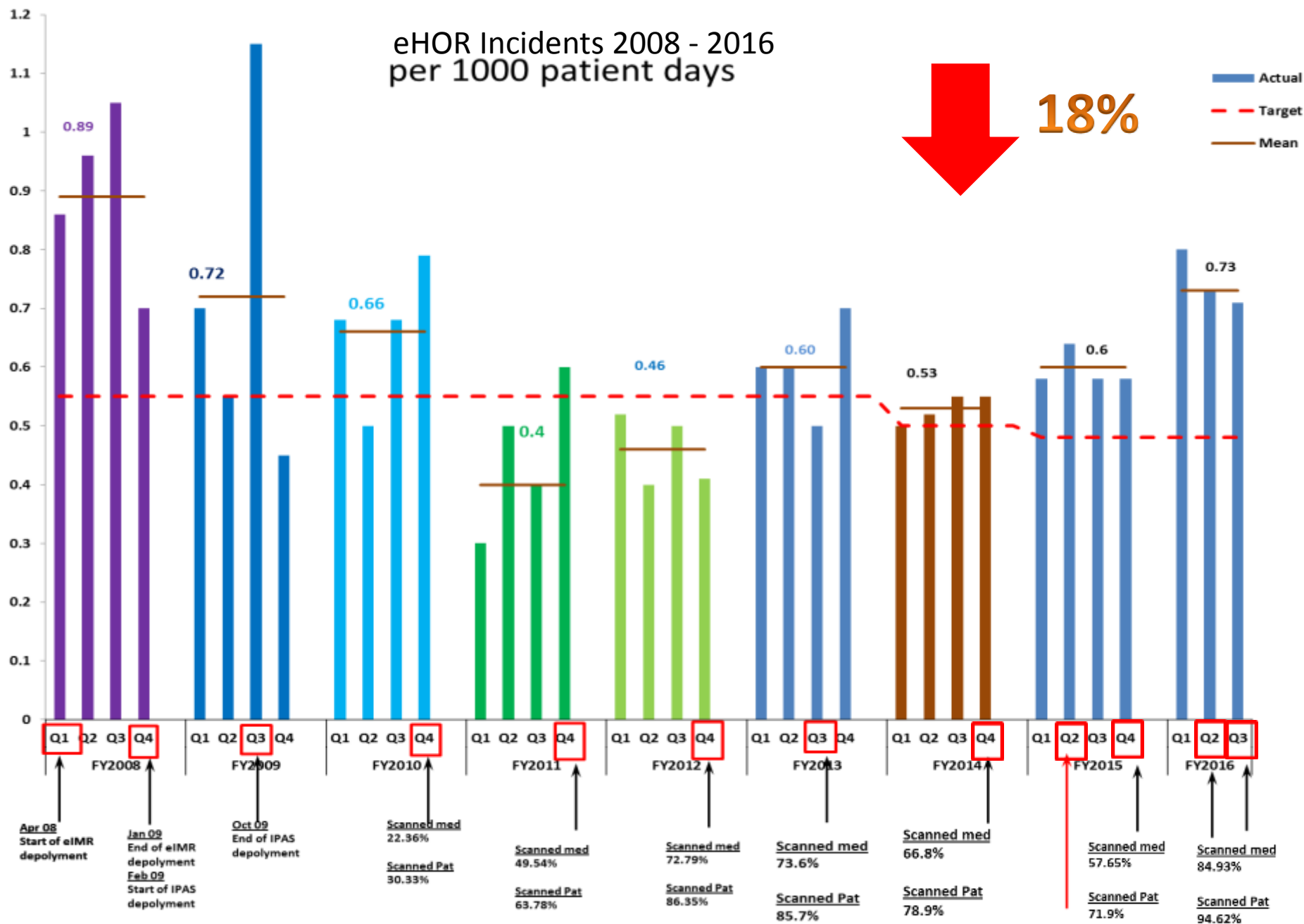


eHOR Incidents 2008 - 2016 per 1000 patient days



18%

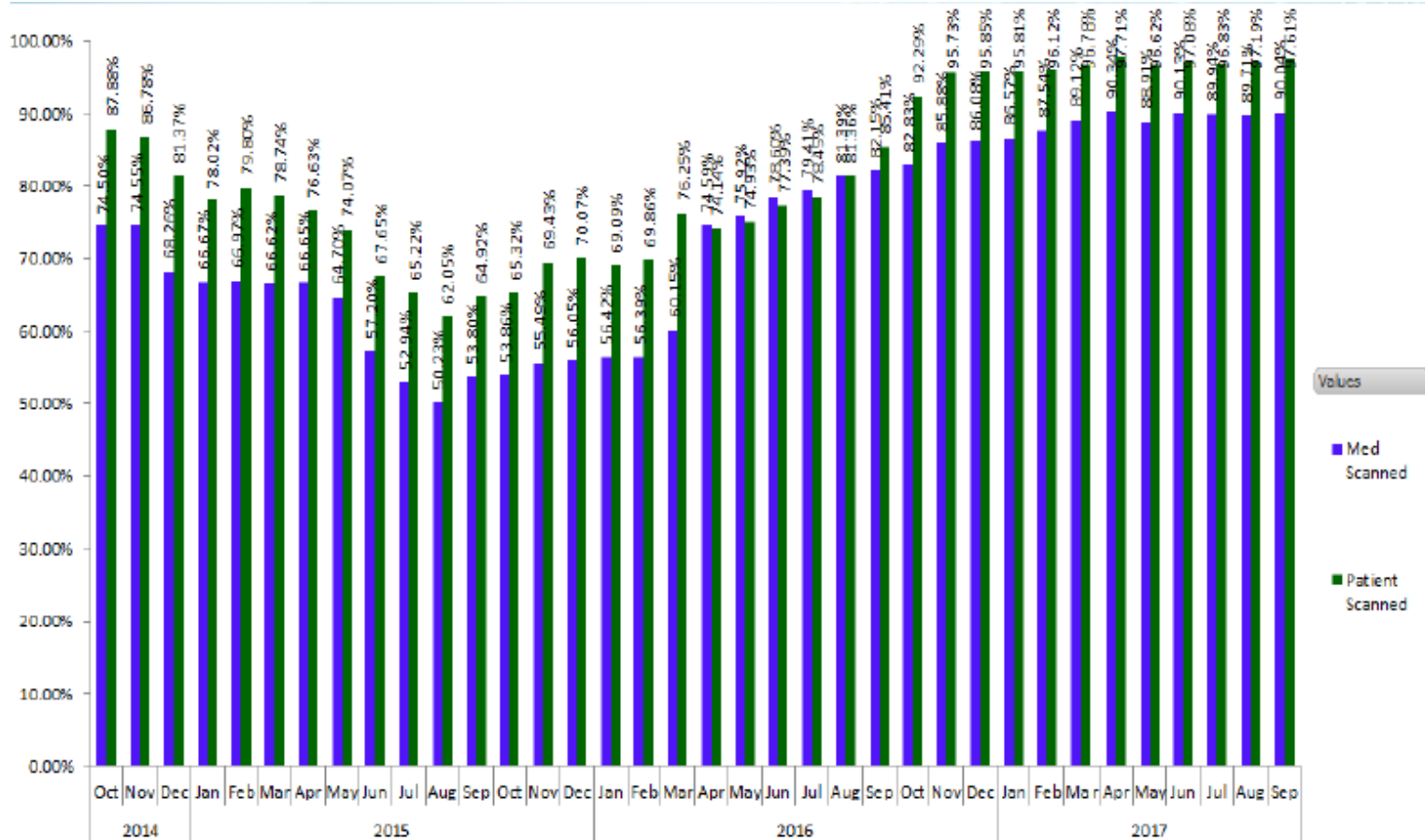
Actual
Target
Mean



