

# The digital revolution – the future orthopaedic surgeon

What is AI?

Experience with AI and its correlation to our clinical world.

# Disclosures

- No financial disclosures
- Co-founder of CAAIR – Horsens. *Centre of Applied Artificial Intelligence Research.*

Special thanks to  
Simon Lauritsen, Enversion A/S  
in preparation of this talk



# Why is Jeppe giving a talk on AI? – He normally talks about hips?

- Clinical translation of AI
  - focus on the evidence-based implementation of artificial intelligence systems in clinical day-to-day routines
- Current AI collaborations on **existing** projects include University of Minnesota (US), Oravizio (Finland), Aarhus University BSS, IQVIA Denmark, Enversion A/S Denmark.
- International Network Programme framework grant by the The Danish Agency for Higher Education and Science to travel to Israel in 2022 to establish AI network with dedicated Israeli partners.
- Appointed member of the *build committee* of the Central Denmark Region's Data Science Laboratory
- + 5.5 mio. DKK AI related funding

# Why is Jeppe giving a talk on AI? – He normally talks about hips?

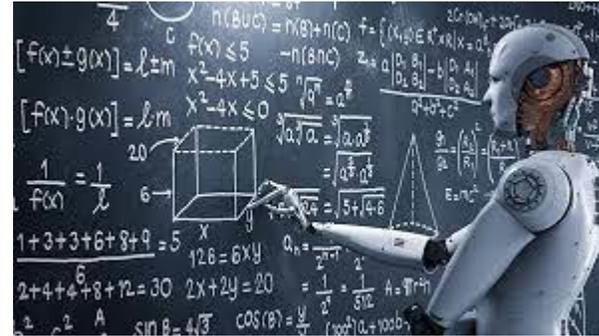
Main supervisor of Industrial-PhD student Simon Lauritzen

Lauritsen SM, Kalør ME, Kongsgaard EL, Lauritsen KM, Jørgensen MJ, **Lange J**, Thiesson B. Early detection of sepsis utilizing deep learning on electronic health record event sequences. Artif Intell Med. 2020

Lauritsen SM, Thiesson B, Jørgensen MJ, Riis AH, Espelund US, Weile JB, **Lange J**. The Framing of machine learning risk prediction models illustrated by evaluation of sepsis in general wards. NPJ Digit Med. 2021

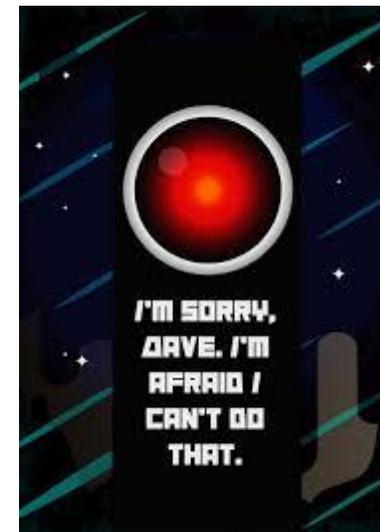
Lauritsen SM, Kristensen M, Olsen MV, Larsen MS, Lauritsen KM, Jørgensen MJ, **Lange J**, Thiesson B. Explainable artificial intelligence model to predict acute critical illness from electronic health records. Nat Commun. 2020

# What is AI?



Artificial intelligence (AI) is intelligence demonstrated by machines, as opposed to **natural intelligence** displayed by animals including humans.

[https://en.wikipedia.org/wiki/Artificial\\_intelligence](https://en.wikipedia.org/wiki/Artificial_intelligence)



# What is AI?

In 1950, Alan Turing discussed how to build intelligent machines and test this intelligence in his paper "[Computing Machinery and Intelligence](#)".



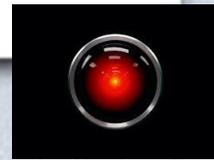
Media saying AI will take over the world



My Neural Network



AI will take over soon



- Rosen CA. Pattern classification by adaptive machines. Science. 1967:

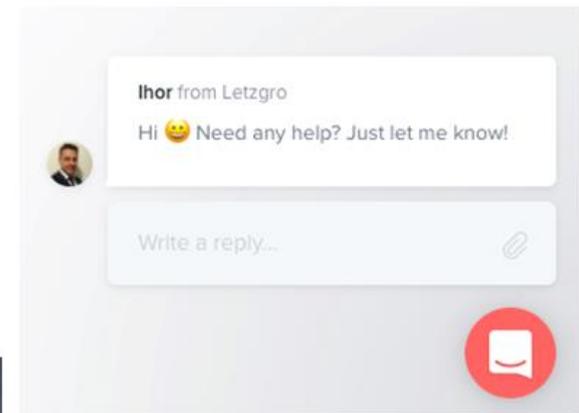
Man's intelligent behavior is due in part to his ability to select, classify, and abstract significant information reaching him from his environment by way of his senses.

