Benchmarking predicting tools for falls in older adults

ITU/PAHO Webinar - Decade of healthy aging: role of digital technologies
Session 1: Healthy Aging in the Digital Age

Pierpaolo Palumbo
University of Bologna
TG Falls – ITU/WHO FGAI4H

Overview

Falls and fall prevention

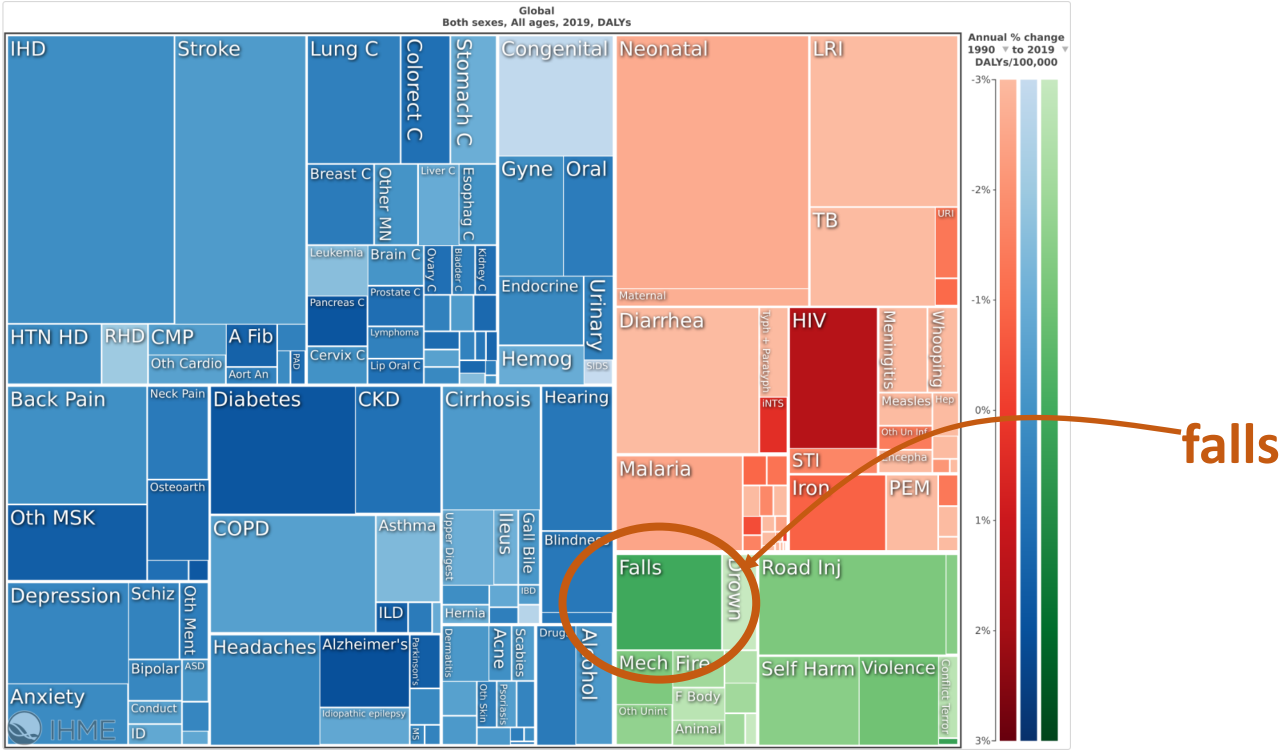
Fall prediction tools

ITU/WHO FGAI4H

Systematic review and IPD meta-analysis

Falls and fall prevention

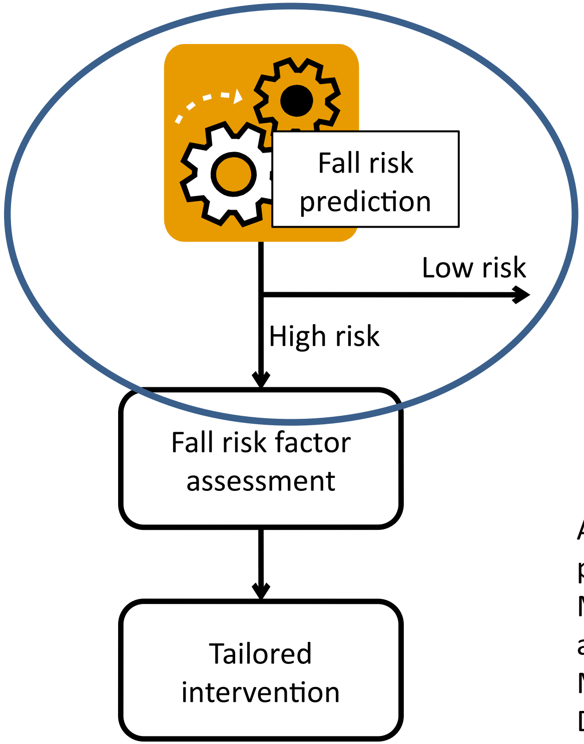
- About 30% older individuals fall at least once a year
- Falls occur as the consequence of multiple risk factors
- Falls may cause fear of falling, physical injuries, loss of independence, hospitalizations, death. About 10% falls require medical attention.
- Falls are preventable (RR ≈0.7-0.8)



Institute for Health Metrics and Evaluation (IHME). GBD Compare Data Visualization. Seattle, WA: IHME, University of Washington, 2020. Available from http://vizhub.healthdata.org/gbd-compare.

