EXPLORING THE POTENTIAL OF DRONES FOR URBAN DELIVERIES IN THE HEALTHCARE SECTOR

Sofia Magnusson & Pauline Hagerfors
Chalmers University of Technology
Drone deliveries of medical goods in urban healthcare
Patient safety improvements enabled by a drone-based logistics system
*Master’s Thesis in the Master’s Program Management and Economics of Innovation*

SOFIA MAGNUSSON
PAULINE HAGERFORS
Co-authors: Iván Sanchez-Diaz & Patrik Alexandersson, Chalmers University of Technology

In collaboration with The Urban Freight Platform (UFP), Volvo Research and Educational Foundations (VREF) & Innovation Platform Region of Västra Götaland
CASE CONTEXT

Gothenburg

2nd largest city in Sweden

Area: 450 sq km (or 5.6 sq miles)

Population: 600k city center

Population: 1M metropolitan area

Density: 1300 / sq km (or 3300 sq miles)

Traffic congestion

The study focus on the largest hospital in the region, spread geographically at three different hospital sites.
BACKGROUND

Urbanization

Centralization of supporting services and goods in healthcare

Patient safety

Drones

Pre-study showed time-saving potential*

*50-70% faster compared to road-based transport
RESEARCH QUESTIONS

RQ1
How can patient safety be supported by a drone-based delivery system of medical goods within an urban healthcare organization?

RQ2
Which types of medical goods are initially most beneficial to be delivered by drones from a patient safety perspective?

DELIMITATIONS

Transplantation logistics
Excluded

Internal transports
Only briefly considered

Technical aspects of drones
Only briefly considered
DATA COLLECTION

RESPONDENTS

- Semi structured interviews
- Observations
- Secondary data
  Transport statistics
The focus of the empirical findings was based on Kriegel's (2009) division of medical goods.

Current state analysis and mapping of:
- Regular deliveries
- On-demand deliveries
- Goods characteristics
- Logistic system risk factors
<table>
<thead>
<tr>
<th>Medical goods</th>
<th>Subcategories</th>
<th>Size</th>
<th>Weight</th>
<th>On-demand deliveries</th>
<th>Transport requirements</th>
<th>Personal information</th>
<th>Economic value</th>
<th>Replace-ability</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Medical devices</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Small to large</td>
<td>Low to high</td>
<td>Rarely</td>
<td>N/A</td>
<td>No</td>
<td>Low to high</td>
<td>Yes</td>
</tr>
<tr>
<td><strong>Pharmaceuticals</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Standardized pharmaceuticals</td>
<td></td>
<td>Small to large</td>
<td>Low to high</td>
<td>Sometimes</td>
<td>Traceability Temperature Humidity Stability* Security (risk of theft)*</td>
<td>Sometimes</td>
<td>Low to high</td>
<td>Yes</td>
</tr>
<tr>
<td>Extempore pharmaceuticals</td>
<td></td>
<td>Small to medium</td>
<td>Low to medium</td>
<td>Rarely</td>
<td>Traceability Temperature Humidity Stability* Security (risk of theft)*</td>
<td>Sometimes</td>
<td>Low to high</td>
<td>Yes</td>
</tr>
<tr>
<td><strong>Sterile goods</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reusable sterile goods</td>
<td></td>
<td>Small to large</td>
<td>Low to high</td>
<td>Rarely</td>
<td>Three-layers package</td>
<td>No</td>
<td>Low to high</td>
<td>Yes</td>
</tr>
<tr>
<td>Consumable sterile goods</td>
<td></td>
<td>Small to medium</td>
<td>Low to medium</td>
<td>Rarely</td>
<td>Three-layers package</td>
<td>No</td>
<td>Low to medium</td>
<td>Yes</td>
</tr>
<tr>
<td><strong>Laboratory samples</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Healthcare laboratory samples</td>
<td></td>
<td>Small</td>
<td>Low to medium</td>
<td>Daily</td>
<td>Traceability Temperature Stability*</td>
<td>Yes</td>
<td>Low</td>
<td>No*</td>
</tr>
<tr>
<td>Research laboratory samples</td>
<td></td>
<td>Small</td>
<td>Low to medium</td>
<td>Depends on each research project</td>
<td>Traceability Temperature Stability*</td>
<td>Yes, until aliquoted. Later coded.</td>
<td>Low</td>
<td>No*</td>
</tr>
<tr>
<td><strong>Blood supplies</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Medium (ca €100)</td>
<td>Yes</td>
</tr>
<tr>
<td>Blood</td>
<td></td>
<td>Small</td>
<td>Low</td>
<td>Daily</td>
<td>Traceability Temperature (2-6 °C) Stability</td>
<td>Yes</td>
<td>Medium (ca €100)</td>
<td>Yes</td>
</tr>
<tr>
<td>Plasma</td>
<td></td>
<td>Small</td>
<td>Low</td>
<td>Sometimes</td>
<td>Traceability Temperature (2-6°C) Stability</td>
<td>Yes</td>
<td>Medium (ca €50)</td>
<td>Yes</td>
</tr>
<tr>
<td>Thrombocytes</td>
<td></td>
<td>Small</td>
<td>Low</td>
<td>Sometimes</td>
<td>Traceability Temperature (20-24°C) Movement</td>
<td>Yes</td>
<td>Medium (ca €200-400)</td>
<td>Yes</td>
</tr>
</tbody>
</table>