This function, pattern recognition, has become a major focus of research by scientists working in the field of artificial intelligence.

# What is AI?



Jyðst medi  
jysk medier  
jydsk medicinsk selskab  
jysk medicinskab  
jysk medias



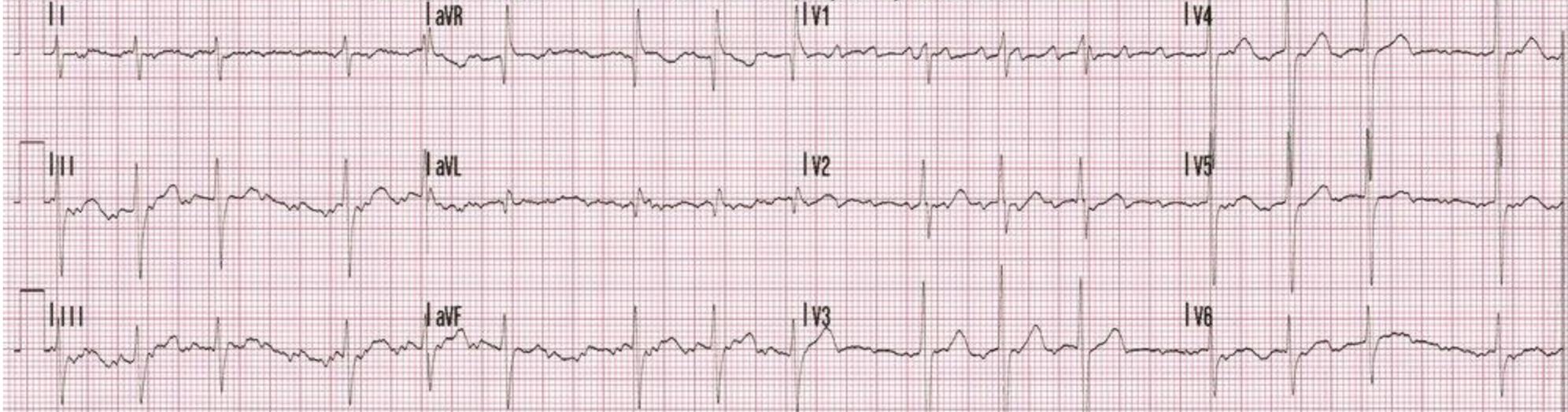
Navn:  
Journal-id:  
Patient-id:  
Køndelse:  
Alder: 81

120220160554

12-afledning 1  
02 Dec. 20  
PR 0.222s  
QT/QTc  
Kon: K P-QRS-T-akser

HF 93 bpm  
16:28:22  
QRS 0.104s  
0.340s/0.397s  
159° -119° 101°

Abnormt EKG **\*\*Ubekræftet\*\***  
• Muligvis atrieflagren  
• Venstresidig aksedeviation  
• Septal og lateral ST-T-abnormalitet kan skyldes myokardieiskæmi



x1,0 0,05-40Hz 25mm/sek.