IPAD mini Migration

eMARS : Electronic Medication Administration System

Scanning Compliance

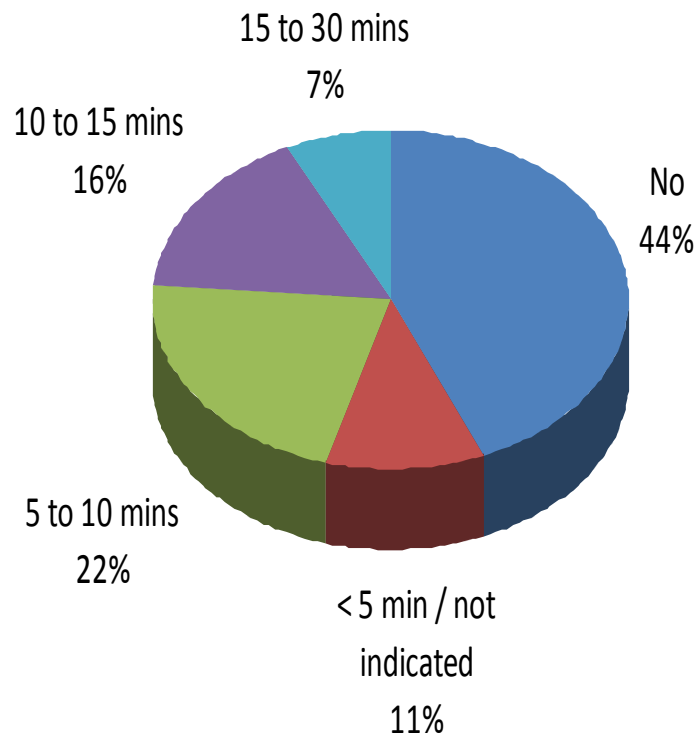


Key Performance Indicators (KPIs)

