Aerosol exposure of US pharmacy workers to active pharmaceuticals

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Introduction

This peer-reviewed study is part of comprehensive evaluation of health risks for workers in pharmacies using air pressure-activated drug dispensing machines. The study tested the working environment of pharmacy workers wearing personal exposure monitors (PEMs) while using the two leading types of air pressure-activated dispensing technologies – the McKesson/Parata Max and the McKesson/Parata RDS.

This is the third major study conducted by AlburtyLab examining the issues relating to pharmacy worker exposure to aerosolized pharmaceuticals.

The study found that workers were exposed to particles in the size range subject to the most health concerns – 2.5 microns or smaller (characterized by EPA as PM-2.5), and that the particles contained active pharmaceutical agents. It finds that a wide range of pharmaceuticals are inhaled and reports the concentrations observed, again raising serious health concerns.

Materials and methods

Monitoring was performed in two US Pharmacies, one which used a McKesson/Parata Max dispensing robot, and one which used a McKesson/Parata RDS dispensing robot.

Ambient aerosol monitoring was conducted over a 24-hour period in each pharmacy using an Aerodynamic Particle Sizer (TSI APS 3321).

Exposure monitoring was accomplished by equipping pharmacy staff with personal exposure monitoring (PEM) devices while working in the pharmacy area during one work shift. Filters from the PEMs were chemically analyzed using HPLC/DAD/MS, which confirmed that all personnel were exposed to airborne PM 2.5 containing active drug agents dispensed by the machines. PEMs monitoring was conducted only during the workday.

(a) (b)

Figure 1. PEM and sampling pump (a) As worn (b)

Results

While observing the real-time particle size and concentration spectra during operation and dispensing, a correlation appeared to be present between filling and delivery of certain prescriptions, and the emission of respirable particles from the machine. This correlation appears as coincident peaks in PM-2.5 and PM-10 mass closely associated (within approximately 2 min) with the dispensing of certain prescriptions.

Figure 2. Parata RDS and Parata Max

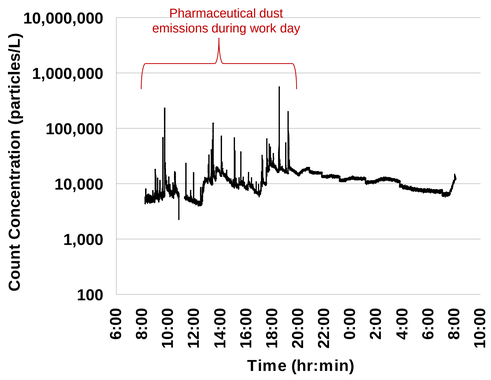

Figure 3. Parata RDS PM-2.5 Count, 24 hr.

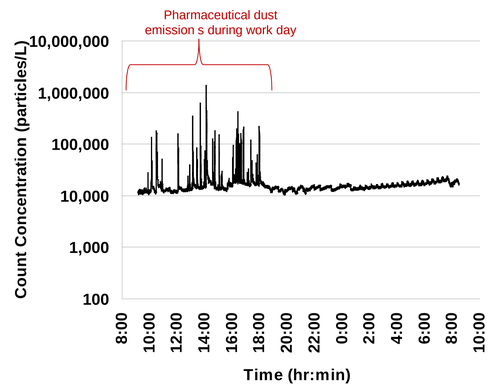

Figure 4. Parata Max PM-2.5 Count, 24 hr.

Recent studies have determined that exposure to PM-2.5 aerosols is associated with adverse cardiovascular events of several types. (Lazaroff, 2007) (Mills, 2007) (Mutlu, 2007) These studies looked into the mechanisms behind the adverse events and determined that inflammation in the lungs caused by breathing PM-2.5 aerosols increases the secretion of interleukin-6, which has been shown to increase clotting.