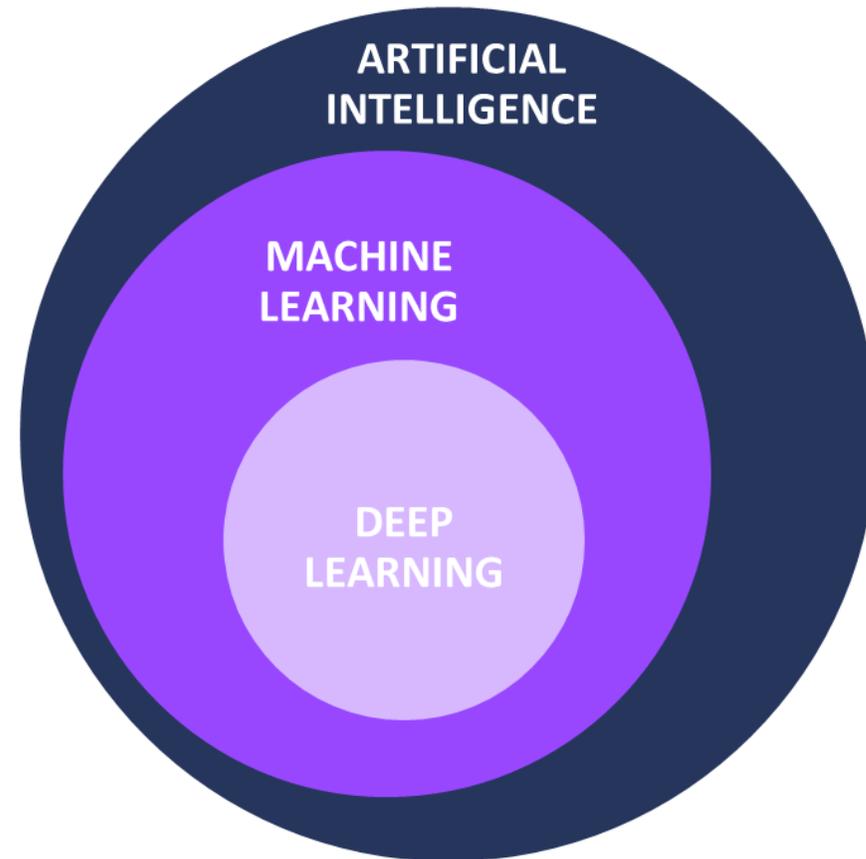
21215059 3160 3313494-010 0LH55R048AB90P LP1542812478

# What is AI (in health care)?



# What is AI?

I am an orthopaedic surgeon –  
Not a data engineer  
Or data scientist  
Or computer wizard....



