Up and Coming Challenges for IV Room Workflow Automation and IV Robotics

Disclosures
The program chair and presenters for this continuing education activity have reported no relevant financial relationships, except:

Lindsey Amerine: Consultant, BD PhaSeal
Angela Yaniv: Institutional Relationship - IV Logics for ApotecaChemo robots; implementation and use of ApotecaChemo.

Objectives
- Describe the advantages of IV workflow systems
- Explain safety risks associated with current compounding processes
- Review implementation strategies
- Determine impact on productivity
- Evaluate potential shortcomings of IV workflow systems

IV Room Workflow Automation and IV Robotics
Chris Boreen, Pharm.D.
PGY-2 Health-System Pharmacy Administration Resident
Cleveland Clinic

Current Practices
- Verification of sterile products has traditionally focused on a variety of methods
  - Visual inspection
  - Source ingredients
  - Final product
  - Calculation review
  - Direct observation
  - Highly manual process

Medication Errors in Sterile Products
- ISMP report
  - 1990-2012: 200 adverse events associated with 71 compounded products
  - 9% error rate in sterile products
  - Majority incorrect dose

Percentage of Hospital Respondents Experiencing a Patient Incident Involving Compounding Errors over Past 5 Years

<table>
<thead>
<tr>
<th>Year</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bar</td>
<td>30</td>
<td>25</td>
<td>30</td>
<td>20</td>
<td>10</td>
</tr>
</tbody>
</table>


Current Safety Gaps
- Syringe pull-back method
- Manual processes
- Calculations
- Product selection
- Error detection

Advantages of IV Workflow Systems

<table>
<thead>
<tr>
<th>Safety Gap</th>
<th>Process Improvement with IV Workflow</th>
</tr>
</thead>
<tbody>
<tr>
<td>Syringe pull-back method</td>
<td>Image capturing</td>
</tr>
<tr>
<td>Calculations</td>
<td>Performed via system</td>
</tr>
<tr>
<td>Product selection</td>
<td>Barcode scanning</td>
</tr>
<tr>
<td>Error detection</td>
<td>Automated tracking</td>
</tr>
</tbody>
</table>

Trends in IV Workflow Adoption

<table>
<thead>
<tr>
<th>Year</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>2011</td>
<td>20</td>
</tr>
<tr>
<td>2012</td>
<td>10</td>
</tr>
</tbody>
</table>


IV Workflow Adoption Based on Facility Size- 2013

<table>
<thead>
<tr>
<th>Facility Size</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-100</td>
<td>10</td>
</tr>
<tr>
<td>101-200</td>
<td>20</td>
</tr>
<tr>
<td>201-400</td>
<td>30</td>
</tr>
<tr>
<td>400+</td>
<td>40</td>
</tr>
</tbody>
</table>

Contributions to Lack of Adoption

- Limited compounding
- Costs
  - Capital and operational impact
  - Project management resources
- Impact on workflow
- Awareness of additional benefits
- Alternative strategies

Cleveland Clinic

Goal: Full implementation of an IV Workflow System for all batch and patient-specific doses across all sterile products areas

<table>
<thead>
<tr>
<th>Sterile Products Site</th>
<th>Patient-Specific Orders/Day</th>
</tr>
</thead>
<tbody>
<tr>
<td>Main Pharmacy</td>
<td>600</td>
</tr>
<tr>
<td>Ambulatory Pharmacy</td>
<td>50</td>
</tr>
<tr>
<td>Heart Center Pharmacy</td>
<td>100</td>
</tr>
<tr>
<td>Cancer Center</td>
<td>200</td>
</tr>
<tr>
<td>Pediatrics</td>
<td>150</td>
</tr>
<tr>
<td>Pediatrics Rehabilitation Center</td>
<td>25</td>
</tr>
<tr>
<td>Total</td>
<td>1125</td>
</tr>
</tbody>
</table>

Implementation Strategies

- Thorough evaluation of systems
  - Sterile products leader
  - End-users
    - Pharmacists
    - Technicians
  - Informatics
    - Integration assessment
    - Interface
    - Formulary
  - Project manager
  - Contracting

Implementation Strategies

- Development of workflows/workflow steps
  - Assembly of end-user groups
    - General
    - Oncology
    - Pediatrics