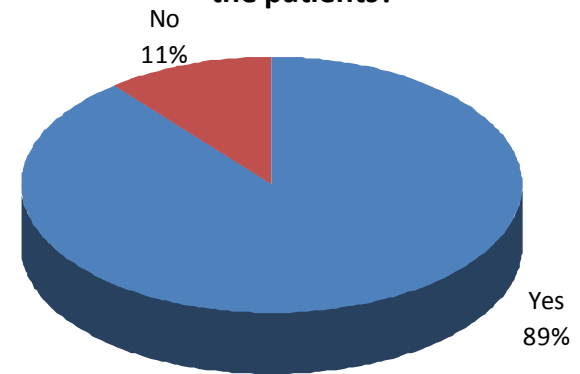
KPIs	Fulfillment	Current Results
At least 80% of Med Orders stocked in Cabinets	Fulfilled	80% of medication orders are stocked in cabinets
Safe Picking of Medications	Fulfilled	Prevented 3 errors per 100 Patient Days
Correct Medications Admin	Fulfilled	Prevented 7.1 errors per 100 Patient Days
Secure Medication Storage	Fulfilled	System mandates user login
Improved work efficiency, redeployment to patient centric activities	Fulfilled	Nursing saves 22 FTEs, but Pharmacy incurs 4 PA FTEs and saves 0.5 pharmacist FTE
Restocking process is streamlined with real time inventory	Fulfilled	Single trips are made to wards to restock medications, compared with double trips previously
Reduction of wastage	Fulfilled	Wastage reduction of \$3 406 per year (18% saving)
Automated billing ensures efficient, timely and accurate billing	Fulfilled	0.6 PA FTE saved with interim implementation of MCE. 1.5 PA FTE projected savings with full implementation
85% of medications to be barcoded	Exceeded	91% of medications administered are barcoded (Prior to outsource: 40%)

Nursing Survey

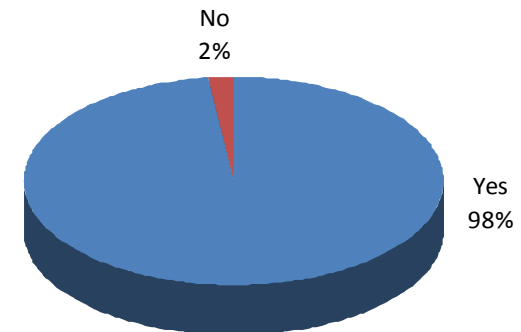
Q2. Compared to the pre-IPAS workflow of medication serving, do you think there was any time saving with the introduction of Automated Dispensing Cabinets?



Q1. With the Automated Dispensing Cabinet, do you feel it has contributed to better safety when serving medication to the patients?



Q3. With the guided light function in the Automated Dispensing Cabinets, do you find it easier to locate the medication in the cabinet?



What Are Nurses Feedbacks On CLMMS?

- Focused Group Discussions with Nurses
 - Efficiency:
 - Faster picking of medications (10 minutes for 6 to 10 patients)
 - Saved time looking for paper medication charts and cupboard keys
 - Increased availability of medications in the wards
 - Can now follow doctors' rounds more frequently than pre-CLMMS
 - Safety:
 - Eradicate illegible handwriting in prescriptions
 - Doctors can order remotely - reduction in verbal orders over phones
 - Staff feels that CLMMS has improved medication safety
 - Others:
 - Increased morale of the staff – with better efficiency and enhanced safety in medication administration

Limitations of IPAS

- Only 91 % of items are barcoded
- 40% of inventory are packaged in-house
- Omnicell automated cabinets can only fulfil 80% of all inpatient med orders

QA of IPAS (Inpatient CLMMS)

Identifying and quantifying weaknesses in the Closed Loop Medication Management System in reducing medication errors using a direct observational approach in NUH

Aim

To conduct a quantitative and qualitative evaluation of the NUH closed loop medication management system in the entire medication use process, from medication ordering by physicians to transcribing and supplying by pharmacy, followed by medication preparation and administration by nurses in the wards

Method

This was a direct observational study performed by two data collectors using an unbiased sampling method

Methods

- Observational study over two years (July 2012 to September 2013)
- 26 general wards, 5 pediatric wards, 7 ICUs, 2 inpatient pharmacies, unit dose satellite pharmacy (UDSP)
- Observation days based on numbers needed for statistically significant analyses
 - Prescribing: 87 days
 - Supply: 78 days
 - Administration: 203 days

