Medical errors: Glossary (variables, metrics and measurement methods)

	Term	Definition	Metrics	Measurement method
Environment feature	**Acuity-adaptable room**	Rooms designed with sufficient space and provision for equipment, medical gases, and power to accommodate any level of patient acuity (Evans, Pati, & Harvey, 2008).	Yes/no, before/after (Hendrich, Fay, & Sorrells, 2004)	**Design manipulation** - The coronary critical care unit and medical step-down unit were redesigned and combined into one acuity-adaptable unit (Hendrich, Fay, & Sorrells, 2004).
	Barcode-assisted dispensing system	A medication dispensing system that uses barcodes to ensure that the correct medication, in its correct dose and formulation, is being dispensed (Poon et al., 2006). A patient is identified by a barcode. The barcode of every drug is scanned and checked against the information in electronic medication administration records before administration. When a wrong drug or wrong patient is scanned, a computer signal pops up and the process is stopped until the right patient or drug is identified (Ros & de Vreeze-Wesselink, 2009).	- Yes/no, before/after (Poon et al., 2006).	**Design manipulation** - A dedicated repacking center (for affixing a barcode onto each medication if the manufacturer had not already done so) was built to implement a barcode-assisted dispensing system in 3 configurations. In 2 configurations, all doses were scanned once during the dispensing process. In the third configuration, only 1 of several doses of the same medication being dispensed was scanned (Poon et al., 2006).
	Bedside assortment picking (BAP) trolley	A new type of drug trolley with separate compartments for ward-specific stock and patient-specific medicines. Equipped with a wireless laptop that connects to electronic medication administration records and guides the nurse to the correct location of a drug (Ros & de Vreeze-Wesselink, 2009).	- Yes/no, before/after (Ros & de Vreeze-Wesselink, 2009).	**Design manipulation** - A new type of drug trolley - bedside assortment picking trolley - was developed and introduced to replace a conventional trolley (Ros & de Vreeze-Wesselink, 2009).
	Computerized physician order entry (CPOE)	Computer-based systems for automating the medication ordering process. A basic CPOE ensures standardized, legible, complete orders by accepting only those orders that are typed and in a standard and complete format (Kaushal & Bates, 2001).	- Yes/no, before/after (King et al., 2003)	**Design manipulation** - A commercially available CPOE system developed by Eclipsys was implemented in two inpatient wards. The CPOE system was originally introduced as Carevision, underwent periodic product upgrades, and is now commercially available as Sunrise Clinical Manager (King et al., 2003).
	Daylight	Light originating from the sun that reaches Earth's surface after reflecting off the sky's vault (Zunde & Bougdah, 2006)	- Average hours of daylight/darkness for each month (Booker & Roseman, 1995)	**Existing data** - Existing data from public weather service (Booker & Roseman, 1995)