Implementation Strategies

<table>
<thead>
<tr>
<th>Workflow Type</th>
<th>Workflow Step</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-Hazardous</td>
<td>1) Components</td>
</tr>
<tr>
<td></td>
<td>2) Prepare</td>
</tr>
<tr>
<td></td>
<td>3) Approve</td>
</tr>
<tr>
<td>Hazardous (Liquid)</td>
<td>1) Components</td>
</tr>
<tr>
<td></td>
<td>2) Prepare Syringes</td>
</tr>
<tr>
<td></td>
<td>3) Syringe Check</td>
</tr>
<tr>
<td></td>
<td>4) Prepare Final Solution</td>
</tr>
<tr>
<td></td>
<td>5) Final Approval</td>
</tr>
<tr>
<td>Hazardous (Powder)</td>
<td>1) Components</td>
</tr>
<tr>
<td></td>
<td>2) Prepare Reconstitution</td>
</tr>
<tr>
<td></td>
<td>3) Reconstitution Check</td>
</tr>
<tr>
<td></td>
<td>4) Prepare Syringes</td>
</tr>
<tr>
<td></td>
<td>5) Syringe Check</td>
</tr>
<tr>
<td></td>
<td>6) Prepare Final Solution</td>
</tr>
<tr>
<td></td>
<td>7) Approve Final Solution</td>
</tr>
</tbody>
</table>
Implementation Strategies

- Initial upload and integration led by informatics team
- Utilized “no match” report
- Frequent meetings with informatics

Formulary Build/Maintenance

- Training
  - Development of training guide
  - Identification of super users
  - Mix off-line and live training
  - Increase staffing for go-live

Implementation Strategies

- Design and implement pre-implementation studies
  - Turnaround time
  - Error detections
- Measure progress throughout

Turnaround Time Analysis

Scan Point
Turnaround Time Analysis

<table>
<thead>
<tr>
<th>Time Point</th>
<th>Pre-implementation</th>
<th>Post-implementation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Set-up Time</td>
<td>10:32 (n = 3962)</td>
<td></td>
</tr>
<tr>
<td>Compounding Time</td>
<td>2:59 (n = 3322)</td>
<td></td>
</tr>
<tr>
<td>Pharmacist Verification</td>
<td>9:20 (n = 3910)</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>22:50</td>
<td></td>
</tr>
</tbody>
</table>

Included non-cart-fill items (stats and first doses)
Excluded doses with a total turnaround time of >4 hours (not scanned)
Pre-implementation data: 12/15/14-1/16/15
Post-implementation data: 1/27/15-3/28/15

Additional Advantages

- Manager decision support
- Error detection
- IV room staffing evaluation
- Waste decrease
- Performance metrics
  - Pharmacists

Analytics

Error Reporting

- Barcode scanning
  - Unexpected component report
- Dose discards
  - Error type tracking
Alternative Strategies

- Manual process
- Limitations in technology
  - Images
  - Accuracy validation
- Alternative methods of automation

Key Takeaways

- Successful implementation of an IV workflow system requires frequent interactions between informatics team and sterile products team
- Focus of systems is clearly safety, but it is critical to leverage analytics to drive decision making
- Thorough evaluation of automation strategy should be completed prior to implementing

Polling Question

- What is your role in your institution?
  A. IT Pharmacist
  B. IT Manager
  C. Operational or Clinical Manager
  D. Assistant/Associate Director
  E. Director/Chief Pharmacy Officer

Polling Question

- What IV automation is used in your pharmacy?
  A. None
  B. IV Workflow Software
  C. Robotics

Polling Question

- In the next three years, my institution will:
  A. Pursue IV workflow software
  B. Enhance existing IV workflow software
  C. Pursue robotics
  D. Enhance existing robotics
  E. Will not pursue either
  F. Will pursue both
Preparation Processes

- Volumetric = Syringe pull-back
  - Pulling syringe plunger with the medication in the syringe barrel to the appropriate syringe volume demarcation on the cylinder of syringe
- Gravimetric = Weighing
  - Weighing the empty syringe and reweighing the syringe with the drug measured
  - Dose is calculated with this weight difference, known residual volume in syringe, and specific gravity of the drug