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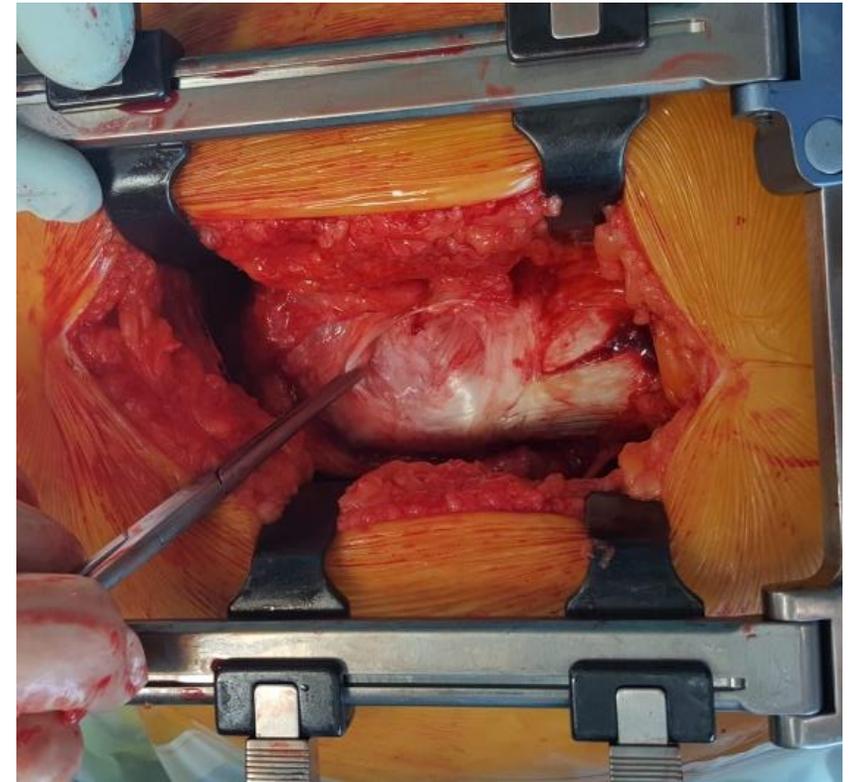
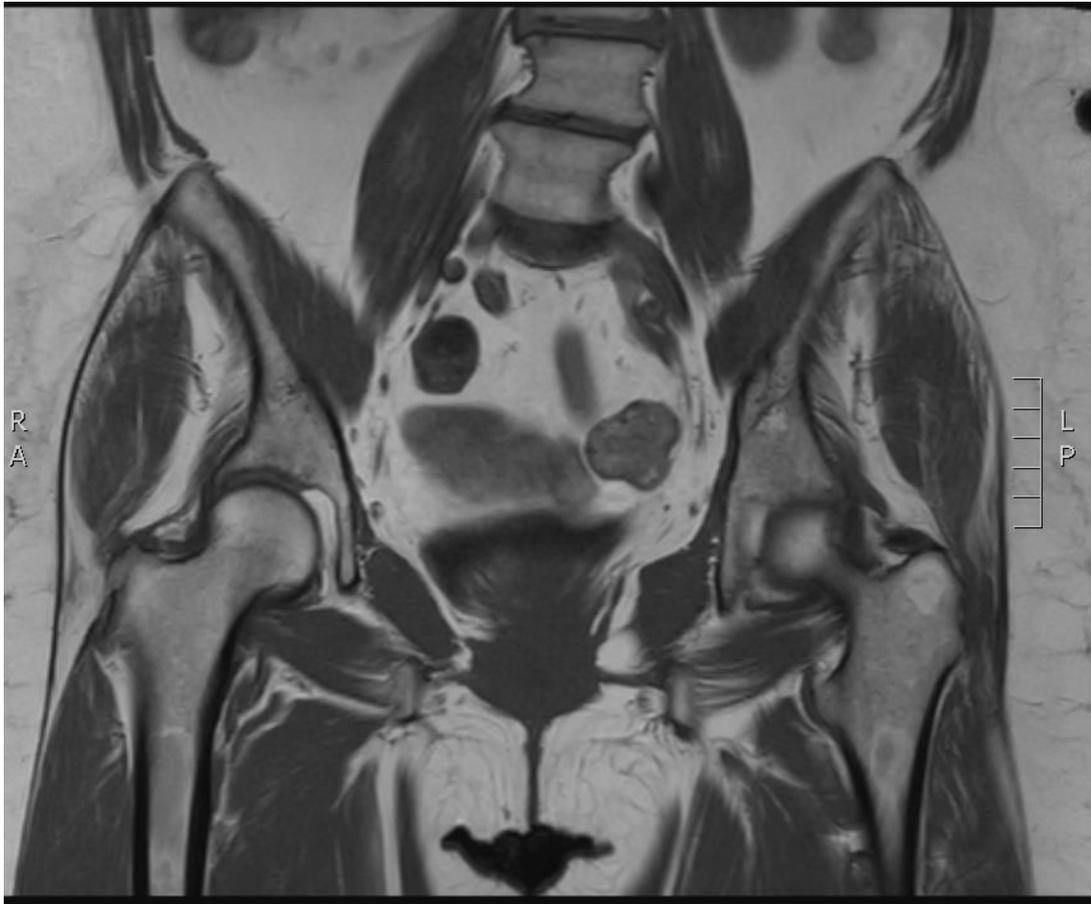
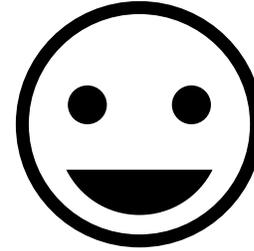
**Prediction module.** The AI-EWS model is designed as a variation of a convolutional neural network (CNN) called a temporal convolutional network (TCN). CNNs have dominated computer vision tasks for the last century and are also highly capable of performing sequential tasks, such as text analysis and machine translation<sup>41</sup>. A TCN<sup>23,24</sup> models the joint probability distribution over sequences by decomposing the distribution over discrete time-steps