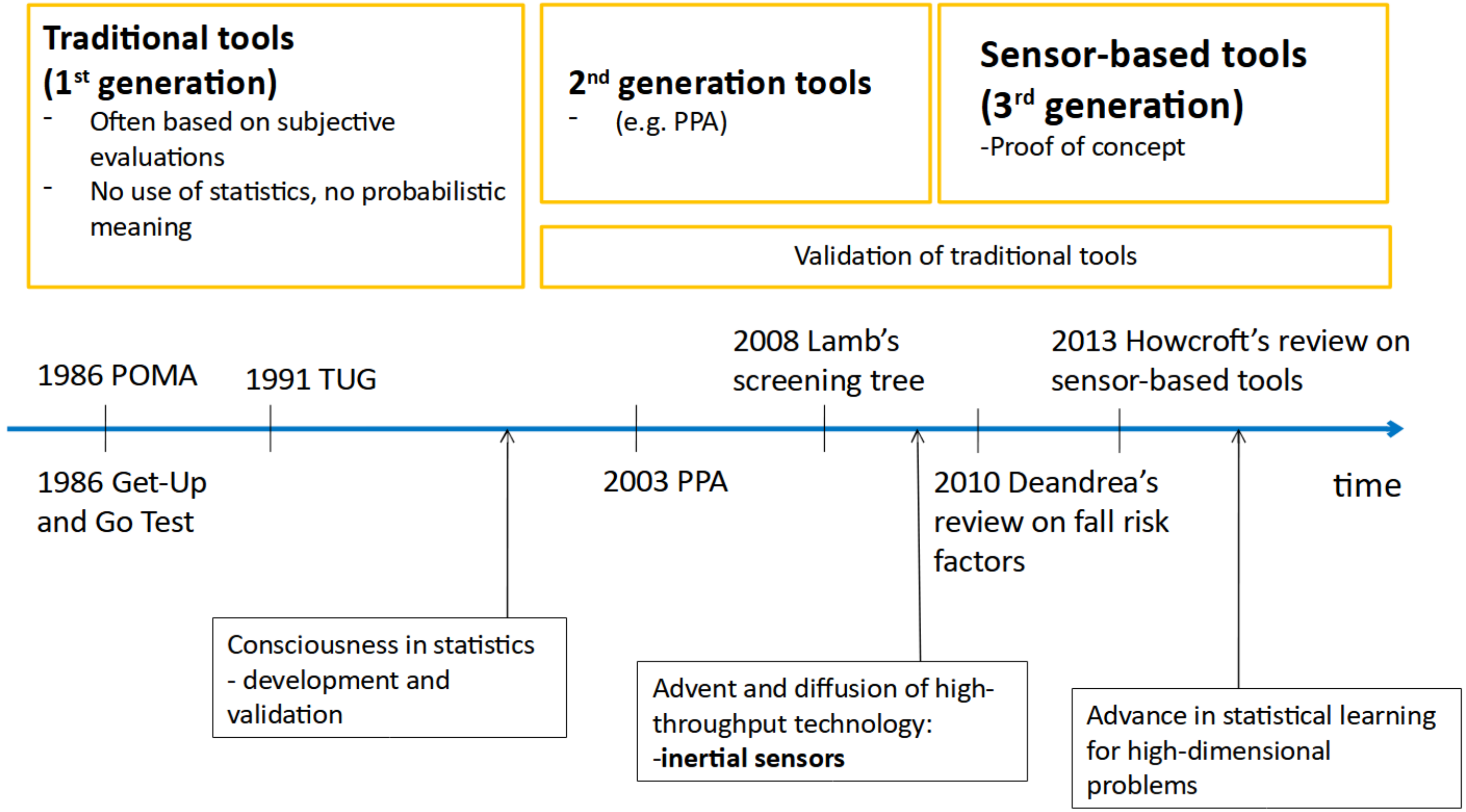
Falls and fall prevention

- About 30% older individuals fall at least once a year
- Falls occur as the consequence of multiple risk factors
- Falls may cause fear of falling, physical injuries, loss of independence, hospitalizations, death. About 10% falls require medical attention.
- Falls are preventable (RR ≈0.7-0.8)
- **Fall prediction tools** are recommended for identifying high risk individuals to target with preventive interventions



AGS/BGS Guidelines clinical practice guideline for prevention of falls in older persons 2011
M. Montero-Odasso, Global guidelines for falls in older adults. Age Ageing, 2022
M.E. Tinetti. NEJM 2003
D.A. Ganz et al. JAMA 2007

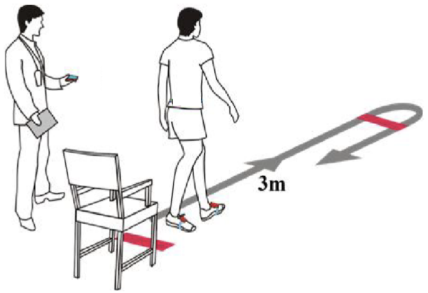
Fall prediction tools



Fall prediction tools

Traditional tools

Timed Up and Go test (TUG)