Variables in IV Preparation

- Syringe accuracy
  - Allowed variance of ± 4% or ± 5%
- Drug concentration equals labeled concentration
- Drugs are reconstituted accurately
- No residual left in syringe or closed-system transfer device

ASHP Summit on IV Safety

- Major barrier to safe IV medication use is lack of standardized IV medication process design
- Analysis of barriers to safe IV medication use
- Verify compounding accuracy
- Through research that supports needed changes that improve IV preparation and dispensing

ISMP Recommendation

- Syringe pull-back preparation method not recommended by ISMP and is considered unsafe
- Based on case reports
- One study evaluating its contribution to introducing errors into the final product

Literature Review

- Multi-center study, observer technique
  - RESULTS: IV compounding error rate = 9% with 63% of errors being “wrong dose errors”
- Narcotic infusion final concentration through laboratory analytical techniques
  - RESULTS: 60% preparations outside 10% allowable variance
- Retrospective comparison of chemotherapy gravimetric and volumetric dosing accuracies
  - RESULTS: Mean deviations: Gravimetric = ±0.05% (± 1.54%) vs Volumetric 3.02% (± 3.39%)

Assessment of final product dosing accuracy when using volumetric technique in the preparation of chemotherapy

Poppe LB, Savage SW, Eckel SF.

J Oncol Pharm Practice 2014; epub ahead of print

References


© 2015 American Society of Health-System Pharmacists
Institutional Overview

- University of North Carolina Hospitals
- North Carolina Cancer Hospital

Study Design

**Primary Objective**
- Determine final product accuracy through using volumetric technique in the preparation of chemotherapy

**Secondary Objectives**
- Determining accuracy of volumetric preparations based on:
  - Volumes prepared
  - Syringe Size Used
  - Patient’s Age
  - Preps requiring reconstitution
  - Drug prescribed
  - Technician preparing agent

Study Design

- Product prepared via syringe pull-back method (volumetric) and weighed with drug in syringe (gravimetric)
- One BSC used with all technicians rotating through
- Weights recorded prior to pharmacists’ check of final product
- No change made in pharmacist checking process post-preparation as weights were not part of verification process

**Data Collection**
- 3.5 months: 12.15.2010 – 03.30.2011
- Specific gravities obtained from manufacturers and verified by Drug Information Center

**Inclusion**
- Chemotherapy doses from BSC with two weights recorded from analytical balance (Mettler Toledo XS200)

**Exclusion**
- Drug did not have specific gravity reported by manufacturer
- Drug given via non-intravenous route
Study Results

1565 chemotherapy doses dispensed

409 excluded (no specific gravity reported)

1156 doses included

Study Results – Primary Outcome

- Mean percent volume difference: -0.53%
  - Range: -64.9% to 94.2% (CI -0.11, 0.1)
  - 71.7% of doses were within ± 5% of ordered dose
  - 87.4% of prepared doses within ± 10% of ordered dose

Study Results – Secondary Outcomes

- Increased percent volume difference
  - Pediatric population
  - Smaller volumes prepared
  - Reconstitution required
- All technicians had similar mean volume differences and ranges
### Study Results – Secondary Outcomes

**Reconstitution**

<table>
<thead>
<tr>
<th>Reconstitution</th>
<th>Sample size (n)</th>
<th>Mean % Volume Difference</th>
<th>Median % Volume Difference</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>242</td>
<td>-3.61%</td>
<td>-1.50%</td>
<td>(-64.9%, 8.44%)</td>
</tr>
<tr>
<td>No (in solution)</td>
<td>914</td>
<td>0.28%</td>
<td>-1.19%</td>
<td>(-28.34%, 94.22%)</td>
</tr>
</tbody>
</table>


### Author Conclusions

- Accuracy of volumetric preparations is highly variable given the ranges of final doses dispensed.
- Future studies are warranted to compare different workflow processes and implications on accuracy of IV preparations.