$p_{\theta}(x) = \prod_{t=1}^T p_{\theta}(x_t | x_{1:t-1})$ , where  $x = \{x_1, x_2, \dots, x_T\}$  is a sequence, and the joint distribution is parameterized by the TCN parameter  $\theta$ . Thus, a TCN operates under the autoregressive premise that only past values affect the current or future values, e.g., if a patient will develop acute critical illness. Moreover, TCNs differ from “ordinary” CNNs by at least one property: the convolutions in TCNs are causal in the sense that a convolution filter at time  $t$  is only dependent on the inputs that are no later than  $t$ , wherein the input subsequence is  $x_1, x_2, \dots, x_t$ . TCNs can take a sequence of any length as input and output a sequence of the same length, similar to RNNs<sup>22,28</sup>. The TCN achieves this by increasing the receptive field of the model with dilated convolutions instead of performing the traditional max pooling operation, as seen in most CNNs. Dilated convolutions achieve a larger receptive field with fewer parameters by having an exponential stride compared to the traditional linear stride. By increasing the receptive field, a temporal hierarchy comparable to multi-scale analysis from computer vision can be achieved<sup>42</sup>. Figure 6 schematizes the xAI-EWS model and the concept of dilated convolutions. At the time of prediction, the xAI-EWS model receives an input matrix of shape time-steps  $\times$  features for each patient.

# What is AI?



# What is AI?

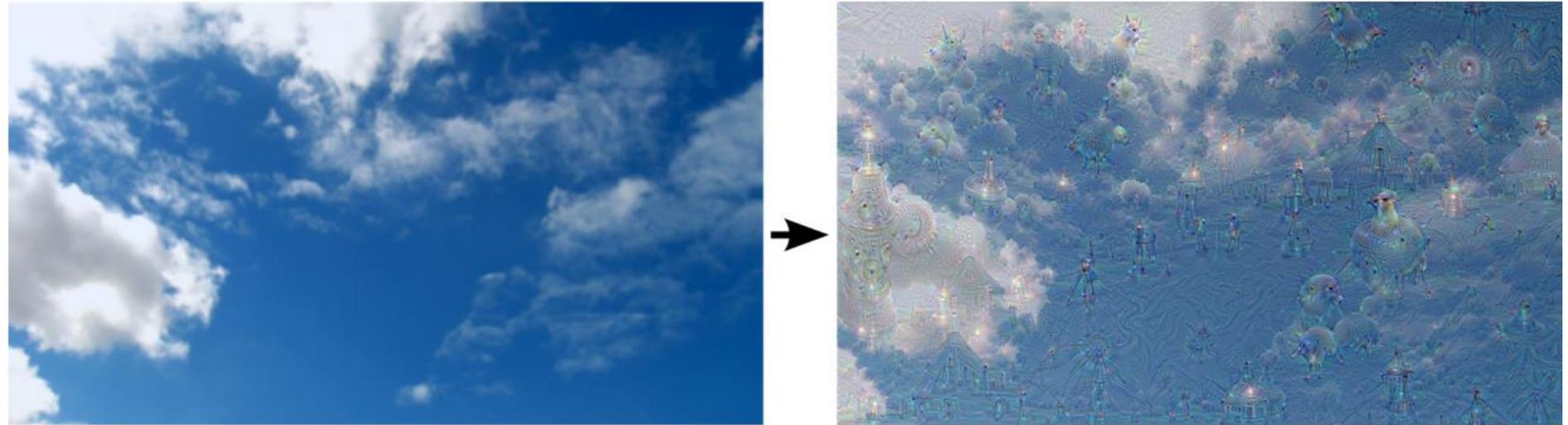


## Experience with AI and its correlation to our clinical ORTHOPEADIC world.

- Automatic processing of "dead" medical data (primarily medical images)
- Predictions of diagnosis or medical events to happen & treatment suggestions based on "living" medical data (EHR, PROM etc)
- Organizational AI modelling, such as number of patients needing surgery

Did not include robotics in this presentation

# Experience with AI



"Admiral Dog!"



"The Pig-Snail"



"The Camel-Bird"



"The Dog-Fish"

# Experience with AI



# Experience with AI

- ...as AI uses data created by people as a starting point, it also inherits human flaws such as **bias based on age, gender or race**. For example, a program will often translate the English term 'nurse' using a female-gendered word, and render 'doctor' as a male noun. **This bias in AI has the potential to widen the gender gap, and even endanger women's lives.**

<https://www.consilium.europa.eu/da/documents-publications/library/library-blog/posts/gender-bias-in-artificial-intelligence/#>