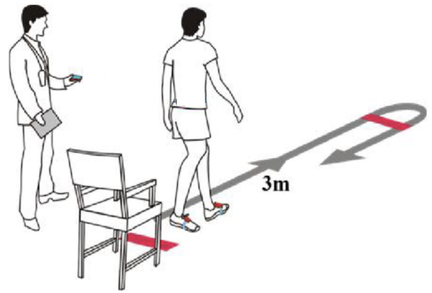


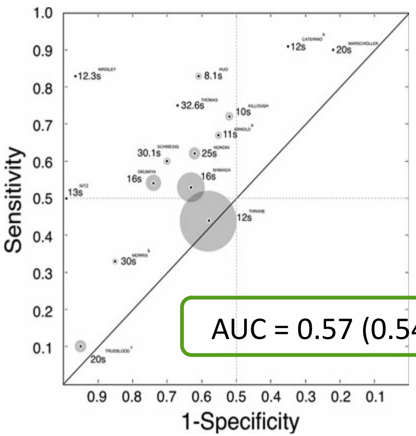
D. Podsiadlo, S. Richardson. J Am Geriatr Soc., 1991

Fall prediction tools

Traditional tools

Timed Up and Go test (TUG)





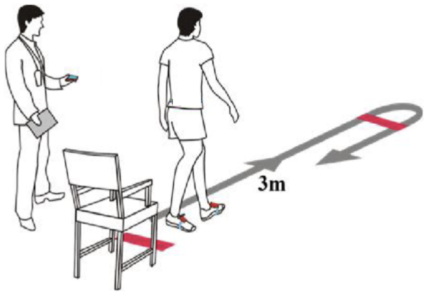
AUC = 0.57 (0.54-0.59)

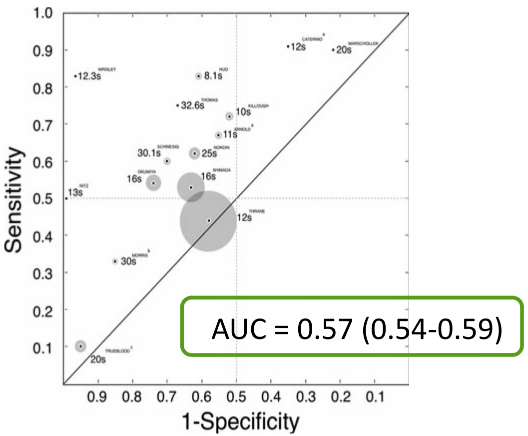
D. Podsiadlo, S. Richardson. J Am Geriatr Soc., 1991
D. Schoene et al., J. Am. Geriatr. Soc., 2013
E. Barry et al., BMC Geriatr., 2014

Fall prediction tools

Traditional tools

Timed Up and Go test (TUG)

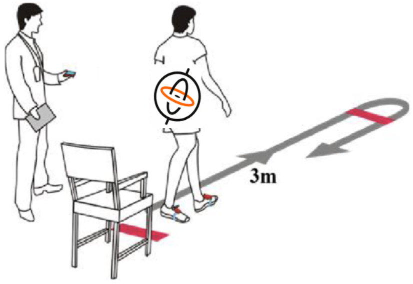




D. Podsiadlo, S. Richardson. J Am Geriatr Soc., 1991
D. Schoene et al., J. Am. Geriatr. Soc., 2013
E. Barry et al., BMC Geriatr., 2014

Sensor-based tools

Instrumented TUG



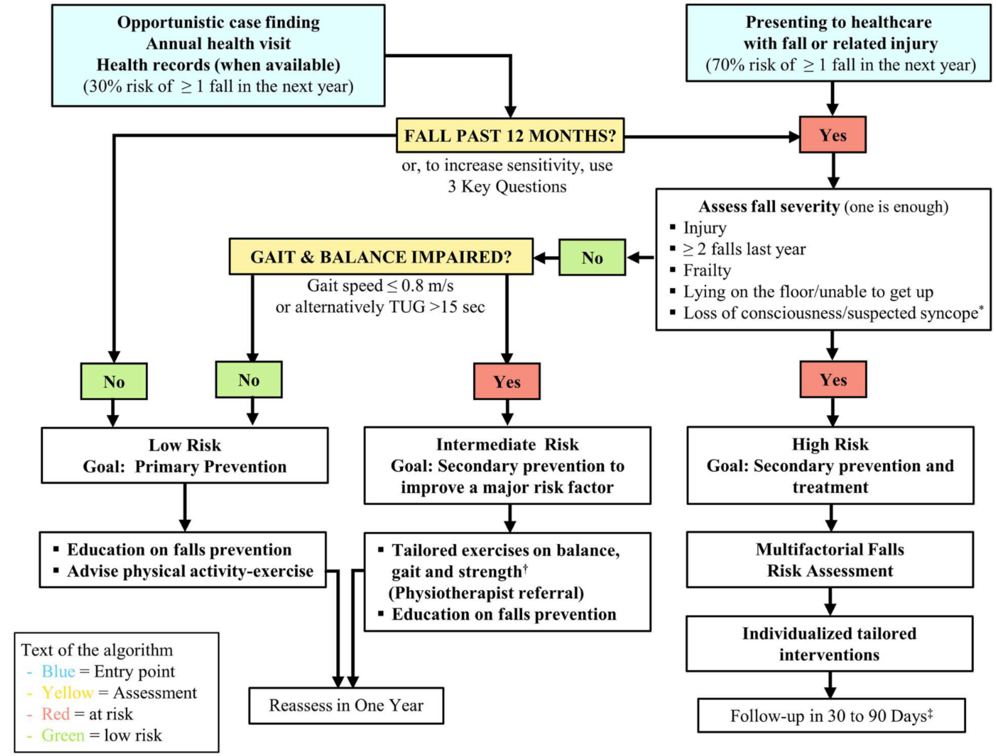
ASSOCIATION TREND AND STRENGTH FOR ALL POSSIBLE TRIADS OF FEATURE CATEGORY, TASK AND SENSOR PLACEMENT