### IV Automation - Gravimetric Preparation

- **IV Workflow Solutions**
  - Cato - BD
  - DoseEdge – Baxter
  - i.v. SOFT - Asynt
- **Robotics**
  - APOTEC Achemo - Loccioni
  - IntelliFILL i.v. - Baxter
  - i.v. STATION and i.v. STATION ONCO - Asynt
  - Riva - Intelligent Hospital Systems
- **User Controlled**
  - Diana – ICU Medical

### Self-Assessment Question

- What impact does the volumetric (syringe pull-back) preparation method have on dosing accuracy?
  - A. Hasn’t been studied
  - B. Highly variable given ranges of doses
  - C. Most accurate method used

---

**IV ROBOTIC TECHNOLOGY: Patient Safety and Accuracy**

Winson Soo-Hoo RPh, MBA
Director, Pharmacy Services
The Childrens Hospital of Philadelphia

---

**Fiscal Year 13**
- 1st Pediatric Hospital in US (1855)
- Tertiary care teaching hospital
- Beds: 516
- Admissions: 28,996
- Patient Days: 154,551
- ER Visits: 90,378
- Day Surgery: 18,342
- Peri-op Service: 31,929
- Ranked #1 2003-2011
- Most Highly Ranked 2012-2013
Fiscal Year 13
- Drug Budget: $30.57 M
- Staff: 161 FTE
- Orders Reviewed: 967,136
- Doses: 2.8 M
  - >95% is dispensed as unit dosed
  - 80% extemporaneous doses

Current State
- Robot that automates the preparation of IV syringes
  - In 2009, CHOP Pharmacy was among the 1st hospitals to implement
  - In 2011, CHOP Pharmacy was the 1st children's hospital to utilize two
  - In 2015, CHOP Pharmacy was the 1st children's hospital to utilize three
- Goal - 70%-80% of IV syringes are prepared through robot

Pre-Automated IV Compounding Robot
- Fiscal Year 2012
  - IV Syringe Preparation
    - 500,809 syringes annually
    - 80% are prepared patient specific
  - FMEA
    - Incorrect Medication / Dose repaired
    - Contamination of preparation

Failure Modes
- Incorrect Medication/Dose
  - Incorrect drug or concentration is retrieved
  - Incorrect diluent is used
  - Incorrect volume is drawn into syringe
  - Incorrect label placed on final container
- Contamination
  - Vial stoppers are not appropriately disinfected
  - Critical sites are contaminated:
    - Vial stopper
    - Syringe tip and plunger
    - Transfer adapter
    - Syringe cap

Automated IV Compounding Robot Attributes
Attributes for Mitigating Product Contamination
- Requires no human intervention once compounding begins
- Provides an ISO 5 compounding environment
- Provides ISO 5 air for loading inventory and keeps critical areas in ISO 5 during packaging and loading
- Has laminar airflow over critical sites during compounding
- Uses UV light sterilization of vial stoppers and bag ports
- Real time monitoring for temp; humidity; particulates
- Removes needles from syringes and caps syringes prior to output

Automated IV Compounding Robot Attributes
Attributes for Mitigating Incorrect Medication/Dose
- Barcode verification of source vials and bags
- Records image of all compounding products as part of audit trail
- Verifies initial weight of syringes, vials and bags
- Verifies specific gravity weight before and after every fluid transfer
- Patient specific label is attached to output product
Implementation Phase

- Steps
  - FMEA
  - RIVA Utilization Strategy
  - Policy and Procedures
  - Staff Training
  - Staff Competency
  - Database Configuration
  - Production Start up

FMEA

- Drug Item Training (Robot Database)
- Robot Cleaning Procedure
- Patient Specific Batch Production
- Non-Patient Specific Batch Production

Automated IV Compounding Robot Utilization Strategies

- 1st Dose
- Non Patient Specific Batch Production
- Patient Specific Batch Production
- Hazardous Medications (e.g. Chemotherapy)
- Medication Safety (e.g. High Alert Medication)
- High Throughput
- Prepare Stock Medication Bags
- JIT

Database Configuration

- Highest Prioritized Failure Mode: Drug Item Training
  - Wrong dispensing concentration entered or wrong units of measure
  - Wrong diluent selected
  - Wrong diluent volume entered
  - Wrong concentration of source container enter
  - Effect: robot would prepare the incorrect dose