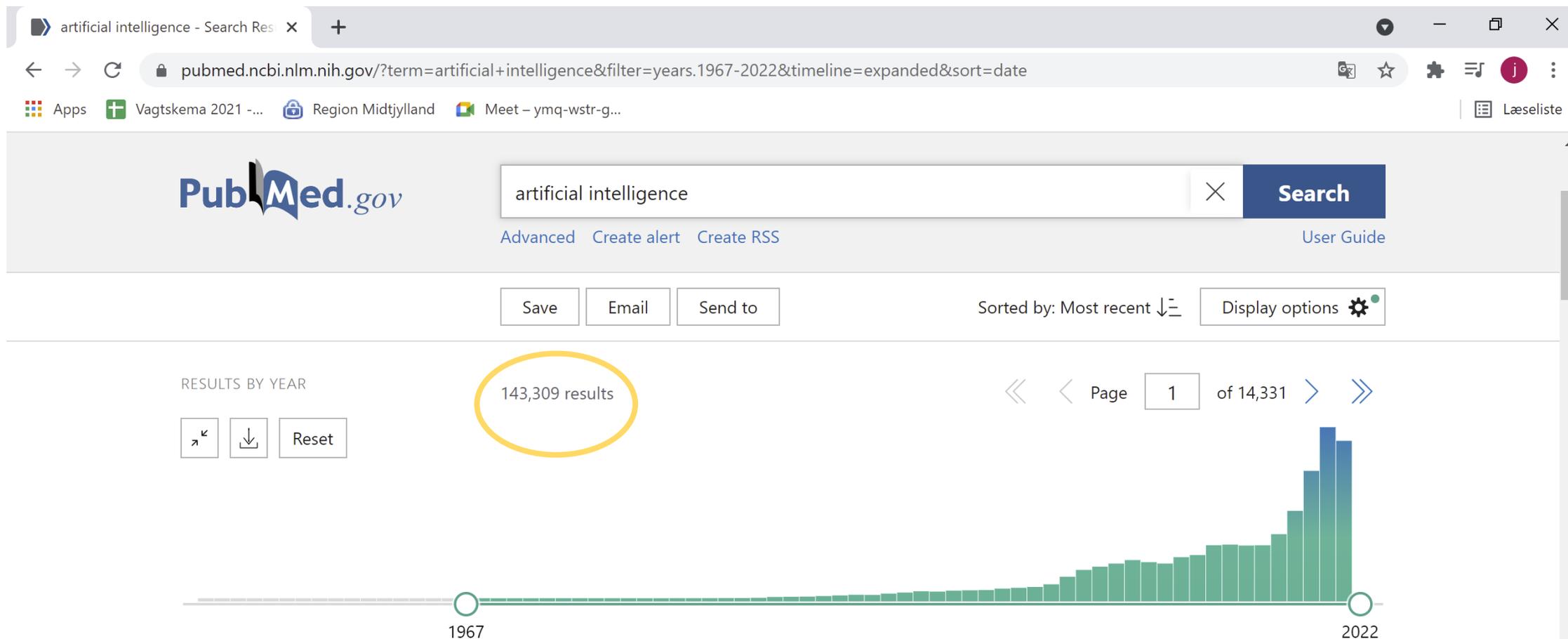
# Experience with AI

Clinical Translation

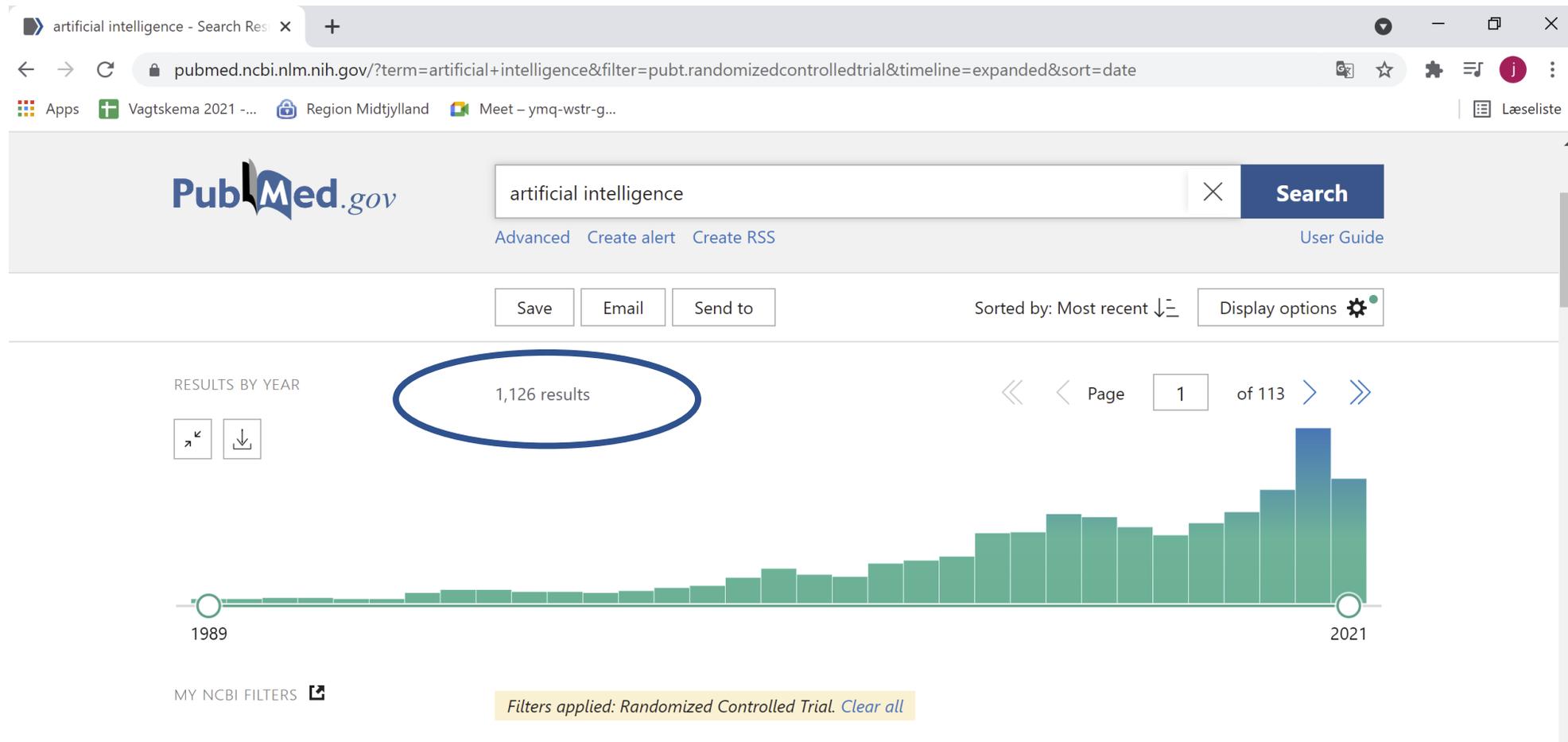


- Causalitet vs. association

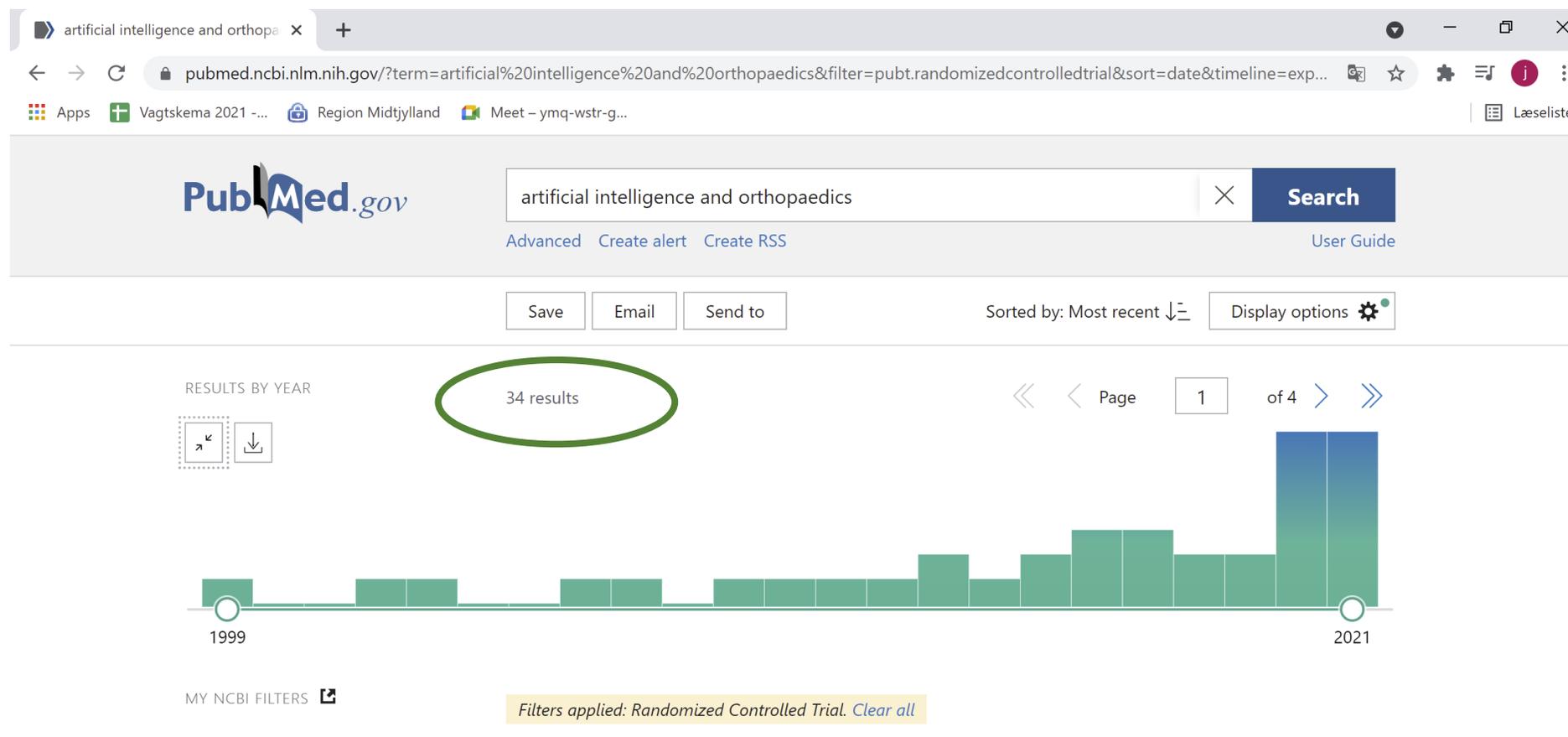
# correlation to our clinical ORTHOPEADIC world.



# correlation to our clinical ORTHOPEADIC world.



# correlation to our clinical ORTHOPEADIC world.



correlation to our clinical ORTHOPEADIC world.

**Of +140.000 medical articles ONLY 2(!) are ortopedic RCT's utilizing AI.**

- Jayakumar P et al.
  - Comparison of an Artificial Intelligence-Enabled Patient Decision Aid vs Educational Material on Decision Quality, Shared Decision-Making, Patient Experience, and Functional Outcomes in Adults With Knee Osteoarthritis: A Randomized Clinical Trial.
  - JAMA Netw Open. 2021 Feb 1;4(2):e2037107