Feature category	Quiet standing	SS	TUG	Walking	Sensor placement
Angular velocity	-	-	-	↓	Lower back
	-	-	-	↑↑	Shins
	-	-	-	-	Upper back
Frequency	-	-	-	↑	Lower back
	-	-	-	↓	Shins
	-	-	-	↑	Upper back
Linear acceleration	↑↑	↑↑	-	-	Lower back
	-	-	-	↓	Shins
	-	-	-	-	Upper back
Spatial	-	-	-	-	Lower back
	-	-	-	-	Shins
	-	-	-	-	Upper back
Temporal	-	-	-	-	Lower back
	-	-	↑	-	Shins
	-	-	-	-	Upper back

SS: Sit-to-Stand / Stand-to-Sit; TUG: Timed Up and Go test

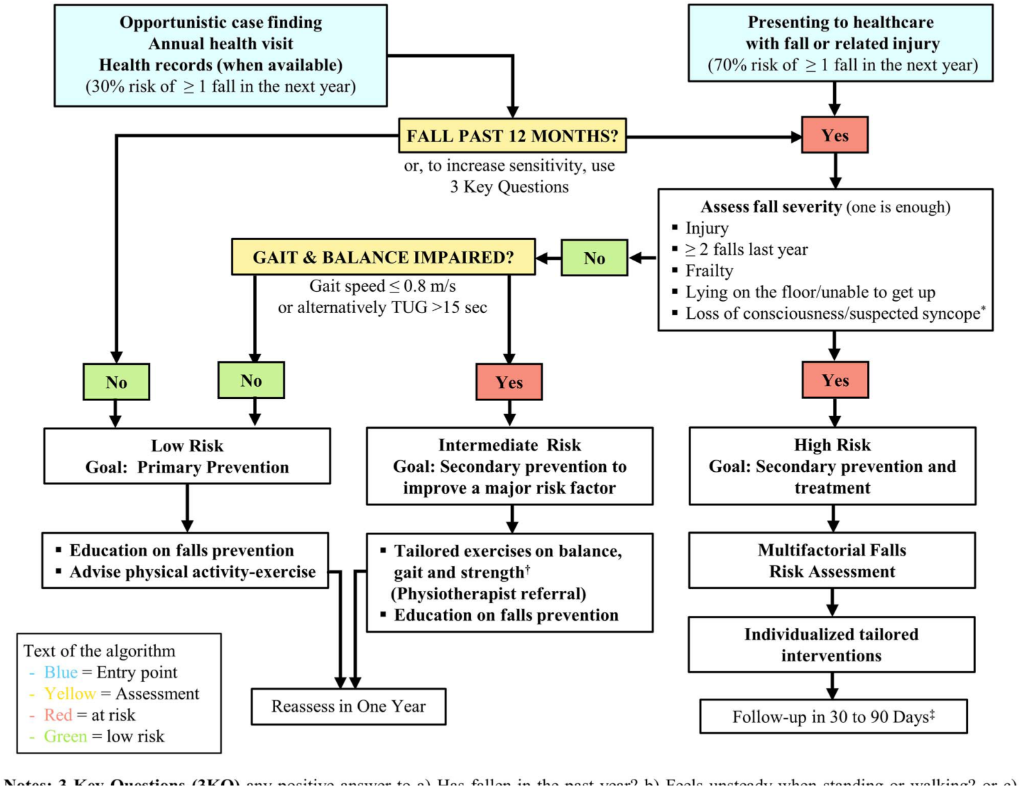
L. Montesinos, R. Castaldo, L. Pecchia. IEEE Trans Neural Syst Rehabil Eng., 2018

Fall prediction tools



M. Montero-Odasso, Global guidelines for falls in older adults. Age Ageing, 2022

Fall prediction tools



- Not trained on data
- Need for validation
- Advocacy for multifactorial models
- Need to address the usability-performance trade-off
- Advantages of a continuous risk score
- EHRs and wearable inertial sensor data
- Need to estimate the clinical and organizational impact

M. Montero-Odasso, Global guidelines for falls in older adults. Age Ageing, 2022
TG Falls ITU/WHO AI4H, Age Ageing, *accepted*