	Term	Definition	Metrics	Measurement method
	Distraction	An external stimulus causing observable responses from healthcare workers without disrupting the ongoing, productive activity (Flynn et al., 1999).	- Distraction condition versus non-distraction condition (Pluyter et al., 2010); - Number of distractions per pharmacist per half hour (Flynn et al., 1999).;	**Experimental manipulation** - In one experimental condition, subjects listened to popular songs combined with social conversation irrelevant to the surgical task and non-optimal laparoscope navigation (Pluyter et al., 2010). **Video recording of actual working** - Two video cameras recorded prescription-filling operations from two different angles throughout each eight-hour study day. The videotapes were reviewed simultaneously to record time of interruption or distraction, prescription-filling task affected, type of interruption or distraction, reason for the interruption or distraction, and study participant affected (Flynn et al., 1999).
	Illumination level (illuminance)	The intensity of luminous flux (Stein, 1997).	- Lux (1 lux=1 lumen/m^2) - Foot-candle (1 ftc = 10.764 lux) (Buchanan et al., 1991)	**Photometer** - Photometer (model IL1350, serial 2048, International Light Inc., Newburyport, MA) with an illuminance sensor (model SCD110, serial 1366, International light). Eight measurements were taken, starting 6 inches from the end of the conveyor belt and every 12 inches thereafter. The amount of illumination represents the mean of the eight measurements taken daily for seven days (Buchanan et al., 1991).
	Interruption	Cessation of productive activity before completing a prescription-filling task, due to any externally imposed, observable, or audible reason. Interruptions can be caused by staff looking at people passing through the ambulatory care pharmacy and related to prescription-processing questions (Flynn et al., 1999). Situation in which a nurse ceased a medication preparation or administration task in order to attend to an external stimulus (Westbrook et al., 2010).	- Number of interruptions per pharmacist per half hour (Flynn et al., 1999); - Number of interruptions during one medication administration (Westbrook et al., 2010).	**Video recording** - See "distraction" **Observation** - Observers (registered nurses and physicians) used a structured observational tool on a PDA to record number of interruptions that a nurse experienced (Westbrook et al., 2010).
	Light fixture (luminaire)	A complete lighting unit consisting of a light source (one or more lamps), and the parts designed to position the light source and connect it to the power supply. Parts for protecting the light source or ballast and for distributing the light may be included (National Fire Protection Association, 2010)	- Different lighting conditions determined by supplemental lighting fixtures and color filters (Buchanan et al., 1991).	**Design manipulation** - The installation of supplemental light fixtures and the removal of color filters (Buchanan et al., 1991).

	Term	Definition	Metrics	Measurement method
	Noise	Auditory stimulus, such as a change in loudness, bearing no informational relationship to the presence or completion of the task. Sound: a change in loudness bearing some informational relationship with the task at hand (Flynn et al., 1996).	- Number of unpredictable/controllable/ uncontrollable sounds per minute; - Equivalent sound level (Leq) per half hour (Flynn et al., 1996).	**Videotape recording** - Two video cameras placed in inconspicuous locations recorded ambient sounds. The videotapes were synchronized with the time that each patient's prescription set was being filled in order to determine which sounds affected performance (Flynn et al., 1996). **Noise-logging dosimeter** - Sound levels were continuously recorded in decibels (A scale) by a noise-logging dosimeter (Quest Electronics Noise-Logging Dosimeter, model M28-12) located at a 70 degree angle above the main prescription-filling area; the Leq was calculated for each half hour using the methods described by Taylor & Lipscomb (1978) for analyzing decibel levels that change over time (Flynn et al., 1996).
	Physical configuration of drug stock shelves	Spatial arrangement of drug items including the amount of space between drug items on shelves (Flynn et al., 2002).	- Separation and space between items versus tightly packed items on shelves (Flynn et al., 2002).	**Environmental inspection** - A pharmacy's drug stock was classified into one of two systems: stocked with space between items or tightly packed onto shelves (Flynn et al., 2002).
Outcome	**Adverse drug event (ADE)**	Harm caused by a drug or the use of a drug (Nebeker, Barach, & Samore, 2004). Potential drug event defined as dispensing errors that can harm patients if not intercepted before medication administration (Poon et al., 2006).	- Number of ADEs per 1,000 patient days; - Percentage of prescriptions involved in potential ADEs divided by the total number of prescriptions (King et al., 2003; Poon et al., 2006)	**Physician review of error reports** - Two physicians accessed the medication error database and reviewed all original incident reports. Severity was reclassified based on patient impact as an ADE, potential ADE, or other (King et al., 2003). - Each of two board-certified internists independently reviewed and rated the severity of each dispensing error by using an explicit set of criteria. Each physician-reviewer determined whether the patient could have had an injury if the dispensing error had reached the patient, defined errors that could harm patients as potential ADEs, and classified potential ADEs as significant, serious, and life-threatening (Poon et al., 2006).