Table 1. Pharmaceuticals found on PEMS Filters

Compounds (Pharmacologic Actions)	
Acetaminophen (NSAID)	Meloxicam (NSAID)
Acetylsalicylic Acid (pain reliever)	Metformin (anti-diabetic)
Amitriptyline (antidepressant)	Methocarbamol (muscle relaxer)
Amoxicillin (antibiotic)	Niacin (Vitamin)
Atenolol (anti-angina)	Oxybutynin (for overactive bladder)
Carisoprodol (muscle relaxer)	Paroxetine (SSRI antidepressant)
Citalopram (antidepressant)	Penicillin (antibiotic)
Clonidine (anti-hypertensive)	Phenobarbital (barbiturate)
Colchicine (for gouty arthritis)	Phentermine (diet suppressant)
Cyclobenzaprine (muscle relaxer)	Prednisone (immunosuppressant)
Desloratadine (anti-allergy)	Prochlorperazine (anti-psychotic)
Diclofenac (NSAID)	Propranolol (beta-blocker)
Enalapril (ACE inhibitor)	Sulfamethoxazole (sulfa antibiotic)
Hydrochlorothiazide (diuretic)	Tamsulosin (for ED)
Hydromorphone (Opioid)	Warfarin (anticoagulant)

All of the filter samples collected were analyzed using high-performance liquid chromatography combined with an ultraviolet diode array detection system (HPLC/DAD). All of these samples were analyzed further by mass spectrometric analysis (HPLC/DAD/MS).

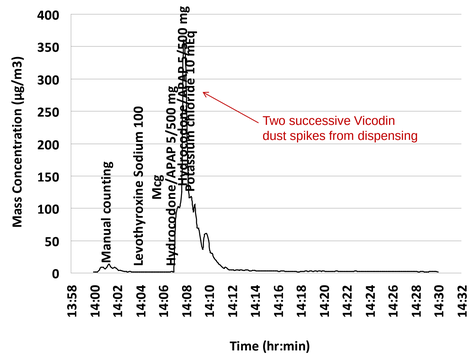

Figure 5. Example of Pharmaceutical Emission from Parata RDS while dispensing Hydrocodone/Acetaminophen (Vicodin®)

During the analysis of the filters collected at the Parata Max-using pharmacy, standard solutions of acetaminophen were prepared at 0.2, 1.0, 5.0, 25.0, and 124.8 ppm and were included in the analysis. With the inclusion of the acetaminophen standards, it was possible to quantitate the acetaminophen in each of the filter samples. The average aerosol concentration of the acetaminophen breathed by each of the PEMS wearers was calculated.

Table 2. Acetaminophen Air Concentration

Pharmacy Technology	Filter ID	Acetaminophen Weight µg	Air Sampled m^3	Air Concentration $\mu g/m^3$
Parata RDS	PEM-2B	0.5	3.20	0.16
Parata RDS	PEM-3C	0.2	4.20	0.05
Parata Max	PEM-1A	79.0	6.67	11.8
Parata Max	PEM-2B	7.0	5.92	1.18
Parata Max	PEM-3C	12.0	6.64	1.81
Parata Max	PEM-4D	14.0	3.40	4.12
Parata Max	Ref Filter	21.0	5.70	3.68
Parata Max	Ref Filter	28.0	5.70	4.91

Conclusions

Through the use of direct monitoring methods, it was determined that personnel working in pharmacies equipped with Parata RDS or Parata Max systems are exposed to aerosolized active pharmaceutical compounds. In comparing the data with EPA established standards, the following observations can be made—PM-2.5 emission peaks correlated with Parata RDS and Parata Max dispensing frequently exceed the 15.0 $\mu g/m^3$ level.

Other relevant factors to consider in evaluating the Parata RDS and Parata Max emissions:

- Personnel in pharmacies are working indoors and are subject to proximity to source, constant exposure, and constrained dispersion factors.
- Active pharmaceutical compounds were determined to be present in these emissions. Thus there is potential for allergic reactions, cross-contamination, and synergistic/antagonistic reactions.

Literature cited

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Mills, N. L. (2007). Ischemic and thrombotic effects of dilute diesel-exhaust inhalation in men with coronary heart disease. *New England Journal of Medicine* 1075-1082.

Mutlu, G. M. (2007). Ambient particulate matter accelerates coagulation via an IL-6-dependent pathway. *Journal of Clinical Investigation* 2952-2961.

Acknowledgments

The Parata RDS and Parata Max are manufactured by Parata Systems, LLC, 2600 Meridian Parkway, Durham, NC 27713, and marketed both directly and by the McKesson Corporation, or through their subsidiaries. Parata RDS, Parata Max, and McKesson are trademarks or registered trademarks of Parata Systems, LLC and/or McKesson Corporation in the U.S. and other countries. This study was partially funded by ScriptPro LLC of Mission, Kansas, a manufacturer of pharmacy automation equipment that competes with McKesson/Parata. ScriptPro's automated dispensing robots were studied in Phases 1 and 2 of this research and found not to emit particles. (Alburty, 2009).

For further information

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