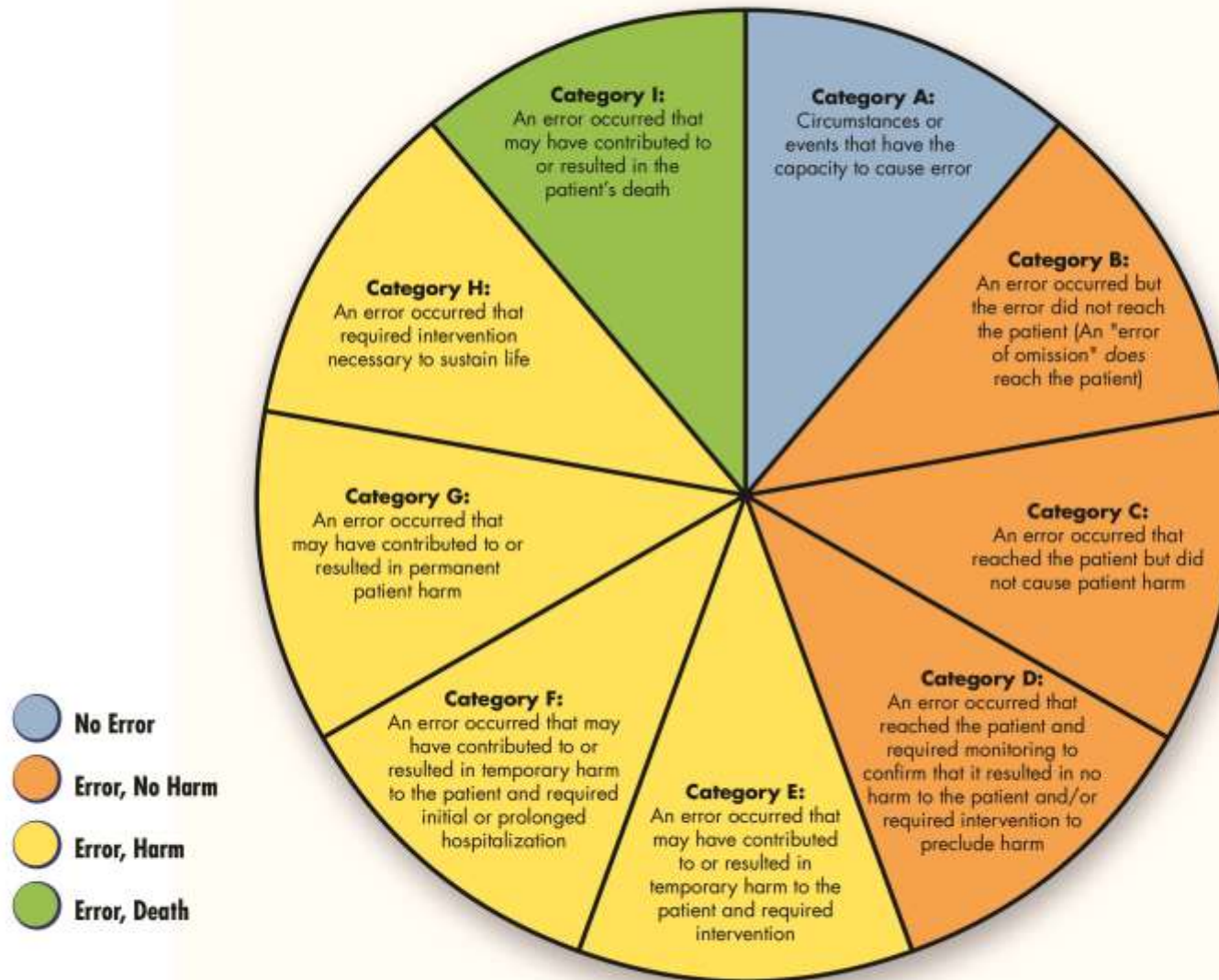
Methods

- Subjects
 - Doctors
 - Pharmacy staff
 - Nurses
- Oral informed consent obtained on observation day
- Convenience sampling
- Unobtrusive manner
- Anonymous study – subjects not identified

Methods

- The numbers and types of medication error(s) in prescribing, supply and administration were observed and recorded to calculate the error rate.
- This study adopted the definition and category of medication errors from the US National Coordinating Council For Medication Error Reporting and Prevention (NCCMERP)

NCC MERP Index for Categorizing Medication Errors



Definitions

Harm

Impairment of the physical, emotional, or psychological function or structure of the body and/or pain resulting therefrom.

Monitoring

To observe or record relevant physiological or psychological signs.

Intervention

May include change in therapy or active medical/surgical treatment.

Intervention Necessary to Sustain Life

Includes cardiovascular and respiratory support (e.g., CPR, defibrillation, intubation, etc.)

