Saving money with simulation

For the first time, extensive research has shown that the use of simulation in healthcare education can significantly reduce costs, as well as improving trainee proficiency.

A Master's thesis written by students at the Copenhagen Business School cites numerous published studies by experts in simulation across the healthcare industry, including Lars Konge, David Stather and Momen M Wahidi

surgicalscience

INTRODUCTION

> *"This study is, to the best of our knowledge, the first study that has investigated the cost-effectiveness and potential cost-savings of simulation-based training (both in) EBUS education specifically and healthcare education more generally when compared to traditional apprenticeship training."*
>
> Laura Reib Hansen and Kasper Magaard Koldby

It is broadly accepted that simulation provides many benefits in healthcare training. Using a simulator helps to familiarise trainees with complex procedures outside the live surgical environment, and affords limitless opportunity to practice. This helps to build confidence, and means trainees are able to reach high proficiency levels quickly and safely.

But some medical training facilities are reluctant to invest in 'new' simulation technology, preferring to continue with traditional training programs that focus on mentoring and supervised live procedures. This is known as the 'apprenticeship' model.

One of the main reasons for this is the perception that simulation equipment is expensive, with significant set-up costs often falling outside standard training budgets.

In 2018, two students from Copenhagen Business School set out to challenge this assumption as part of their MSc. Business Administration and Innovation in Health Care course. Their Master's thesis, titled: Simulation-Based Training in Healthcare Education is one of the most thorough research papers ever undertaken to specifically calculate the true cost of simulation in medical training.

The thesis looks at trainees in the field of endobronchial ultrasound (EBUS), and compares the progress of those trained using simulation versus those trained using the more traditional 'apprenticeship' model. All the data the authors used to calculate the financial impact of simulation - both in terms of costs and timesaving - are based on published studies by some of the most renowned researchers in the field of medical simulation and public records (wages and purchase costs).

Their findings are definitive.

Firstly, they prove conclusively that using simulation significantly reduces the amount of time required for trainees to become proficient in performing EBUS procedures independently. But, more importantly, they suggest that simulation programs deliver a potential cost-saving of up to **$34,000 per trainee** versus the apprenticeship model.

In this paper, we will look at their methodology, and analyse some of the key findings.

THE THESIS

The 120-page thesis was written by Laura Reib Hansen and Kasper Magaard Koldby as part of their MSc. Business Administration and Innovation in Health Care course at the Copenhagen Business School.

Hansen and Koldby set out to investigate whether the initial investment required to set up simulation infrastructure could be offset during the training process by cost-savings made in the operating room, and on the extensive supervision required if using the apprenticeship model.

They hypothesise that:
The simulation training course incorporated in the ERS (European Respiratory Society) program can reduce the duration of the subsequent supervised clinical training when compared to the traditional apprenticeship model and thereby potentially save educational costs.