Database Configuration

- Includes
  - Dispensing concentration
  - Units of measure
  - Diluent
  - Diluent volume
  - Concentration of source container
  - Specific gravity of solution
  - Expiration time after puncture
  - Mixing time
  - Container specifications: diameter, height, bung crip height/diameter, bung depth

Database Configuration

- Data Input Procedure:
  - 1st person- Performs 1st measurements and documents data on spreadsheet
  - 2nd person- Performs 2nd measurements and inputs data in robot
  - 1st person validates robot entry by comparing 1st and 2nd measurements. Ensures variance of measurements is not greater than 5%
  - 3rd person- Validates robot-prepared product with manually prepared product through spectrophotometry
Phase I: Non-patient specific batch
- 8 hours/day (2300-0700)
- 250 doses/day
  - Acetylcysteine Inj, atropine Inj, calcium gluconate Inj, cefazolin Inj, dexamethasone Inj, lidocaine Inj, neostigmine Inj, pentobarbital Inj, succinylcholine Inj, thiopental Inj

Phase II - Patient specific doses
- 8 hours per day (0700-1500)
- 150 doses/day
  - Cefazolin Inj, Clindamycin Inj, Gentamicin Inj, Ondansetron Inj, Ranitidine Inj

Phase II - Non Patient specific doses
- Ketamine Inj, Fentanyl Inj, Dopamine Inf, Epinephrine Inf

Phase III
- 2nd robot
- JIT Batch Production
- Seven (7) batches over 24 hours: (4)AM, (2)PM, (1)Nights
- 800 doses/day
  - Vancomycin Inj, Cefepime Inj, Ampicillin/ Sulbactam Inj, Acyclovir Inj, Gentamicin Inj, Tobramycin Inj, Dicloxacillin Inj, Ceftriaxone Inj

Maximize Productivity
Goal
- Maximize the production of robot-prepared products by decreasing robot non-maintenance idle time.
- Ensure robot production queues are scheduled and allotted with appropriate production time

Maximize Productivity
Standard Work Intervention
- Develop Robot Health Status Board
- Data Provided on the Health Status Board includes:
  - Daily Schedule in order of priority (must be completed in order)
  - Scheduled Queue Start Time
  - Cycle Time and Number of Doses to complete
  - Projected End Time
  - Calculated Total Queue Run Time
  - % Deviation
  - Total Time calculated for Queue Data Entry
  - Supply Retrieval
  - Supply Load

Maximize Productivity
Robot Production Health Status Board
- Provides a visual schedule and status of the robot production process in real time
- Assists the staff and administrators with workflow adjustments due to unforeseen events (callouts, downtime, etc)
- Provides a clear understanding of length of time to complete a particular queue
- Provides data to Administration in order to further refine the workflow process
Maximize Productivity

Standard Work Intervention
- Using information provided by the Robot Production Health Status Board, scheduling of queues are based on cycle times and anticipated end time
- Allows the coordination of staff to be present at product production change over. Decrease idle time during product change over.
- Robot production runs are not over-scheduled. Daily scheduled robot production output are more accurate and reliable
- Greater scheduled robot production output reliability results in improved compliance to USP 797 quarantine guidelines

Results

Number of Doses Produced by Automated IV Compounding Robot

- Pre-Standard Work June 2013 to November 2013
- Post-Standard Work December 2013 to April 2014

- Average doses prepared by robot increased by 30% from 10,242 to 13,341 after standard work implementation

Maximize Productivity

Standard Work Intervention
- For the following Anesthesia/Automated Dispensing Cabinet Medications, convert from a multiply batch per week production schedule:  
  - Monday: Atropine 0.4 mg/ml, 2.5 ml
  - Tuesday: Nalbuphine 10 mg/ml, 1 ml
  - Wednesday: Sodium Bicarb 1 mg/ml, 10 ml
  - Thursday: Dexamethasone 4 mg/ml, 2.5 ml
  - Friday: Succinylcholine 20 mg/ml, 5 ml
  - Saturday: Calcium Gluconate 100 mg/ml, 5 ml
  - Sunday: Vecuronium 1 mg/ml, 5 ml
- Decrease number of product change over with their potential associated idle time

Results

Robot Non-Productive Idle Time

- Pre-Standard Work vs Post Standard Work

- Average robot non-productive idle time decreased by 33% from 257 hours to 172 hours per month