Classification of error

- Category A
 - Circumstances or events that **have the capacity** to cause error
- Category B
 - An **error occurred** but the error **did not reach the patient**
- Category C
 - An **error occurred** that **reached the patient** but **did not cause patient harm**

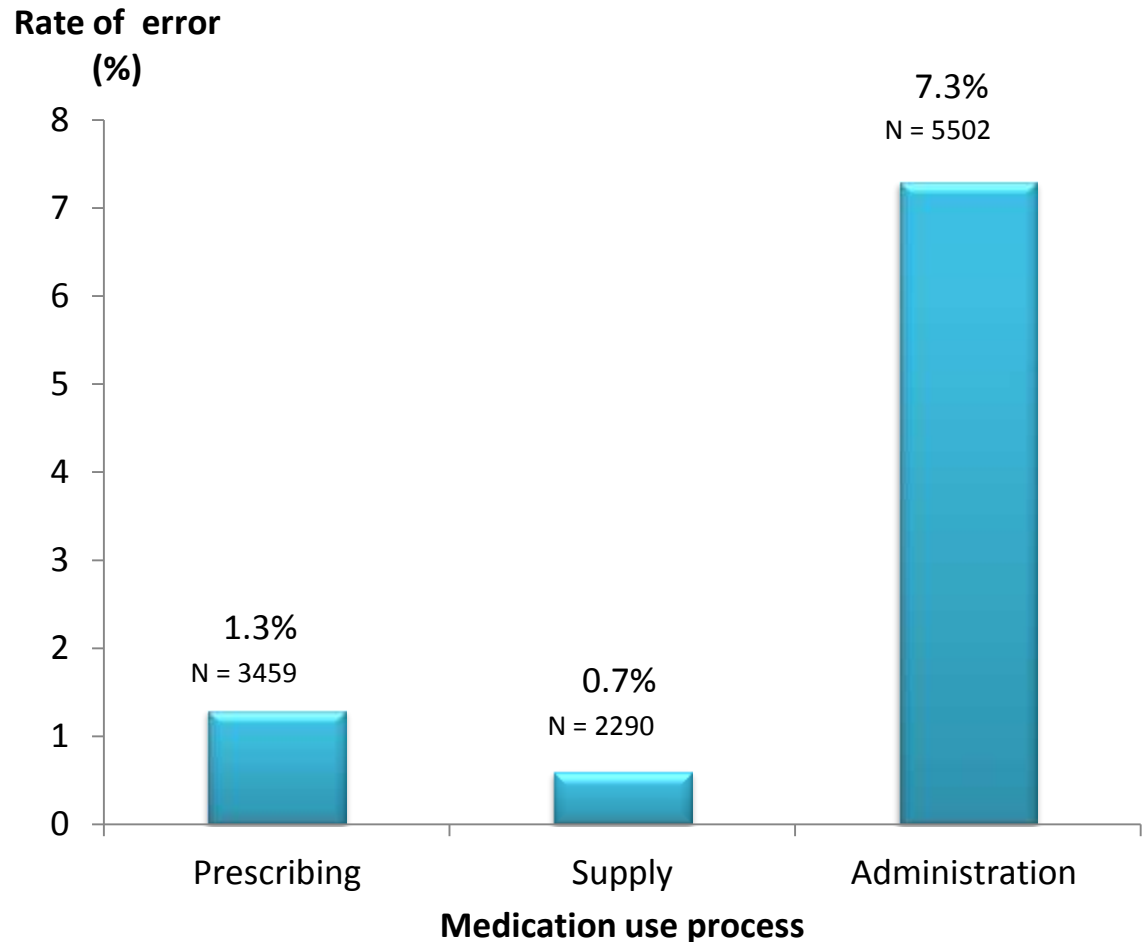
Medication error rate

- Included only errors that occurred (Category B and above)
- Error rate (%) =
$$\frac{\text{No. of errors}}{\text{Total no. of opportunity for error (OFE)}} \times 100$$
- An opportunity for error (OFE) is:
 - Prescribing – each drug prescribed, discontinued or continued
 - Supply – each process in repackaging; nurse request supply; ward stock restocking
 - Administration – the preparation and administration of a medication