	Term	Definition	Metrics	Measurement method
	Medication administration procedural failure	Failure to comply with specific medication administration procedures, including failure to read a medication label, failure to check patient's identification, temporary storage of medication in an unsecured environment, failure to record on a medication chart, use of a nonaseptic technique, failure to check pulse/blood pressure/blood glucose level (when applicable), failure of 2 nurses to check preparation of a dangerous drug or IV medication (Moorthy et al., 2003).	- Percentage of medications with procedural failures (Westbrook et al., 2010).	**Direct observation** - Observers (registered nurses and physicians) used a structured observational tool on a PDA to record nursing procedures related to medication administration (Westbrook et al., 2010).
	Medication error	Error that occurs while ordering, transcribing, dispensing, administering, or monitoring medications, irrespective of the outcome (Kaushal & Bates, 2001).	- Number of dispensing errors per pharmacist per hour (Flynn et al., 1999); - Percentage of prescriptions involved in errors divided by the total number of prescriptions (Buchanan et al., 1991; ; Flynn et al., 1999; Westbrook et al., 2010). - Number of nurse medication errors per month (Booker & Roseman, 1995). - Severity of error: five severity rating levels (1 - little or no effect on patient, 2 - likely to lead to increase in level of care, 3 - likely to lead to permanent reduction in bodily functioning, 4 - likely to lead to a major permanent loss of function, 5 - likely to lead to death); two categories (major errors - levels 4-5, minor errors - levels 1-3) (Westbrook et al., 2010).	**Direct observation & expert evaluation** - Filled prescriptions evaluated by researcher to detect deviations from physician's orders (Flynn et al., 1999; Flynn et al., 2002) - After the routine final check by a pharmacist but before the drug was dispensed to the patient, every prescription was reviewed for content by the observer (Buchanan et al., 1991) - A trained research pharmacist-observer inspected the medications that had already undergone the usual 3-step dispensing process to look for dispensing errors and classify the error types (Poon et al., 2006) - The direct observation method consists of an observer witnessing the administration of medicines to patients by the nurse. The observer checks the administration of each dose by the nurse with the help of an exact copy of the medication administration record. The observer does not interfere if an error is observed. If the observer estimated that the patient's safety is compromised, a warning is given to the nurse before the medicine is actually taken by the patient (Ros & de Vreeze-Wesselink, 2009). - Observers (registered nurses and physicians) used a structured observational tool on a PDA to record details of medication administrated and compare the data with patients' medication charts to determine whether the medication administrated differed from what was ordered (Westbrook et al., 2010).

	Term	Definition	Metrics	Measurement method
				Adverse event reporting system - A passive reporting system. The nurse and physician involved in a medication error complete an incident report and document the incident. The severity of patient harm is rated as none, mild, moderate, or severe. Medication errors are then sent to the pharmacy department and entered into a spreadsheet database (King et al., 2003). - The annual medication error index was measured by the hospital's standard system for reporting adverse events (Hendrich, Fay, & Sorrells, 2004). - Errors were documented on a standard error reporting form completed by the nurse committing the error and/or staff discovering the error (Booker & Roseman, 1995).
	Surgical errors	Errors in the performance of surgical procedures. In a laparoscopic task, skill-based errors involved dropped objects and objects placed inaccurately in the disc--either on their side or incompletely within the zone; knowledge-based errors occurred when objects were placed in the wrong zone (Moorthy et al., 2003).	- Number of errors in a surgical task (task error score) (Moorthy et al., 2003; Pluyter et al., 2010)	**Surgery simulation system** - Xitact LC 3.0 virtual reality simulator (Xitact SA, Morges, Switzerland). The clip and cut assessed (CCA) task in the Clip and Cut (C&C) module was used. Task errors were recorded by the simulator (Pluyter et al., 2010).
	Transport, patient intra-hospital transport	Transport of patients within the hospital (Ulrich & Zhu, 2007)	- Number of patient transports between nursing units /month (Hendrich, Fay, & Sorrells, 2004).	**Medical and operational data** - Data collected from Transition System, Inc. (TSI) by Vanderbilt University Medical Center, Nashville, TN (Hendrich, Fay, & Sorrells, 2004).