Characteristics of medical goods logistics
Ex. Regular deliveries of healthcare laboratory samples between the three hospital sites
# Empirical Findings

## Regular Deliveries
- Extensive network
- High volumes
- Non-urgent goods
- Goods usually pass consolidation hubs at each hospital site
- Available daytime, weekdays

## On-Demand Deliveries
- Time critical goods
- Low volumes, small and lightweight goods
- Unpredictable need
- Goods delivered directly to units
- Limited availability of currently used transport modes

## Goods Characteristics
- Goods vary in:
  - Size
  - Weight
  - Transport requirements
  - Personal information
  - Economic value
  - Replaceability

## Logistics System Risk Factors
- Deviations
  - Unreliable lead times
  - Human errors
  - Lack of traceability
- Lack of security
  - No authorizations
  - Boxes not lockable
- High number of transfers
DISCUSSION AND CONCLUSION
RQ1

How can patient safety be supported by a drone-based delivery system of medical goods within an urban healthcare organization?
BENEFITS OF DRONE DELIVERIES

Centralization
- Increased service levels
- Resource efficiency
- Specialization
- On-demand deliveries
- Reduced lead times
- Reliable deliveries

Healthcare
- Less human errors
- Cost savings
- Traceability
- Flexibility
- Security

Drones
- Less road-based traffic and pollution

Logistics to support patient safety
## PATIENT SAFETY BENEFITS ENABLED BY THE USE OF DRONES

<table>
<thead>
<tr>
<th>Patient safety aim</th>
<th>Enablers through autonomous drone deliveries</th>
</tr>
</thead>
<tbody>
<tr>
<td>Safe</td>
<td>Reduced risk of errors and number of transfers related to deliveries. Improved security, traceability and transparency in the delivery system.</td>
</tr>
<tr>
<td>Effective</td>
<td>Reduced overcapacity in terms of payload and human resources.</td>
</tr>
<tr>
<td>Patient-centered</td>
<td>Less waiting time for patients, which improves flow efficiency and patient centricity.</td>
</tr>
<tr>
<td>Timely</td>
<td>Increased reliability in delivery lead time. Reduction in the number of deviations.</td>
</tr>
<tr>
<td>Efficient</td>
<td>Increased utilization rates due to fewer delays and possibilities for further centralization.</td>
</tr>
<tr>
<td>Equitable</td>
<td>Improved flexibility of deliveries in terms of both location and time.</td>
</tr>
</tbody>
</table>

Patient safety aims according to Vincent (2010). Potential benefits identified by authors.
RQ2

Which types of medical goods are initially most beneficial to be delivered by drones from a patient safety perspective?
GOODS COMPATIBLE WITH DRONE DELIVERIES IN AN INITIAL STATE

CRITERIA OF GOODS COMPATIBLE WITH DRONE DELIVERIES

- Low volumes
- Urgently needed goods
- Lightweight and small goods
- Replaceable goods
- Low to medium economic value
- High frequency of on-demand deliveries

CRITERIA APPLIED TO DELIVERIES IN THE CASE STUDY

Blood supplies

Healthcare laboratory samples

Not suitable for all samples due to their irreplaceability
Much more complex delivery system
PROJECT STATUS AND FURTHER RESEARCH

● Ongoing collaborative research project
  ○ Research Institute of Sweden
  ○ Innovation Platform VGR
  ○ Drone navigation software company
● Successful test flights this summer

Need for extensive further research. Examples:
● Last leg deliveries
● Technical requirements; weather conditions etc.
● Operational aspects
  ● Internal solutions
  ● Drone operators/control tower
THANK YOU FOR LISTENING

TIME FOR QUESTIONS

Full report: https://hdl.handle.net/20.500.12380/256792
Contact: sofia.m.magnusson@pwc.com & pauline.hagerfors@tmceurope.com