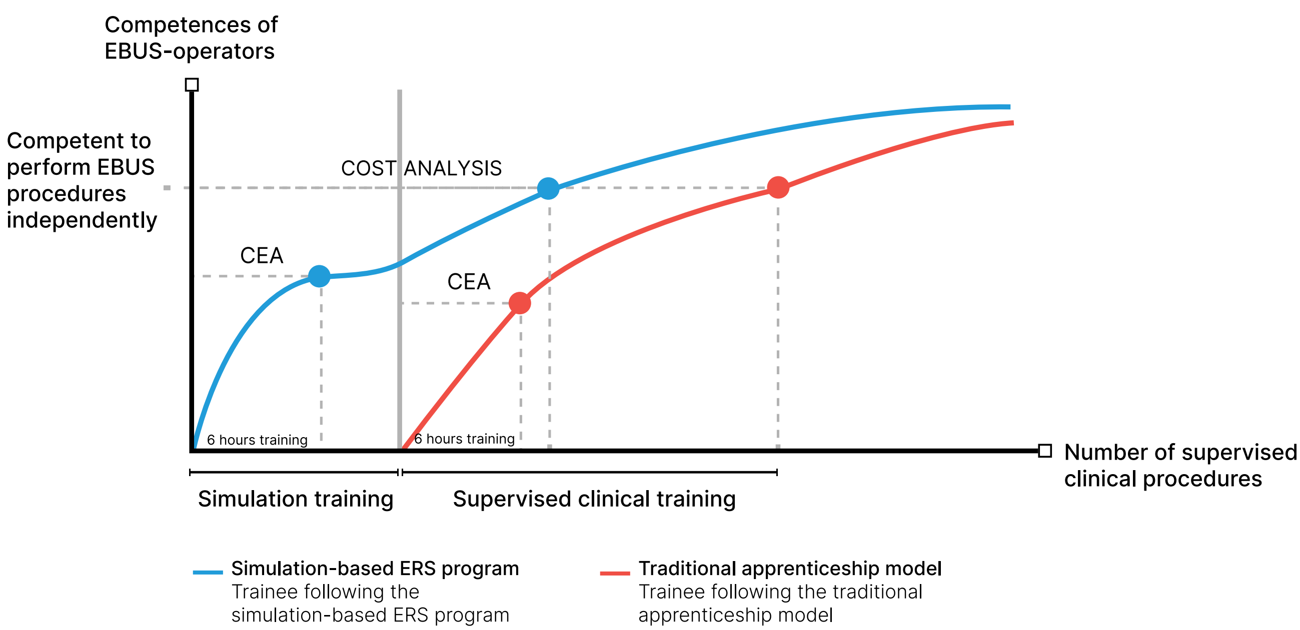


Figure 4. Graphical illustration of the different time horizons of the cost-effectiveness analysis and the cost analysis based on the learning curves of the simulation-based ERS program and the traditional apprenticeship model. The figure is based on the one illustrated in the article by Konge et al. (2015).

Their research was supported by the Copenhagen Academy for Medical Education and Simulation (CAMES), Denmark's leading academy for medical education and simulation. Konge undertook a study of students specialising in pulmonary medicine, half of whom were trained using the traditional apprenticeship model, and half of whom were trained using state-of-the-art EBUS simulation technology.

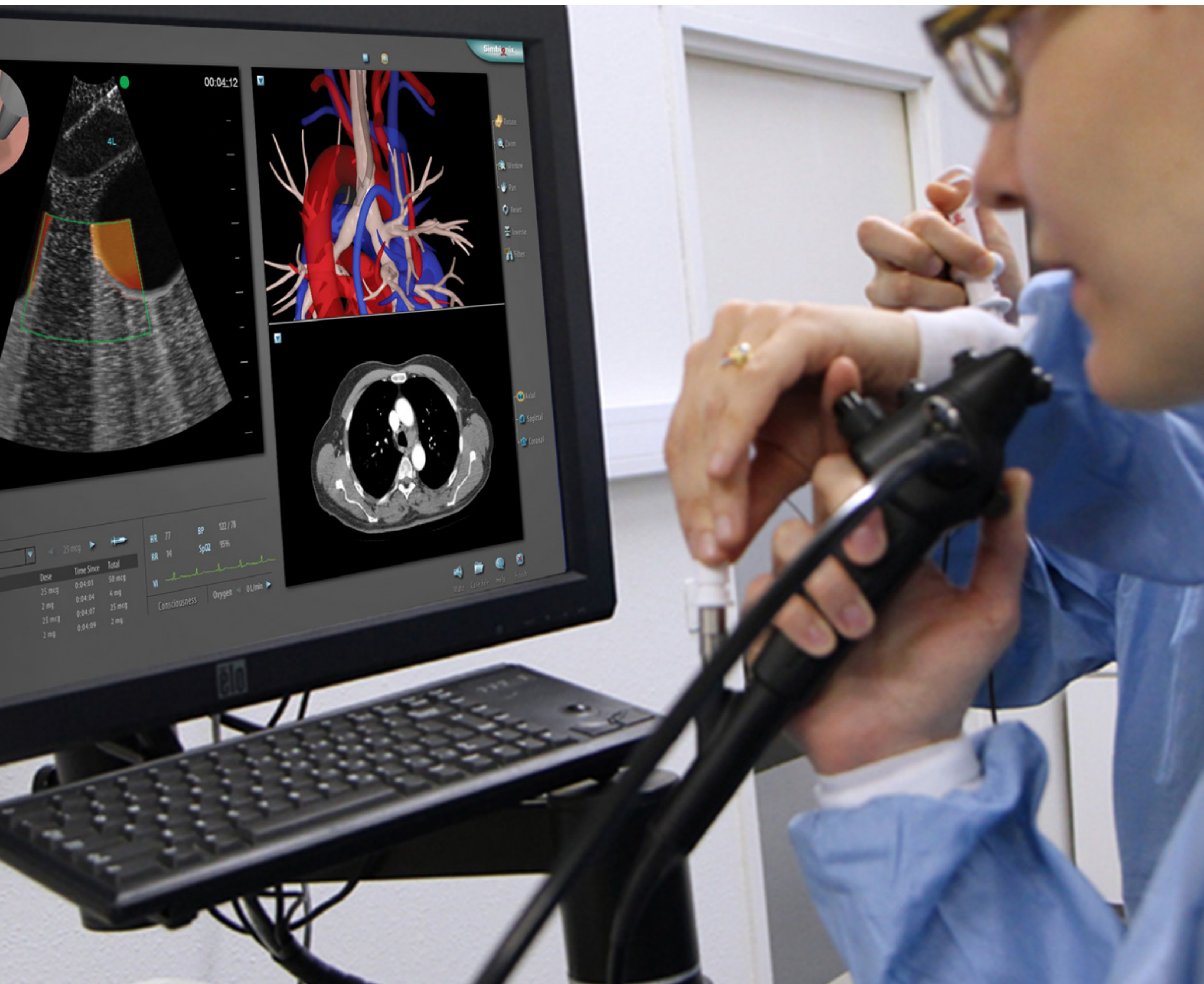
Although the subjects in the study were Danish, and the specialism was EBUS procedures only, the comprehensive nature of the research means it could also be applied to many other surgical disciplines and geographical regions.