Medical errors: Article analysis

Reference	Environmental feature		Outcome		Study design	Results	Setting	Sample
	Variable	Metric	Variable	Metric				
Booker, J. M., & Roseman, C. (1995). A seasonal pattern of hospital medication errors in Alaska. *Psychiatry Research, 57* (3), 251-257.	Length of daylight	Average hours of darkness for each month (hr, data from public weather service)	Medication errors (omission, wrong time, wrong patient, wrong dose, wrong medication, error in transcription of physician's order, allergic medication, repeated medication, wrong route of administration, medication discontinued without physician authorization)	# of errors per month (error reporting form completed by the nurse committing the error and/or staff discovering the error)	Observational study, correlational analysis	The number of errors per month was positively associated with the average length of darkness two months earlier.	A 140-bed acute care hospital in Alaska	262 medication errors by nurses in a 5-year period
Buchanan, T. L., Barker, K. N., Gibson, J. T., Jiang, B. C., & Pearson, R. E. (1991). Illumination and errors in dispensing. *American Journal of Hospital Pharmacy, 48* (10), 2137-2145.	Illumination level	Three lighting levels by manipulating supplemental lighting fixtures (no supplemental fixtures - 45 ftc, two standard 4-foot fluorescent lighting fixtures with color filter - 102 ftc, and without color filter - 146 ftc); lighting level measured using photometer	Prescription-dispensing error rate	Number of prescriptions deviating in one or more ways from prescriber's written orders divided by the total number of prescriptions checked by each pharmacist and reviewed by the observer	Experiment, within-subject repeated measurements	Pharmacists made significant fewer errors in dispensing prescriptions when illumination level was high (146 ftc, 2.6%) than when the illumination level was relatively low (3.8%).	An outpatient pharmacy in a acute-care Army hospital	Five pharmacists
Flynn, E. A., Barker, K. N., Gibson, J. T., Pearson, R. E., Berger, B. A., & Smith, L. A. (1999). Impact of interruptions and distractions on dispensing errors in an ambulatory care pharmacy. *American Journal of Health Systems Pharmacy, 56* (13), 1319-1325.	Interruption (the cessation of productive activity before current prescription-filling task was completed for any externally imposed, observable, or audible reason); Distraction (an external stimulus followed by the pharmacist continuing productive activity while responding to the stimulus in a manner that was observable)	# of interruptions and distractions per pharmacist per half hour (videotape review)	Prescription-dispensing error rate	# of dispensing errors per pharmacist per half hour; # of prescriptions involved errors divided by the total # of prescriptions (%, filled prescriptions evaluated by researcher to detect deviations from physician's orders)	Observational study, correlational analysis	The number of interruptions and distractions per half hour was positively related to the number of dispensing errors per half hour. Sources of interruptions and distractions included unrelated traffics, prescription-processing questions, etc. It was recommended to eliminate traffic from other areas by relocating the ambulatory care pharmacy, providing visual barriers around the pharmacy, or rerouting traffic to an entrance that does not require passage through the ambulatory care pharmacy.	An ambulatory pharmacy at a general acute care hospital	14 pharmacists and 10 technicians
Flynn, E. A., Barker, K. N., Gibson, J. T., Pearson, R. E., Smith, L. A., & Berger, B. A. (1996). Relationships between ambient sounds and the accuracy of pharmacists' prescription-filling performance. *Human Factors, 38* (4), 614-622.	Frequency of unpredictable, controllable / uncontrollable sounds; Sound level	# of unpredictable / controllable / uncontrollable sounds per minute (videotape review); Equivalent sound level (Leq) per each half hour (noise-logging dosimeter)	Prescription-dispensing error	Whether or not one or more dispensing errors exist in selected prescription set	Observational study, repeated measurements within subjects	Unpredictable and controllable sounds might have a arousal effect and reduced dispensing errors. The error rate increased to a point then decreased when equivalent sound levels increased.	A pharmacy at a general acute care hospital	31 matched pairs of prescription sets by 12 pharmacists
Flynn, E.A., Dorris, N.T, Holman, G.T., Garnahan, B.J., & Barker, K.N. (2002). Medication dispensing errors in community pharmacies: A nationwide study. *Proceedings of the Human Factors and Ergonomics Society 46th Annual Meeting* , 1448-1451.	Illumination level; Sound level; Physical configuration of drug stock storage shelves	Illumination level - above vs. below 94 ftc, measured by a Sper Scientific light meter; Sound level - recorded by a Sper Scientific sound meter; Physical configuration of drug stock storage shelves - separation and space in between items vs. tightly packed items on shelves	Prescription-dispensing error and near error (dispensing error refers to any deviation from the interpretable prescription including content errors [incorrect drug, form, quantity, and strength] and labeling errors [incorrect instructions and information]; near error refers to an error discovered and corrected by the pharmacy staff)	# of dispensing errors and near errors % of dispensing errors and near errors (un-disguised observation to detect deviations from physician's orders)	Observational study	The physical configuration of drug stock storage shelves with separation and space in between drug items was associated with fewer content errors than the configuration with minimal space between items. More errors were made in pharmacies with lower lighting levels. Higher lighting level and lower sound level was also associated with higher rate of detection of errors by pharmacy staff.	50 pharmacies in six states (chain, independent, and health-system pharmacies)	5784 prescriptions, 91 errors, 74 near errors
Hendrich, A. L., Fay, J., & Sorrells, A. K. (2004). Effects of acuity-adaptable rooms on flow of patients and delivery of care. *American Journal of Critical Care, 13* (1), 35-45.	Acuity-adaptable room	Renovation of nursing unit by combining two separate units (critical care unit and step-down unit) into one acuity adaptable unit	Patient transports between units; Annual index of medication errors	# of transports/month (medical records); # of errors/patient days (hospital's adverse event reporting system)	Comparison of data collected before/after the renovation of nursing unit	After moving to acuity-adaptable rooms, the number of patient transports between units decreased by 90%; the annual index of medication errors decreased by 70%.	Coronary care unit (critical and progressive care)	2 years of data before renovation and 3 years of data after