Results

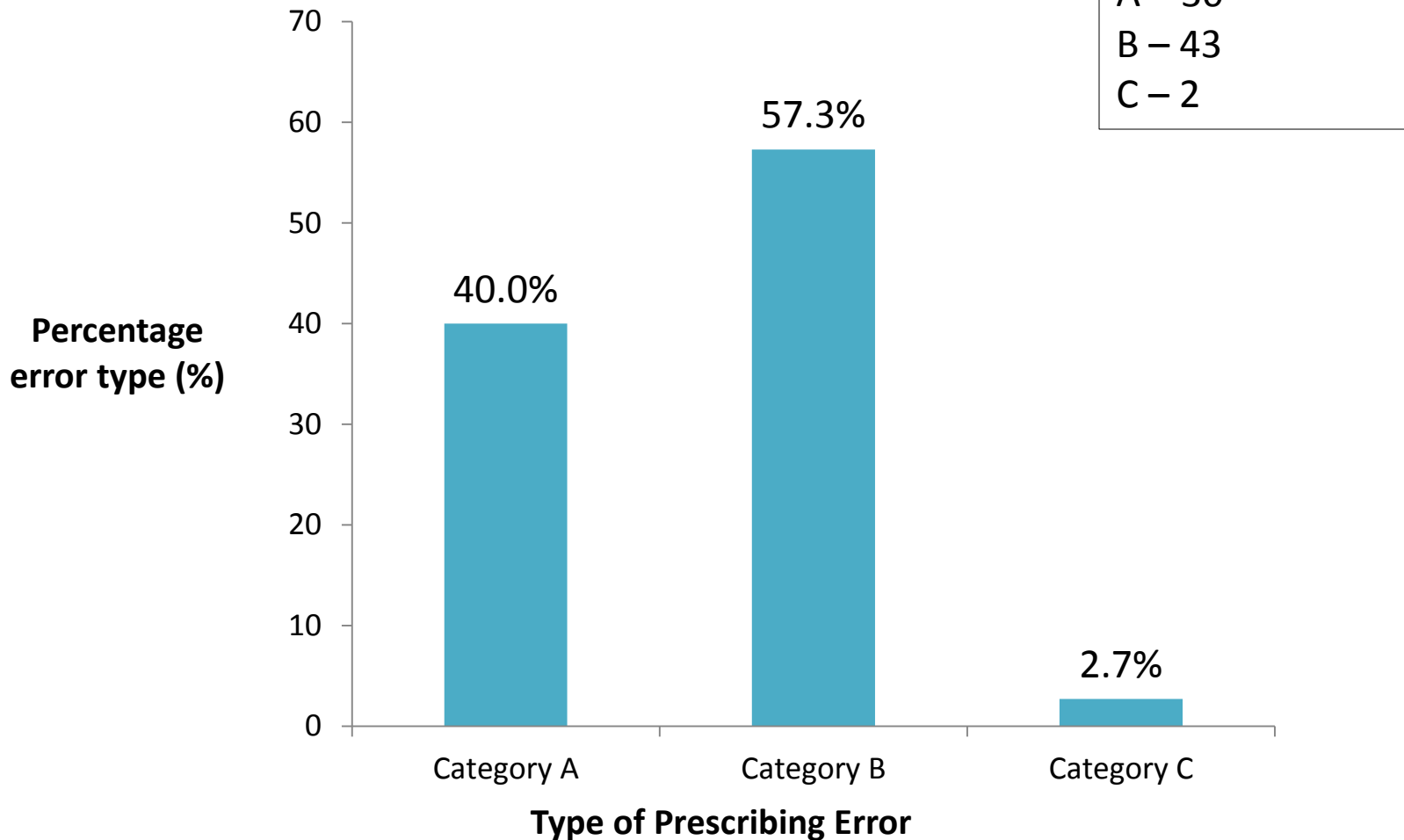
Rate of error for each medication use process

- Prescribing
 - 3459 OFEs
 - 1.3% error
- Supply
 - 2290 OFEs
 - 0.7% error
- Administration
 - 5502 OFEs
 - 7.3% error