WHAT IS EBUS?

EBUS (endobronchial ultrasound) bronchoscopy is a procedure used to diagnose different types of lung disorders, including inflammation, infections or cancer. Performed by a pulmonologist, EBUS bronchoscopy uses a flexible tube that goes through your mouth and into your windpipe and lungs.

EBUS predominantly checks for lung cancer tumours, so it is crucial that practitioners reach a high level of proficiency before independently performing them on patients.

The thesis notes that there are relatively few medical trainees specialising in pulmonary medicine in Denmark, and therefore relatively few people qualified to supervise them, so the impact of removing these supervising physicians from regular work during the training period is significant.



THE KEY QUESTIONS

Fundamental to the thesis was the calculation of 'incremental costs' for each model - that is, costs that occurred in addition to the standard training program.

Generally, simulation programs are perceived as having a high up-front cost. The best simulators are expensive to purchase, and they also come with significant associated maintenance and infrastructure costs - as well as staffing costs to efficiently run the equipment and facilities.

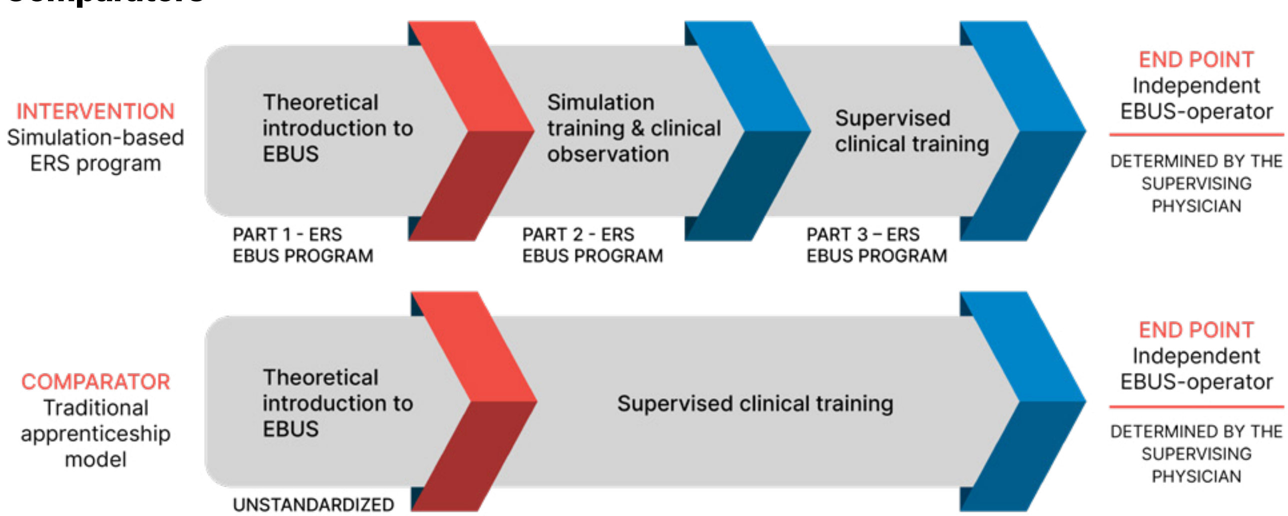
With the apprenticeship model, most of the additional costs are 'hidden', in that they occur due to extra time spent by trainees in the operating room under supervision.
Hansen and Koldby's goal was to ascertain how quickly trainees reached a level where they could perform EBUS procedures independently. Within this, they wanted to address three key questions:.