ITU/WHO Focus Group on "Artificial Intelligence for Health"

To establish a standardized assessment framework for the evaluation of AI-based methods for health, diagnosis, triage or treatment decisions

July 2018 – September 2023

AI for Health
An ITU Focus Group
In collaboration with WHO

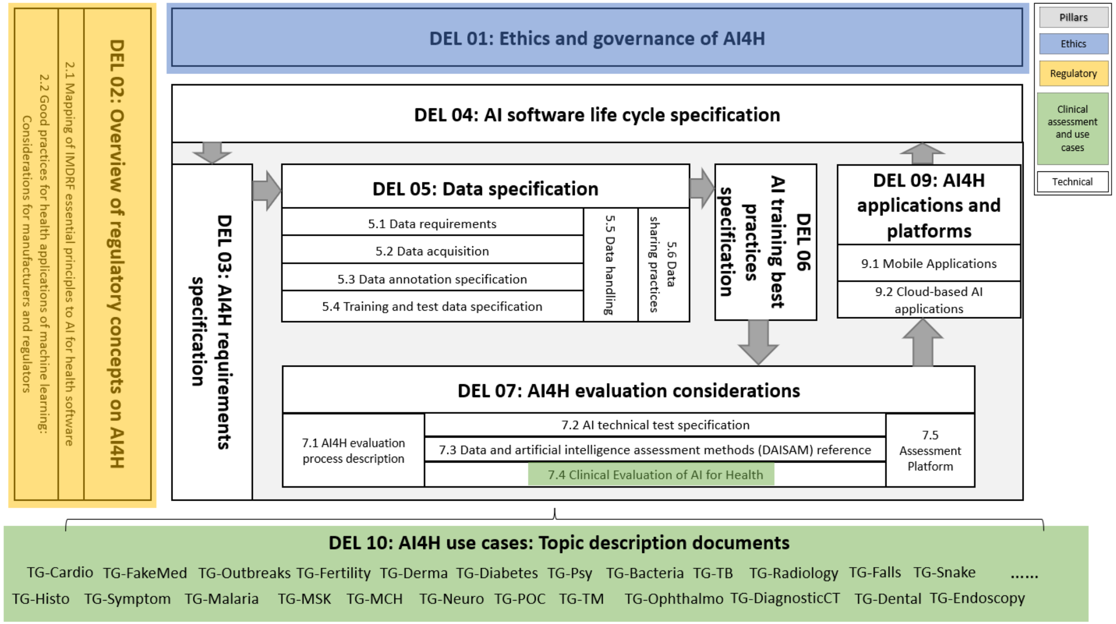
https://www.itu.int/en/ITU-T/focusgroups/ai4h/

Wiegand T, et al. WHO and ITU establish benchmarking process for artificial intelligence in health. Lancet. 2019

ITU/WHO Focus Group on "Artificial Intelligence for Health"

To establish a standardized assessment framework for the evaluation of AI-based methods for health, diagnosis, triage or treatment decisions

July 2018 – September 2023



AI for Health
An ITU Focus Group
In collaboration with WHO

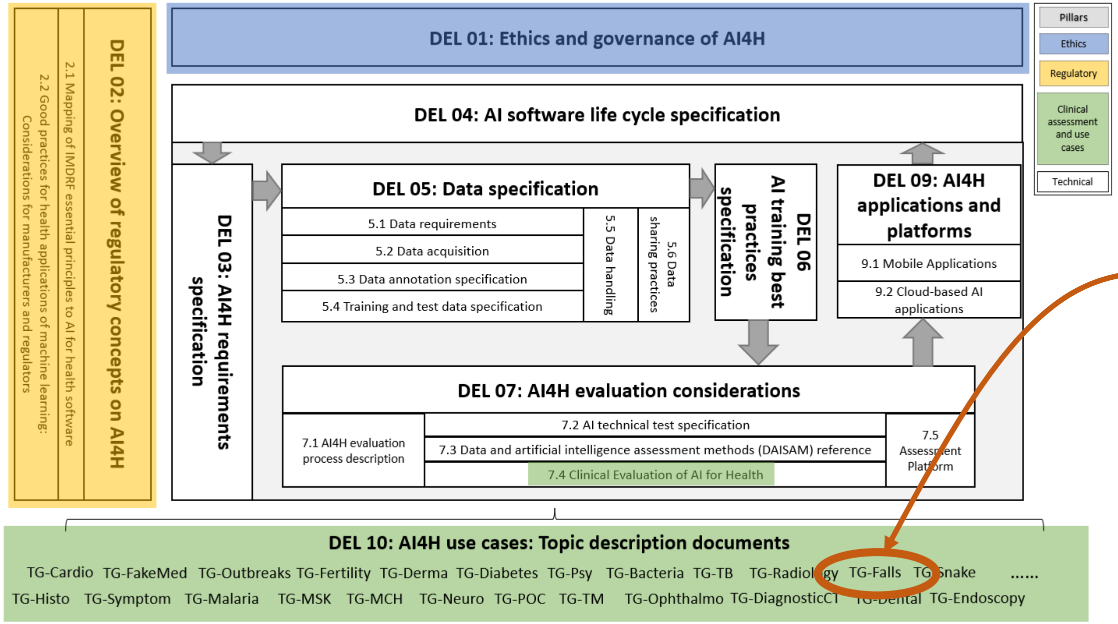
https://www.itu.int/en/ITU-T/focusgroups/ai4h/

