Prospective, Real-Time Use of an Optimization Application for Non-Urgent Patient Transfers Using Fixed-Wing Aircraft.

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Background
Aircraft are used for interfacility patient transfers to provide timely transfer to referral centers. Some transfers are non-emergent and can be scheduled and routed for efficient aircraft use. Commercial airlines have comprehensive programs and infrastructure to ensure optimized flight schedules and aircraft utilization. Air medical services operate on a smaller scale, do not operate on a fixed schedule, and cannot predict demand or utilization due to the nature of their service. However, air ambulance services have the same need to optimize utilization to minimize cost while meeting demand. Optimized deployment of air medical resources enhance access while decreasing cost.

Objectives
This study compared real-time use of a novel optimization application and algorithm derived from historical call, aviation, and financial data with traditional manual methods to plan non-emergent patient transfers using fixed wing aircraft. The study hypothesis is that an optimization application will decrease aircraft utilization while meeting all scheduled patient transfer requirements.

Application Information
Set-covering approach model, solved using commercial integer program solver. Cost calculated for all possible aircraft trips using route generating algorithm written in C++ with software selecting minimum-cost combination.

Methods
Prospective, randomized study comparing optimization application and algorithm ("study") with traditional manual ("manual") methods for flight schedules of non-urgent fixed wing patient transfers.

Study setting: Province of Ontario, Canada
Timeframe: June 8 to August 17, 2011

Steps:
1) Retrieve schedule and route planning information from dispatch data.
2) Use application to derive optimized flight schedules and routes.
3) Calculate total flying time and distance for each proposed schedules and routes; determine flights where a patient was on board the aircraft.
4) Calculate cost for each flight based on data from financial records.
5) Compare "study" versus "manual" methods for flight schedules and route plans.

Data analysis
Time, distance, and costs – continuous variables, descriptive statistics. Differences in times, distances, proportions of empty legs, and cost – mean, with ratios for distances; compared using unpaired t-test, with p<0.05 considered significant. Reasons for deviations from planned schedules reported - descriptive statistics.

Outcome Measures
Primary: differences in flights and distance flown, comparing "manual" and "study" derived flight schedules.
Secondary: ratios of actual distances flown versus minimum distance and cost required to satisfy transport requests.

Results

<table>
<thead>
<tr>
<th></th>
<th>“Manual”</th>
<th>“Study”</th>
</tr>
</thead>
<tbody>
<tr>
<td>days</td>
<td>33</td>
<td>25</td>
</tr>
<tr>
<td>transfers</td>
<td>479</td>
<td>360</td>
</tr>
<tr>
<td>daily mean (transfers)</td>
<td>14.5 ± 6.9</td>
<td>14.4 ± 4.5</td>
</tr>
<tr>
<td>hours flown</td>
<td>856</td>
<td>639</td>
</tr>
<tr>
<td>daily mean (hrs)</td>
<td>25.9 ± 12.8</td>
<td>25.6 ± 8.0</td>
</tr>
<tr>
<td>distance flown (km)</td>
<td>289,627</td>
<td>216,944</td>
</tr>
<tr>
<td>daily mean (distance)</td>
<td>8777 ± 4239</td>
<td>8678 ± 2711</td>
</tr>
<tr>
<td>ratio (km flown / km)</td>
<td>1.5 ± 0.22</td>
<td>1.4 ± 0.18</td>
</tr>
<tr>
<td>cost per km flown</td>
<td>$5.04 ± 0.69</td>
<td>$4.64 ± 0.64</td>
</tr>
</tbody>
</table>

Actual average daily savings*: $912 (3.2%), 0.82 flying hours (3.1%), 286 km flown (3.2%)

*While differences are not statistically significant, the "study" application yielded actual operational and fiscal savings in all categories.

Reasons for deviation or change in plans made in "study" arm:
- emergency or unscheduled demand for aircraft, resulting in schedule interruptions
- route and schedule deviations due to weather

Limitations
Actual distance flown by aircraft may differ from true distance between original and destination due to weather, flight path, and other aviation factors.

Conclusions
Use of novel optimization application can function in real-world setting to decrease aircraft utilization and cost of non-urgent patient transfers on fixed wing aircraft. Further work is needed to implement "schedule repair" option to rebuild schedules mid-day to take into account last-minute transfer demands that interrupt schedule, resulting in suboptimal utilization.