- Anthony CA et al.
  - Acceptance and Commitment Therapy Delivered via a Mobile Phone Messaging Robot to Decrease Postoperative Opioid Use in Patients With Orthopedic Trauma: Randomized Controlled Trial.
  - J Med Internet Res. 2020 Jul 29;22(7):e17750.

correlation to our clinical ORTHOPEADIC world.

**Be sceptical, but not cynical..... AI is feasible and can change our orthopaedic world to the better. BUT REMEMBER stepwise introduction ad modum Malchau**

- AI research demands
  - Large multisectorial and technical groups – this is not a one-man-show!
  - Time – making an ML model is "easy" (can be done in free statistical software "R").  
Bridging the deployment gap is strenuous!

All literature to begin with:

- Perspectives: A surgeon's guide to machine learning  
International Journal of Surgery 94 (2021) 106133
- Artificial intelligence in orthopaedics: false hope or not? A narrative review along the line of Gartner's hype cycle *EFORT Open Rev* 2020;5:593-603.
- Prediction models for diagnosis and prognosis of covid-19: systematic review and critical appraisal *BMJ* 2020; 369:m1328
- Artificial Intelligence for the Orthopaedic Surgeon: An Overview of Potential Benefits, Limitations, and Clinical Applications *J Am Acad Orthop Surg* 2021;29:235-243
- CORR Synthesis: When Should the Orthopaedic Surgeon Use Artificial Intelligence, Machine Learning, and Deep Learning? *Clin Orthop Relat Res* (2021) 479:1497-1505
- Machine learning in orthopaedic surgery. *World J Orthop* 2021; 12(9): 685-699

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Thank you for your attention

