# Development of Preoperative Computer Models which Accurately Predict Answers to all Individual Questions on SRS-22 at 2 year follow up: A Step towards Individualized Medicine


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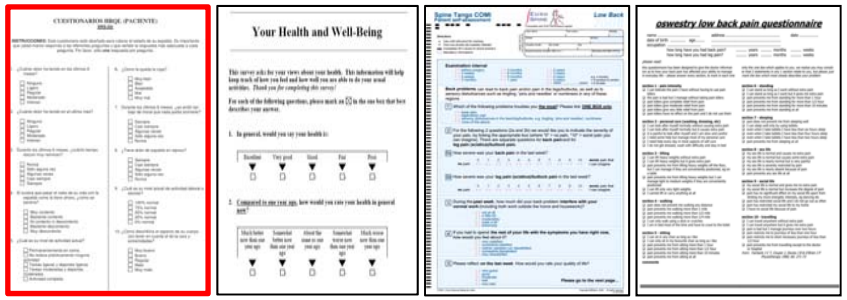
Health related quality of life (HRQoL) instruments are essential in a value-driven healthcare economy.

SRS-22R, an HRQL instrument for spinal deformity, provides summary scores spanning several health domains, but these may be difficult for patients to utilize in planning their specific care goals.




The purpose of this study was to create a predictive model for individual SRS-22 questions at 1 and 2 years after Adult Spinal Deformity (ASD) surgery.

# Methods

Two prospective observational cohorts were retrospectively queried for ASD patients with SRS-22 data at baseline, 1 year and 2 years after surgery.

European Spine Study Group (ESSG) Database

International Spine Study Group (ISSG) Database

*Multi-center ASD databases with identical fixed data fields*

Predictive modeling (Machine Learning)

150 Covariates were used in the training models and included demographic data, surgical data, and perioperative complication data.

a) Patient characteristics:

- a.1) Demographic data (age, gender, employment)
- a.2) Comorbidities
- a.3) Magnitude of the deformity (radiographic parameters)
- a.4) HRQoL ODI, SF36, SRSr22 (domains and individual answers to these questionnaires)

b) Surgical characteristics:

- b.1) Type of surgery (levels fused, osteotomies, interbody fusions, decompressions…)
- b.2) Immediate postoperative outcomes (blood loss and surgical time)

c) Site-Fixed effects:

- c.1) Surgeon
- c.2) Site

Variable selection and feature engineering was not performed before the training of the models to reduce the amount of pre-processing bias.

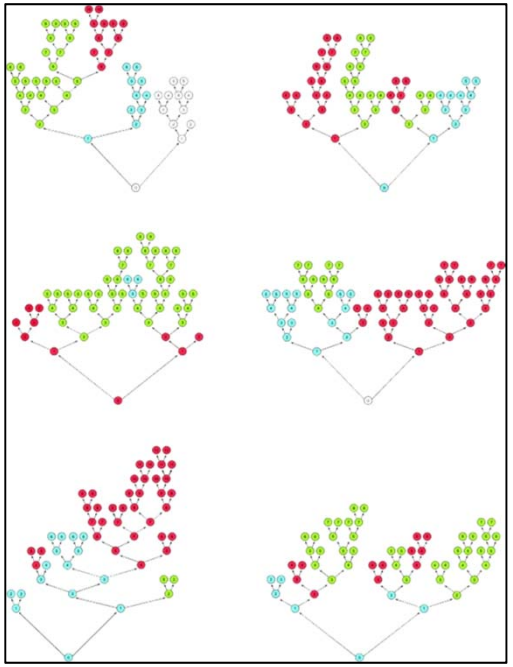
## Training:

6 different prediction algorithms were trained:

1. GBM: Gradient Boosting Machine
2. GLMnet: Elastic-Net Regularized Generalized Linear Model
3. ELnet: Elastic-Net regularization
4. RF: Random forest
5. XGBL: Extreme Gradient Boosting-Linear
6. XGBT: Extreme Gradient Boosting-Tree.