Results - prescribing

Percentage of Prescribing Error by Category



Results – Prescribing

Table of the top few prescribing errors and their percentages

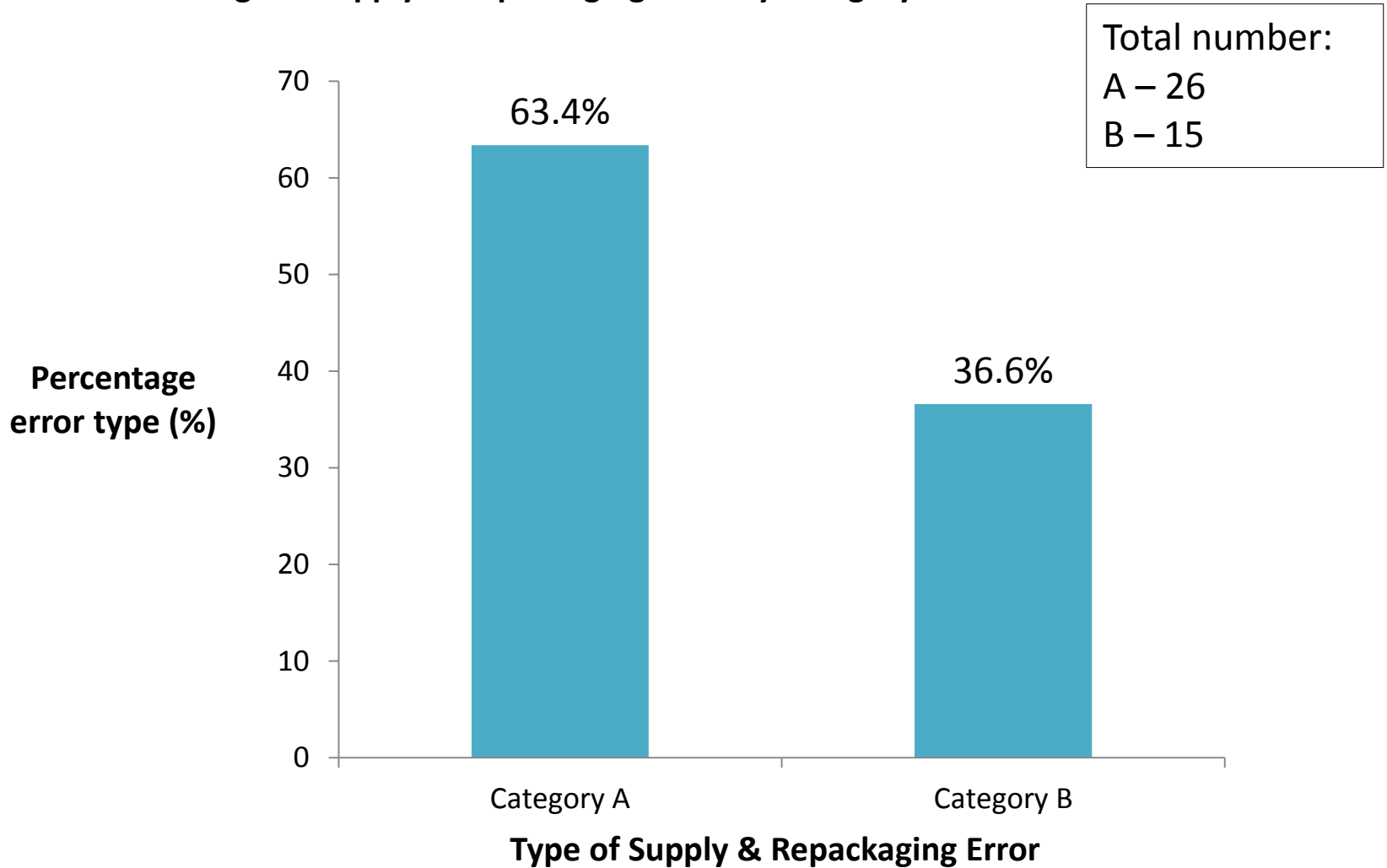
Category A (30/3459 x 100 = 0.87%)	Category B & C (45/3459 x 100 = 1.3%)
Potential error causing events: 1) Workflow issue 2) System issue	1) Dose error (22.2%) <ul style="list-style-type: none">• Did not discontinue old drugs 2) Wrong frequency (17.8%) 3) Omission error (15.6%) <ul style="list-style-type: none">• Did not prescribe “ONCE” doses 4) Duplication (15.6%) <ul style="list-style-type: none">• Did not discontinue old drugs

Discussion - Prescribing

- Many prescribing errors were category B errors
 - Importance of first dose review
 - To increase first dose review rate (currently at 85%)
 - Streamline pharmacists' roster
 - Engage physicians in reviewing
- Limitations of system prompts
 - Ignoring of system prompts/ prompt fatigue
 - Monitoring done by NHG P&T
 - Checking rules to be maximized and prioritized
- Workflow issues
 - Users may not be familiar with workflow processes and system functionalities
 - Conduct trainings, surveys, assessment