Automated IV Compounding Robot

Quality/Safety
- Robot reduces potential contamination/potential error
- Prepare and repackage Fentanyl (Inj 10mcg/mL, 1ml for NICU
- Repackage medications in syringes for Anesthesiology (i.e. atropine, calcium gluconate, neostigmine, pancuronium, etc)
- Primer for Bar Code Point of Administration for FY14

Cost
- Repackage multi-dose vials into smaller packages (e.g. THAM, Pentobarbital, Ketamine, etc.) - $150,000 annual savings

Delivery
- Repackage Shortage Medication (e.g. Calcium gluconate, Morphine PF)
- Just-in-Time Production Process
IV Robotics
Integration in the Ambulatory Setting

Angela W. Yaniv, B.S.Pharm., Pharm.D.
Assistant Director of Pharmacy
Cleveland Clinic

Objectives
 Compare advantages and disadvantages of customer vs vendor ownership of the product database
 Discuss interface development and integration of the robot with the electronic health record (EHR)
 Describe the use of an IV robot for patient-specific compounding in the ambulatory setting

Self-Assessment Question
 What impact does the accuracy of the product database have on the safety of robotically prepared doses?

Practice Setting

Robot Installation and Milestones

Installed – 7/24/11
Development and training – Aug-Sep, 2011
First patient dose – 10/14/11
Ohio Board of Pharmacy evaluation – 2/24/2012
Drug/Product Database
- Vendor develops, validates, and owns
- At time of installation, 57 drugs and approximately 300 vial formats were validated and available for our use
- New drugs and vial formats are validated and available shortly after market introduction

Advantages of Vendor vs Customer Database Management
- **Vendor**
  - Any validated product is available to add to any robot
  - Rigorous evaluation prior to clinical use
  - Many clinical sites using the same data
- **Customer**
  - Local control and validation
  - Add new products quickly

Disadvantages of Vendor vs Customer Database Management
- **Vendor**
  - Wait for vendor validation before adding a new product
  - Additions in conjunction with the vendor
- **Customer**
  - Customer responsibility for data collection and entry
  - Thorough checks and documentation system must be in place

Database and Safety
- Accurate recognition
- Accurate handling
- Accurate dosing

Polling Question
Would you prefer customer or vendor database ownership?
- Customer
- Vendor
Interface and Integration

- A must for patient-specific robotic compounding
  - Avoid transcription errors
  - Must be tested and validated

Interface and Integration

- HL7 interface from Epic to Apoteca
  - Developed with pharmacy IT and vendor
  - All doses from chemo pharmacy cross the interface and reside in the background
  - “Call up” a dose to prepare by scanning the Epic barcode

Pearls

- Consider the amount of flexibility needed between manual and robotic compounded
  - Turn around time
  - Ability to spread compounding throughout the day
  - Build in to your system change process
  - Consider need for interfacing with other systems or two-way interface with primary EHR

Integration in the Ambulatory Workflow

- Predictable peaks
- Managing turn-around time expectations
- Total production capacity during peaks

Integration in the Ambulatory Workflow

- One dose at a time
- Steps compared to manual compounding
- Checks compared to manual compounding

Ambulatory Setting Goals and Expectations

- Total dose output
  - Less than batch or advanced preparation
- Duration of use
  - Likely to mirror ambulatory clinic hours
  - Consider adjusting staffing to extend daily operation
Ambulatory Setting Pearls

- Workflow changes
  - Involve front-line staff in planning for integration with manual compounding
- Control what you can
  - Advanced reconstitution
  - Incorporation of hospital doses or other “make-ahead” products before or after ambulatory infusion appointments

Ambulatory Setting Pearls

- Select appropriate doses for the robot
  - More compounding steps take longer for people and the robot
  - Group same-drug doses to increase efficiency
- Manage turn around time expectations
  - Educate nursing
  - Educate pharmacy staff on order of administration for multi-drug protocols
  - It doesn’t all have to be ready at the same time

Self-Assessment Question 1

- What impact does the accuracy of the product database have on the safety of robotically prepared doses?
  - Assures safe handling of vials and other materials
  - Assures recognition of ingredients
  - Assures dose accuracy
  - All of the above

Answer: All of the above