> 1. What is the cost-effectiveness of simulation training in the initial part of EBUS operators' learning curve when compared to supervised clinical training?
>
> 2. What are the incremental costs of the complete simulation-based ERS program when compared to the traditional apprenticeship model?
>
> 3. What is the budget impact of adopting the simulation-based ERS program in the education of EBUS operators in Denmark when compared to the traditional apprenticeship model?

Those trainees following the apprenticeship model were mentored by senior physicians, and supervised in the operating room at all times until they reached a level of independence.

Those trainees following the simulation model worked on a GI BRONCH Mentor simulator from Surgical Science, and followed the standard protocols for simulation training as set out by the European Respiratory Society (ERS). They were also mentored by supervising physicians, but were able to carry out much of their training outside of the operating room.

Comparators



FINDINGS

Two key findings were that:

> 1. When trainees are participating in EBUS procedures, the time taken in the operating room is significantly longer than when procedures are performed by experienced physicians.
>
> 2. Trainees using the simulation method required significantly fewer supervised procedures before reaching independence than those trained using the apprenticeship model.

MODEL PARAMETERS	ESTIMATES
Procedure time without trainee participation (minutes)	37.69 min
Additional procedure time with trainee participation (procedure time with trainee participation) (minutes)	+20.63 min (58.32 min)
Additional propofol used per procedure with trainee participation (mg)	41.17 mg
Number of supervised clinical procedures required to become an independent EBUS operator with the simulation-based ERS program	13
Number of supervised clinical procedures required to become an independent EBUS the traditional apprenticeship model	50

In summary, each EBUS procedure takes **20 minutes longer on average** than normal when a trainee is participating.

Trainees using the apprenticeship model required **37 extra procedures on average** to reach independence than those using simulation.

Hansen and Koldby performed 'deterministic sensitivity analysis' on these findings to identify the parameters within the data. This 'stress test' showed that the highest number of sessions required by a trainee using simulation was 19, while the lowest for an apprenticeship trainee was 40 procedures, demonstrating the clear value of simulation in helping trainees reach independence in the operating room.

GRANULARITY OF INCREMENTAL COSTS COMPARED FOR THE FIRST TIME

The value of the research carried out by Hansen and Koldby is in its level of detail. The data in the thesis has great depth and considers every conceivable incremental cost attached to both models.

For those following the simulation process, 'incremental costs' incurred that were above and beyond the standard cost of the apprenticeship model included:

- Purchase of simulation equipment (BRONCH Mentor from Surgical Science)
- Purchase of simulation accessories
- Cost of maintenance of equipment and utensils
- Cost of maintaining physical training environment
- Cost of staffing the training facilities
- Salary cost for post-graduate trainees
- Supervision costs for training on the simulator and in the operating room

On the traditional apprenticeship model, there were no incremental set up costs, but many 'hidden' costs associated with the additional time spent in the operating room under supervision.

Every time a trainee sets foot in the operating room to perform an EBUS (or any surgical procedure), the costs increase significantly due to the safety and supervision protocols required. By calculating how much extra time is spent in the operating room for these trainees, Hansen and Koldby could assess the incremental costs based on the salaries of the staff involved, and the cost of extra sedation medication required. They measured the impact of:

- Additional time in the operating room for supervising physicians outside of their regular duties
- Additional time in the operating room for nurses and other surgical staff
- Additional time in the operating room for the trainees themselves
- Extra cost of sedation (profopol) for patients undergoing longer procedures

Having established that significantly more procedures needed to be supervised for those trainees using the apprenticeship model (on average, 37 more per student), these additional operating room costs quickly accumulated.