Results – supply & repackaging

Percentage of Supply & Repackaging Error by Category



Results – supply & repackaging

Table of the top few supply and repackaging errors and their percentages

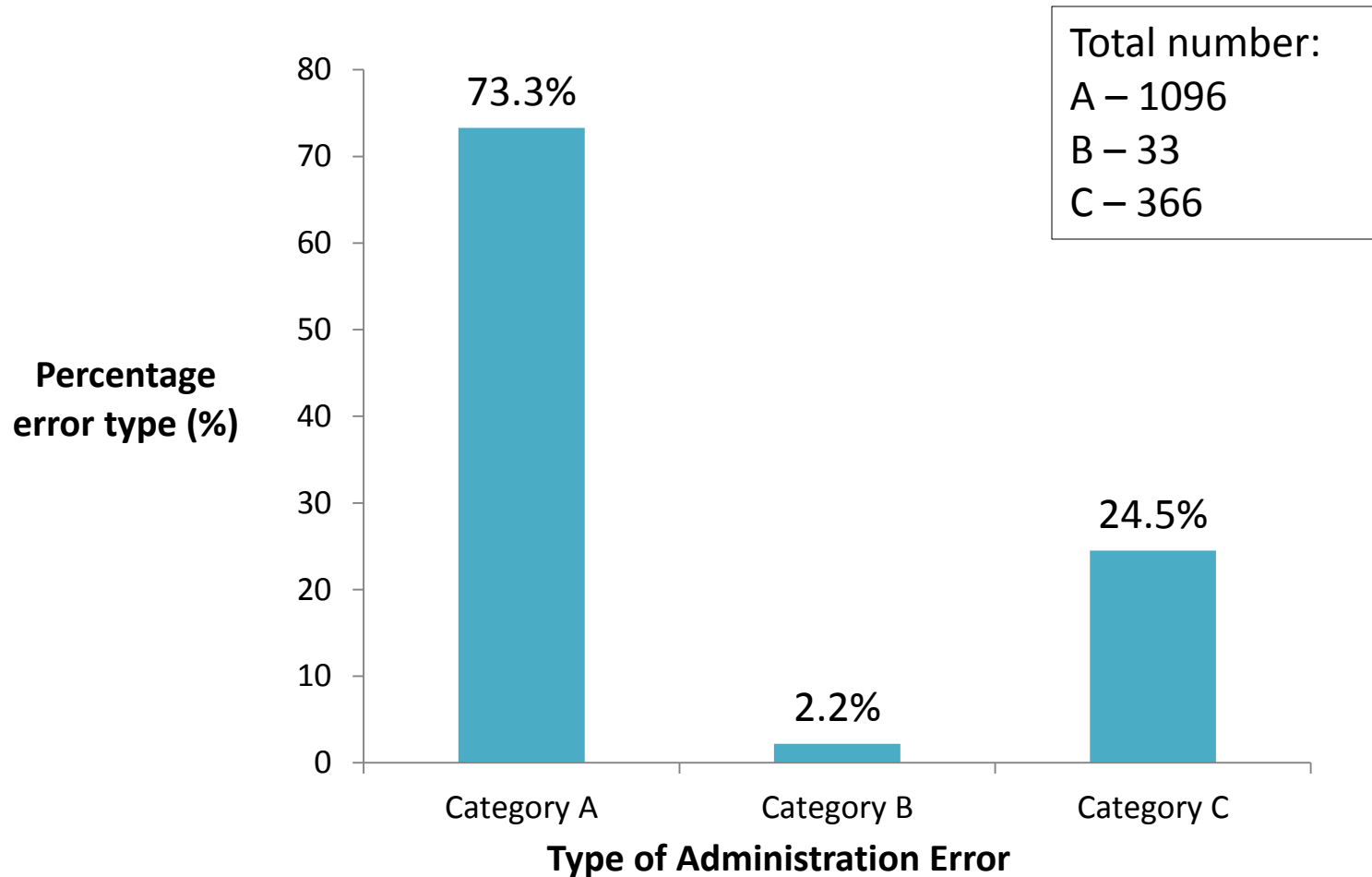
Category A (26/2290 x 100 = 1.14%)	Category B (15/2290 x 100 = 0.7%)
Potential error causing events: 1) Workflow issue 2) Wrong quantity	1) Labeling issue (53.3%) <ul style="list-style-type: none">• Auxiliary labels• Expiry date and batch number

Discussion - Supply

- Inpatient pharmacy
 - Inconsistencies in medication packing work processes
 - Deploy floor manager to supervise
- ADC
 - Insufficient workplace for ward stock restocking
 - Restocking in separate trips
 - Inability to perform multiple barcode verifications
 - Feedback to vendor for improvement

Results – administration

Percentage of Administration Error by Category



Results – administration

Table of the top few administration errors and their percentages

Category A (1095/5502 x 100 = 19.9%)	Category B & C (399/5502 x 100 = 7.3%)
Potential error causing events: 1) Improper use of the system 2) Non usage of PDA 3) No medication identification	1) Wrong preparation technique (41.4%) <ul style="list-style-type: none">• IV dilution not according to order in eIMR 2) Time error (28.8%) <ul style="list-style-type: none">• Medications ordered as pre-meals were given after meal 3) Wrong rate (13.8%) <ul style="list-style-type: none">• Medicines were not run according to rates on the eIMR

Discussion - Administration

- PDA usage
 - Barcode verification not consistently performed
 - Monthly monitoring and sharing of data to users
 - Medications not barcoded (currently at 9%)
 - To maximize outsource repackaging
- IV drug preparation
 - Order details on eIMR not complied with during administration
 - Pharmacotherapeutic lectures by Pharmacy
 - Review guidelines for IV preparation, consolidate and update template for dilution ordering on eIMR

Conclusions

- Medication errors, although greatly reduced, still persist despite implementation of CLMMS.
- CLMMS may effectively prevent medication errors but also create potential error causing events when the proper use of the system is not adhered to.
- Comparison of the observational study results with voluntary and system trigger reports highlighted that direct observational study and audits are important to detect potential errors or errors that cannot be detected through system triggers.
- It is recommended that continuous monitoring and periodic audits of compliance to usage of system and established work process be implemented.
- **The results of this study was presented to the NUH Medication Safety Committee to improve medication safety.**

Thank You