Reference	Environmental feature		Outcome		Study design	Results	Setting	Sample
	Variable	Metric	Variable	Metric				
King, W. J., Paice, N., Rangrej, J., Forestell, G. J., & Swartz, R. (2003). The effect of computerized physician order entry on medication errors and adverse drug events in pediatric inpatients. ***Pediatrics, 112*** **(3 Pt 1), 506-509.**	Computerized physician order entry (CPOE)	CPOE implemented in 2 nursing units, compared with other units using hand written orders	Rate of medication error (reported adverse event involving medication prescription, dispensing, administration, or monitoring); Rate of adverse drug event (ADE, a medication error resulting in an injury to the patient)	# of medication errors per 1000 patient days (adverse event reporting database); # of ADEs per 1000 patient days (physician review)	Quasi-experiment; Retrospective	The CPOE resulted into significant decrease in reported medication error rates (4.48 to 3.13 errors per 1000 patient days) in the intervention units. After the implementation of CPOE, the medication rate was 40% lower in the intervention units than in the control units. Only 18 ADEs were identified. No effects of CPOE on ADE rate were demonstrated.	A tertiary pediatric hospital	36103 discharges and 179183 patient days
Moorthy, K., Munz, Y., Dosis, A., Bann, S., & Darzi, A. (2003). The effect of stress-inducing conditions on the performance of a laparoscopic task. ***Surgical Endoscopy, 17*** **(9), 1481-1484.**	Noise	Operating room background noise (80 to 85 dB) vs. quiet condition	Surgical error (skill-based, knowledge-based)	Error score (summation of all the errors for the task)	Simulated experiment, within-subject repeated measurements	Significantly more errors were made under noisy condition than quiet condition. High noise levels in operating rooms may induce stress and increase surgical errors.	Operating rooms	13 surgeons with various level of experience
Pluyter, J. R., Buzink, S. N., Rutkowski, A. F., & Jakimowicz, J. J. (2010). Do absorption and realistic distraction influence performance of component task surgical procedure? ***Surgical Endoscopy, 24*** **(4), 902-907.**	Distractions (popular songs combined with social conversation irrelevant to the surgical task and nonoptimal laparoscope navigation)	Distracting condition vs. non-distraction condition	Surgical performance of a clip and cut assessed (CCA) task	Task score, task completion, task errors, total time (measured by the simulator)	Simulated experiment, within-subject repeated measurements	Surgical task performance declined and errors increased significantly when a surgical task was performed under distracting condition.	Operating rooms	12 medical trainees
Poon, E. G., Cina, J. L., Churchill, W., Patel, N., Featherstone, E., Rothschild, J. M., . . . Gandhi, T.K. (2006). Medication dispensing errors and potential adverse drug events before and after implementing bar code technology in the pharmacy. ***Annals of Internal Medicine, 145*** **(6), 426-434.**	A bar-code-assisted dispensing system; a dedicated medication repackaging center in pharmacy	Implementation of the bar-code-assisted dispensing system in 3 configurations, building of the dedicated medication repackaging center during the conversion process	Target dispensing errors (errors that the bar code technology was specifically designed to address, including wrong medication, wrong strength or dose, wrong formulation, expired medication); Target potential adverse drug event (errors that can harm patients)	Target dispensing error rate (%, direct observation by a trained research pharmacist); Target adverse drug event rate (%, errors reviewed by 2 board-certified internists)	Before-after study	After the implementation of the bar-code system, rates of dispensing error and potential adverse drug event decreased significantly. System configurations that required scanning of every dose had a bigger reduction in errors than configuration that did not require scanning of every dose.	Hospital pharmacy at a 735-bed hospital	About 370,000 medications