Again, the authors applied 'deterministic sensitivity analysis' to the salary costs for all the staff involved, from physicians, to support staff, and the trainees themselves, and applied the average salaries in each case - but even applying the lowest salaries in each case resulted in significant incremental cost.

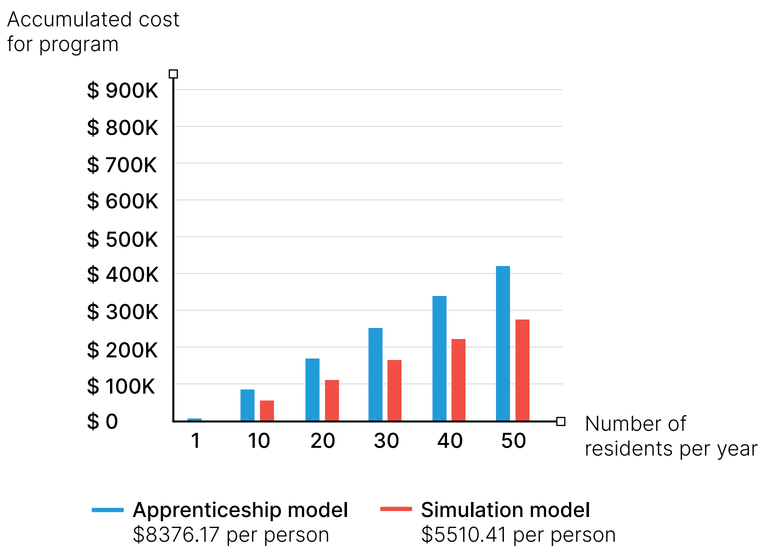
BUDGET IMPACT

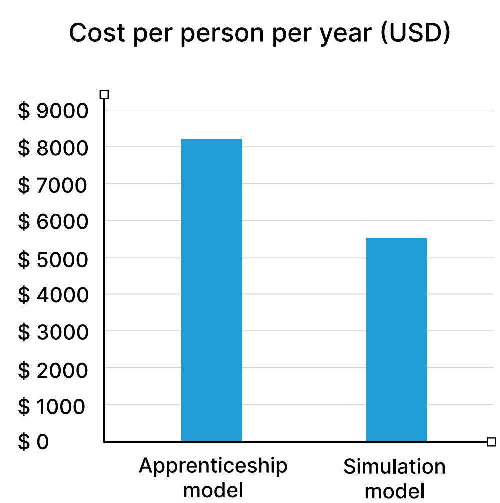
Although the set-up costs for the simulation model were significant, when looking at the five-year cycle of a trainee's development, the extra costs associated with supervision far outstripped them:

INTERVENTION	AVERAGE COST PER EDUCATED OPERATOR	PROPORTION OF ELIGIBLE POPULATION	SIZE OF ELIGIBLE POPULATION PER YEAR	ANNUAL COST OF PROGRAM
Traditional apprenticeship model	57,125 DKK	100%	4	228,502 DKK
Simulation-based ERS program	37,581 DKK	100%	4	150,324 DKK
BUDGET IMPACT (ONE YEAR)				**-78,177 DKK ($12,675)**
BUDGET IMPACT (FIVE YEARS)				**-390,877 DKK ($63,375)**

Table 20. Budget impact analysis of the simulation-based ERS program in EBUS education for a one-year and five-year time horizon.

The 'budget impact analysis' in the thesis suggests that, to train four trainees on EBUS using simulation would result in a cost-saving of **390,887 DKK (US$63,375)** over a five-year period.





Saved: $2865,76 per person, if simulation-based training is used as explained in the white paper.

Extrapolating that data across further procedures within pulmonary medicine, and taking into account the full annual intake of Danish trainees (17), the thesis suggested a total potential cost-saving of **18.3m DKK (US$2.9m) - or 215,000 DKK (US$34,000)** per trainee, per year.