Wiegand T, et al. WHO and ITU establish benchmarking process for artificial intelligence in health. Lancet. 2019

ITU/WHO Focus Group on "Artificial Intelligence for Health"

To establish a standardized assessment framework for the evaluation of AI-based methods for health, diagnosis, triage or treatment decisions

July 2018 – September 2023



AI for Health
An ITU Focus Group
In collaboration with WHO

https://www.itu.int/en/ITU-T/focusgroups/ai4h/

Wiegand T, et al. WHO and ITU establish benchmarking process for artificial intelligence in health. Lancet. 2019

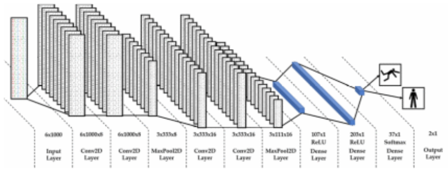
ITU/WHO Focus Group on "Artificial Intelligence for Health"

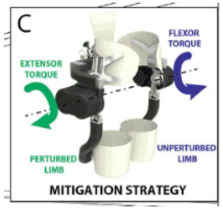
AI systems evaluation frameworks

ALTAI
TEHAI
Park et al. 2020
SPIRIT-AI
CONSORT-AI
PROBAST
TRIPOD
MI-CLAIM
STARD-AI
IJMEDI checklist
GRASP
...

- Intended use and benefits
- Data validity
- Algorithmic validity
- Clinical validity
- Safety
- Ethical validity
- Regulatory validity

AI SYSTEMS FOR FALLS





Pre-development | Development | Implementation | Post-implementation

Images from: F. Buisseret et al., "Timed Up and Go and Six-Minute Walking Tests with Wearable Inertial Sensor: One Step Further for the Prediction of the Risk of Fall in Elderly Nursing Home People," Sensors (Basel)., vol. 20, no. 11, pp. 1–15, Jun. 2020 and V. Monaco et al., "An ecologically-controlled exoskeleton can improve balance recovery after slippage," Sci. Rep., vol. 7, p. 46721, May 2017.

ITU/WHO Focus Group on "Artificial Intelligence for Health"

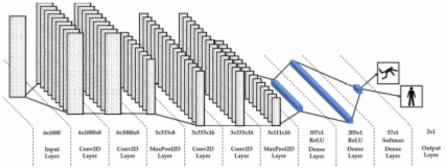
AI systems evaluation frameworks

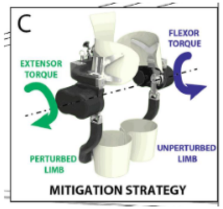
ALTAI
TEHAI
Park et al. 2020
SPIRIT-AI
CONSORT-AI
PROBAST
TRIPOD
MI-CLAIM
STARD-AI
IJMEDI checklist
GRASP
...

- Intended use and benefits
- Data validity
- Algorithmic validity
- Clinical validity
- Safety
- Ethical validity
- Regulatory validity

AI SYSTEMS FOR FALLS

Wearable sensor-based fall prediction tools. Systematic review and IPD meta-analysis





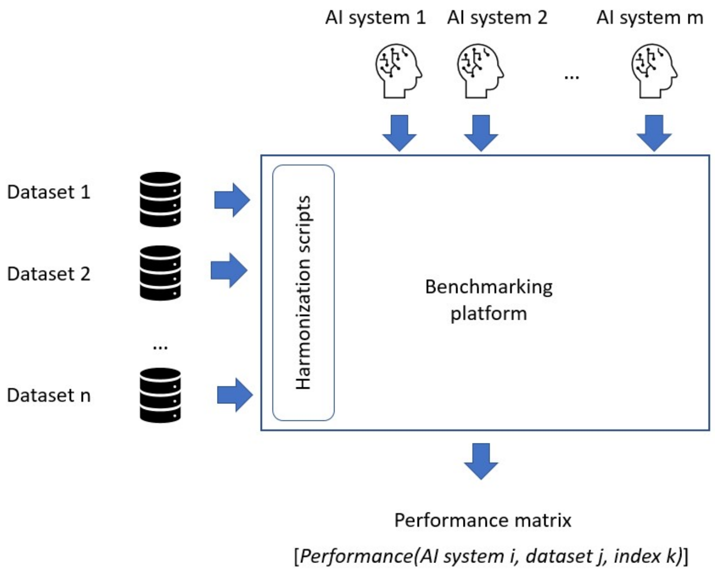
Pre-development | Development | Implementation | Post-implementation

Images from: F. Buisseret et al., "Timed Up and Go and Six-Minute Walking Tests with Wearable Inertial Sensor: One Step Further for the Prediction of the Risk of Fall in Elderly Nursing Home People," Sensors (Basel)., vol. 20, no. 11, pp. 1–15, Jun. 2020 and V. Monaco et al., "An ecologically-controlled exoskeleton can improve balance recovery after slippage," Sci. Rep., vol. 7, p. 46721, May 2017.