Ros, H. & de Vreeze-Wesselink, E. (2009). Reducing the number of dispensing errors by implementing a combination of a CPOE system and a bar-code-assisted dispensing system: The BAP concept. ***EJHP Science, 15*** **(4), 86-92.**	Computerized physician order entry (CPOE); A bar code-assisted dispensing system using a bedside assortment picking (BAP) trolley	Implementation of the CPOE system and the bedside assortment picking (BAP) trolley	Dispensing error (unordered drug, extra dose, wrong dose, omission, wrong time, wrong route of administration, wrong form, wrong administration technique)	Dispensing error rate (# of errors divided by the sum of all doses ordered and the number of unordered doses given, expressed in %, direct observation)	Before-after study (baseline, implementation of CPOE, and then implementation of BAP trolley)	The dispensing error rate reduced by 47% after the implementation of the CPOE system (from 3.1% to 1.7%). BAP trolley resulted in an additional reduction in dispensing errors of 49% (from 1.7% to 0.84%). For BAP trolley, a well-protected cordless network is needed.	A 36-bed neurology ward in The Netherlands.	Over 12,500 doses
Westbrook, J. I., Woods, A., Rob, Marilyn, I., Dunsmuir, W. T. M., & Day, R. O. (2010). Association of interruptions with an increased risk and severity of medication administration errors. ***Archives of Internal Medicine, 170*** **(8), 683-690.**	Interruptions	# of interruptions during one medication administration	Medication administration procedural failure rate (% of medications with procedural failures); Medication administration error rate (% of medications with errors); Severity of error (five severity rating level and two categories - major and minor errors)	Percentage of administrations with procedural failures (%, direct observation using a structured tool on a PDA); Percentage of administrations with medication errors (%, comparison of observational data with medical charts); Error severity - major vs. minor errors (researcher determination based on 5-point severity assessment scale)	Observational	Overall, procedural failures occurred in 74.4% of medication administrations, and errors occurred in 25% of administrations. The rates of procedural failures and medication errors as well as error severity were positively related to the numbers of interruptions per medication administration.	Two Australian hospitals	4271 drug administrations for 720 patients

Medical errors: Matrix of relationships

		Outcome				
	Variable	Medication errors	Medication administration procedural	Adverse drug event	Surgical errors	Intra-hospital patient transfer
Environment feature	Distraction/Interruption					
	Noise					
	Light fixture					
	Illumination level					
	Daylight					
	Acuity-adaptable room					
	Bar-code-assisted dispensing system					
	Bedside assortment picking (BAP) trolley					
	Physical configuration of drug stock shelves					
	Computerized physician order entry (CPOE)					

Note: Cells shaded in gray indicate the existence of evidence supporting relationships between environmental features and outcomes