Potential cost saving per program per year

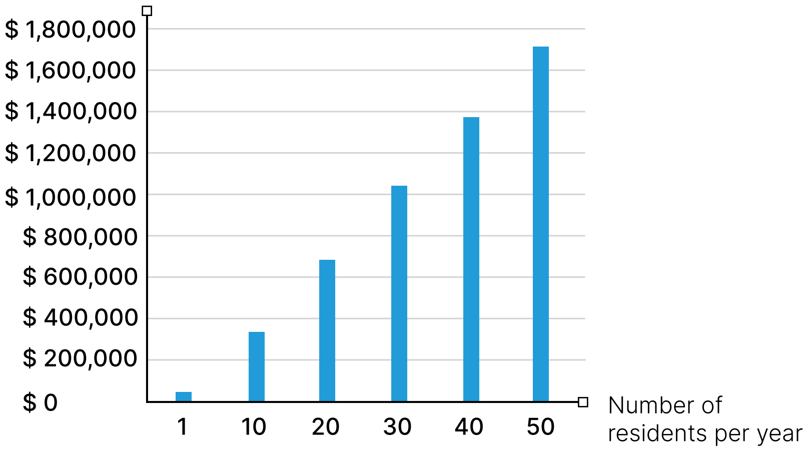


Table. Extrapolation of data from EBUS procedure to 11 technical procedures in pulmonary medicine that are identified to be suitable for simulation-based training and are expected to be mastered by future specialists in pulmonary medicine.

TIME SAVINGS ALLOW FOR GREATER PRODUCTIVITY FOR SUPERVISING PHYSICIANS

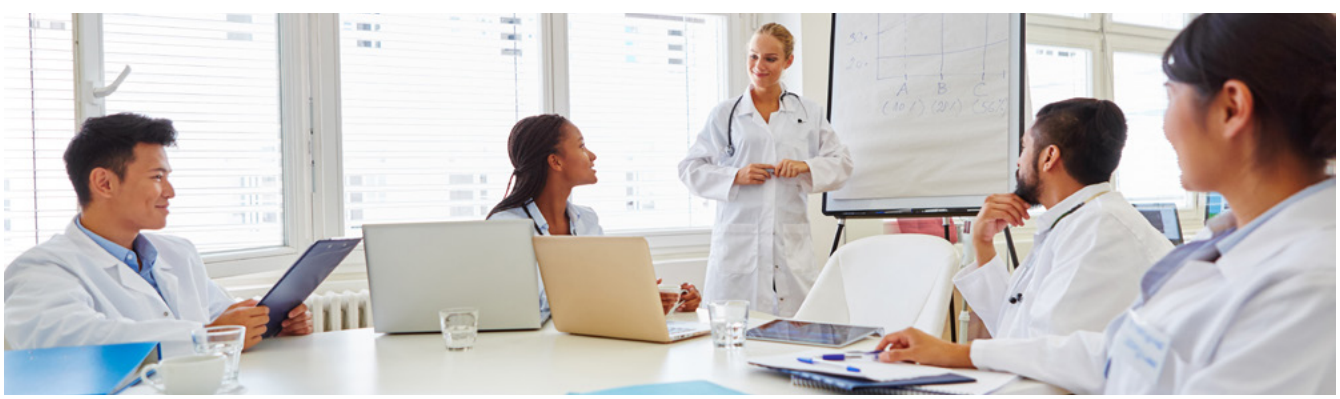
The findings of the thesis are clear: Using a simulation-based training program significantly reduces the amount of time it takes for a trainee to reach the competence threshold required to perform EBUS procedures independently.

But there are other ‘collateral benefits’ for the simulation model, too. With the time saved observing trainees, supervising physicians are able to devote more time to performing their own EBUS procedures, or other key tasks. The thesis found that simulation saved supervising physicians more than 32 hours in the operating room, per trainee, for EBUS procedures alone.

Again, extrapolating this data across the whole country, and the entire pulmonary medicine discipline, this equated to almost **6000 saved hours** - enough time for these senior physicians to perform almost 9000 extra EBUS procedures themselves.

MODEL PARAMETER	ESTIMATE (HOURS)
Time of senior physician used with the simulation-based ERS program	17
Time of senior physician used with the traditional apprenticeship model	49
SENIOR PHYSICIAN TIME SAVER PER EDUCATED EBUS OPERATOR	-32

Table 24. Senior physician time saved per educated EBUS operator



LIMITATIONS OF THE RESEARCH

Hansen and Koldby's research is extremely thorough in terms of its granularity, but it is limited to the Danish educational context, with costs calculated based on data provided by CAMES and information from Danish collective agreements.