Systematic review and IPD meta-analysis

Review title:
"Systematic review and individual participant data meta-analysis of publicly available datasets for wearable inertial sensor-based fall risk assessment"

Aim/question:
- Which datasets are available for training and validating models for wearable inertial sensor-based fall risk assessment? *
- What is the prognostic value for falls of features and models derived from wearable inertial sensors?



* Khan, S. M. *et al.* A global review of publicly available datasets for ophthalmological imaging: barriers to access, usability, and generalisability. *Lancet Digit. Heal.* **3**, e51–e66 (2021).

Systematic review and IPD meta-analysis

Inclusion criteria:
Peer-reviewed articles/conference proceedings in English including datasets with the following characteristics:

- Datasets including at least 20 individuals
- Datasets where the predicting features comprised of at least one inertial sensor-based feature
- Datasets from any community-dwelling population
- Datasets with individual-level (not aggregated) information about falls*
- Falls collected after the predicting features (prospective design) #

* occurrence of at least one fall in a given time period OR number of falls OR date of first fall occurrence
# retrospective studies included only for sensitivity analyses

Review on datasets for wearable inertial sensor-based fall prediction

↓

Analyses on the pooled dataset

Registration: PROSPERO 2022 CRD42022367394
https://www.crd.york.ac.uk/prospero/display_record.php?RecordID=367394

PROSPERO
International prospective register of systematic reviews

Systematic review and IPD meta-analysis

Features to extract [1]:

- Study population
  - Sampled population
  - Sample size
  - Geographic location
- Study design
  - Clinical features for fall prediction
  - Characteristics of inertial sensors (acc., acc. + gyro, etc.)
  - Protocol for inertial sensor assessment (sensor location, standardized task/free living)
- Outcome measures
  - Fall definition
  - Protocol for collecting fall information (fall diaries, phone calls, etc.)
- Dataset accessibility (open access, open access with barriers, regulated access, not accessible)

Quality assessment:

- PROBAST (Prediction model Risk Of Bias ASsessment Tool) [2]
- Risk of bias, applicability
- Participants, predictors, outcome, ~~analysis~~
- 11 + ~~9~~ signalling questions

[1] Moons KGM et al. Critical appraisal and data extraction for systematic reviews of prediction modelling studies: the CHARMS checklist. PLoS Med. 2014 Oct ;11(10):e1001744.
[2] Wolff RF et al. PROBAST: A tool to assess the risk of bias and applicability of prediction model studies. Ann Intern Med. 2019 Jan 1;170(1):51–8.

Systematic review and IPD meta-analysis

Access request:
- Email
- Form: rationale, data management, authorship policy [1]

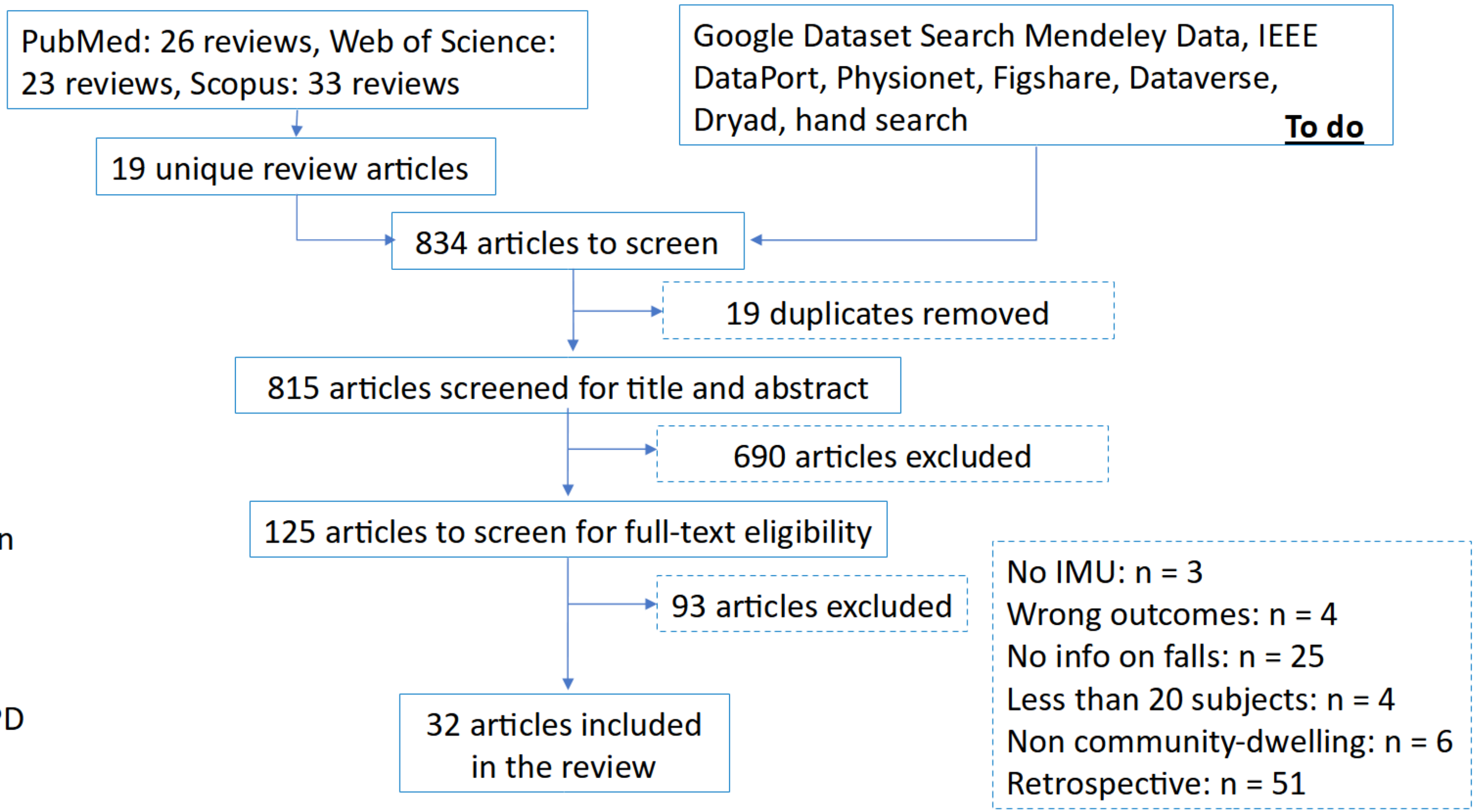
Meta-analysis:
- Data storage facility: secure, large
- Three data sharing (DS) possibilities
  - DS1: sharing dataset, including raw sensor data, into a secure centralised repository. one-stage IPD meta-analysis
  - DS2: To run the signal processing scripts prepared by the TG-Falls at their own premises and share data on digital biomarkers and falls at individual level
  - DS3: To run at their own premises the processing scripts prepared by the TG-Falls for calculating the digital biomarkers and their association with falls, and share the final association/performance measures (e.g., odds ratios, AUC).
- Univariate analysis: i) ORs, RaRs, and HRs, ii) Mixed-effect logistic regressions
- Multivariate model [2]