"The analytical model used can, to some extent, be generalized to other countries by adjusting the input parameters of the model to the country of interest. Such adjustments can relate to differences in staff wages between countries, but they can also address cultural differences in the organization of the supervised clinical training and hereby in the duration of the training. Thus, by adapting the input parameters to the specific local conditions, the analytical model can be transferred to other decision contexts."

Laura Reib Hansen and Kasper Magaard Koldby

The authors also acknowledge that their research is specific to EBUS procedures, and does not address the considerable variance in the scope of training across the healthcare industry. However, they remain confident that their model demonstrates the value of simulation in any area of medicine:

"Based on a generalization of the results of the thesis, it is indicated that substantial cost-savings can be realized by adopting simulation-based training more generally in the education of healthcare professionals across different medical procedures and specialties."

Laura Reib Hansen and Kasper Magaard Koldby

CONCLUSION: DEFINITIVE PROOF IN THE COST-EFFECTIVENESS OF SIMULATION

There has never been any doubt about the benefits of using simulation in medical training in terms of improved proficiency, trainee confidence, and potentially better patient outcomes. But this paper proves conclusively that it is also significantly cheaper than traditional training methods.

The report is important for a number of reasons. It is particularly useful for those looking to demonstrate the cost-effectiveness of simulation to stakeholders with medical training facilities as it uses real, quantifiable data to move the argument away from the hypothetical and into practical scenarios.

This thesis may only provide an analytical model for the training of EBUS and other related procedures, but it has the potential to be transferred to other healthcare contexts where the apprenticeship model necessitates many supervised procedures in the operating room.

In short, it is the most comprehensive and compelling evidence that has ever been produced to support the idea that simulation within medical training can drive cost savings as well as improved performance.

“What is fantastic about this thesis is it provides clear answers to questions that have been asked for years around the true hidden costs of supervising trainees in the operating room - and the ways in which simulation can reduce these. Most people in the medical training space have always been pro-simulation, but have lacked the evidence to justify its incorporation. Now we have data that conclusively proves that simulation can actually reduce overall training costs.”

Anders Melander, Senior Director Medical Affairs,
Surgical Science

“Simulation-based training has the potential to both improve patient safety and reduce educational costs as less clinical training of inexperienced trainees is conducted on patients and the time spent with a supervising senior physician is shortened.”

Laura Reib Hansen and Kasper Magaard Koldby

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Selected bibliography:

Hansen and Koldby quote several published studies extensively throughout their master's thesis. These include works by Lars Konge at the Copenhagen Academy for Medical Education and Simulation (CAMES) - one of the foremost experts in the field of simulation in medical education.

Also referenced are three studies by David Stather et al which, among other things, provide clear evidence of the increased use of sedation medication (propofol) when trainees are performing supervised procedures in a live surgical environment.

Here is a selection of the studies cited in the thesis:

Konge, Lars, Paul Frost Clementsen, Charlotte Ringsted, Valentina Minddal, Klaus Richter Larsen, and Jouke T. Annema. 2015. "Simulator Training for Endobronchial Ultrasound: A Randomised Controlled Trial." *European Respiratory Journal*46 (4): 1140–49. https://doi.org/10.1183/13993003.02352-2015.

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Stather, David R., Paul Mac Eachern, Alex Chee, Elaine Dumoulin, and Alain Tremblay. 2012. "Evaluation of Clinical Endobronchial Ultrasound Skills Following Clinical versus Simulation Training: EBUS: Simulation versus Clinical Training." *Respirology*17 (2): 291–99. https://doi.org/10.1111/j.1440-1843.2011.02068.x.

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Stather, David Ryan, Paul Maceachern, Alex Chee, Elaine Dumoulin, and Alain Tremblay. 2013. "Trainee Impact on Advanced Diagnostic Bronchoscopy: An Analysis of 607 Consecutive Procedures in an Interventional Pulmonary Practice: Trainee Impact on Advanced Bronchoscopy." *Respirology*18 (1): 179–84. https://doi.org/10.1111/j.1440-1843.2012.02270.x.

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