One-stage meta-analysis

Two-stage meta-analysis

[1] https://www.icmje.org/recommendations/browse/roles-and-responsibilities/defining-the-role-of-authors-and-contributors.html
[2] Ahmed I, Debray TPA, Moons KGM, Riley RD. Developing and validating risk prediction models in an individual participant data meta-analysis. BMC Med Res Methodol. 2014;14(3).

Systematic review and IPD meta-analysis



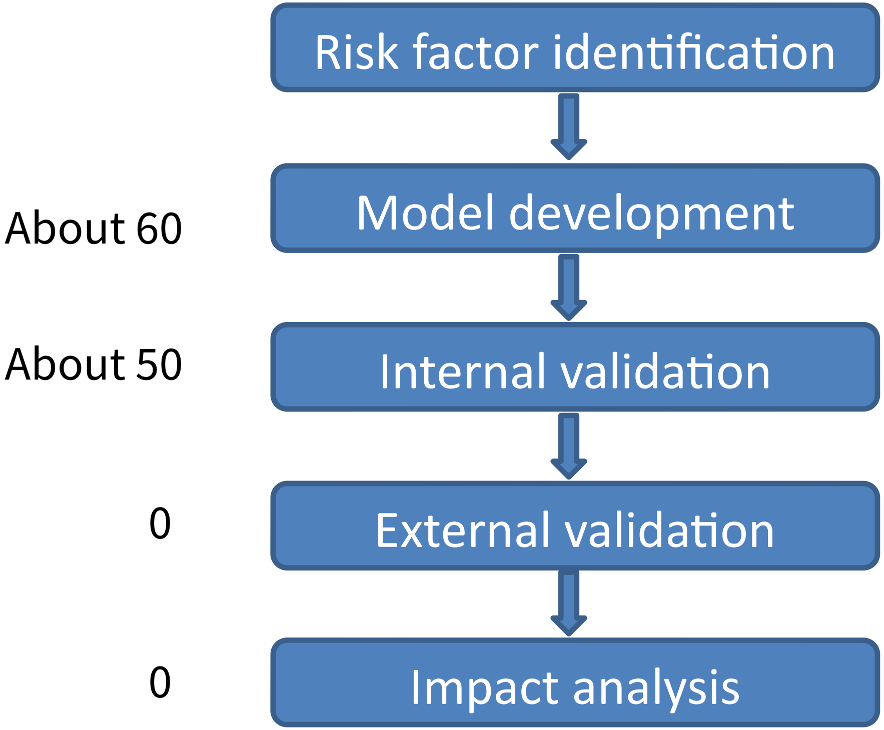
In progress

- Feature extraction

To do

- Access request
- One/two-stage IPD meta-analysis

Systematic review and IPD meta-analysis



E. W. Steyerberg et al., "Prognosis Research Strategy (PROGRESS) 3: Prognostic Model Research," PLoS Med. 2013.

ITU

Jose Luis Albites Sanabria, Barry Greene, Killian McManus, Luca Palmerini, Inês Sousa, Kimberley S. van Schooten, Eva Weicken, Markus Wenzel, Eugenio Zuccarelli

Thank you!