…with 3-time horizons:

a) Baseline to 1 year
b) Baseline to 2 years
c) 1 year to 2 years



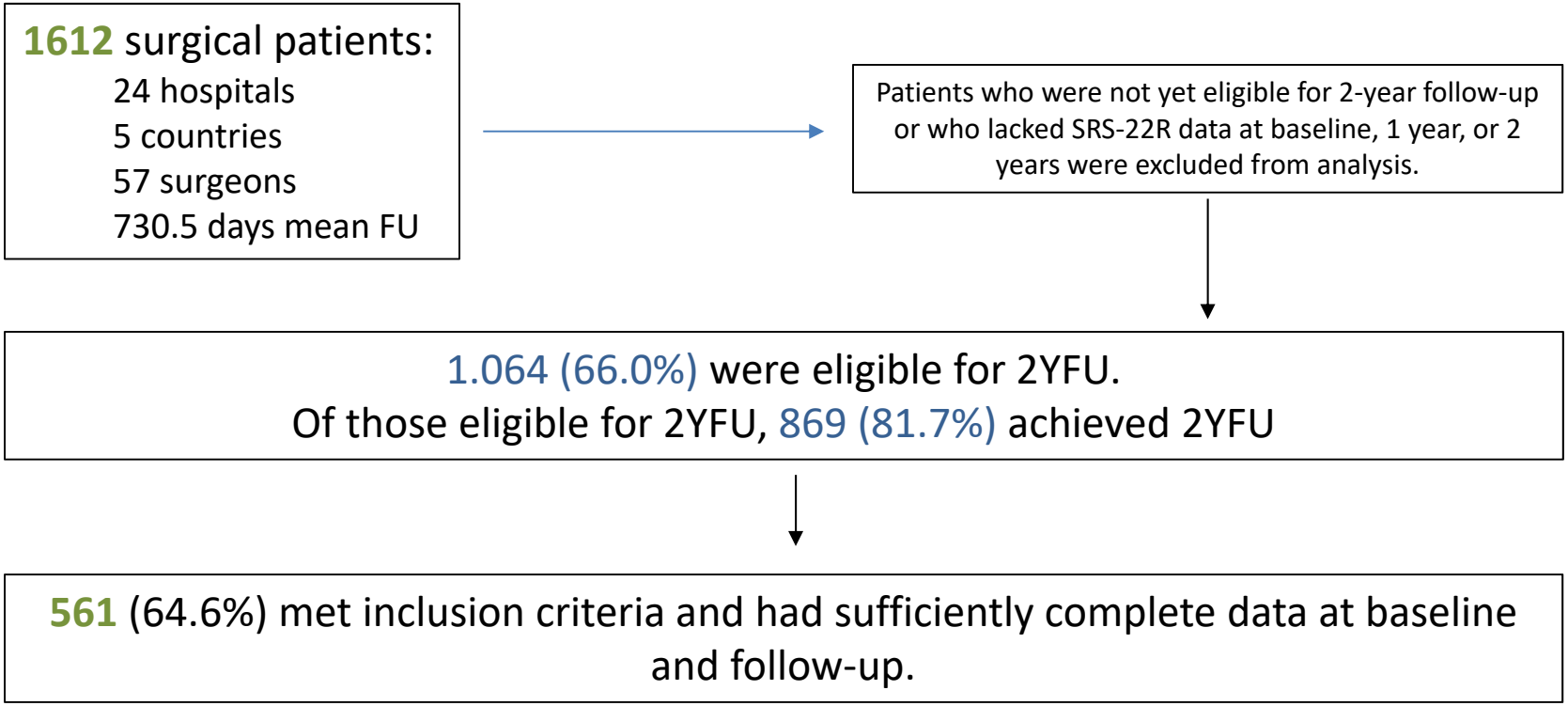
## Validation:

External validation was accomplished via an 80/20 data split for training/testing each model.

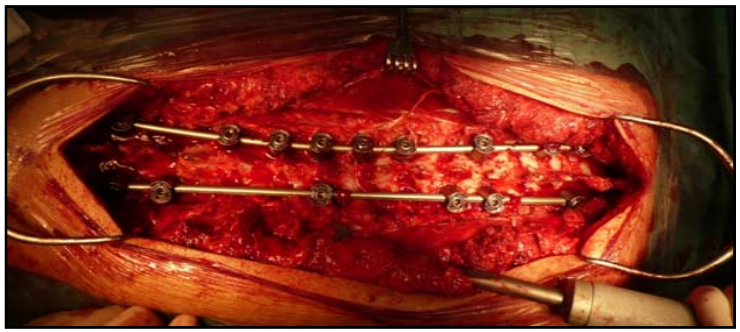
Goodness of fit was measured using the AUROC in the test set.

Variable importance were calculated.

# Results


1612 surgical patients:
24 hospitals
5 countries
57 surgeons
730.5 days mean FU
Patients who were not yet eligible for 2-year follow-up or who lacked SRS-22R data at baseline, 1 year, or 2 years were excluded from analysis.
1.064 (66.0%) were eligible for 2YFU.
Of those eligible for 2YFU, 869 (81.7%) achieved 2YFU
561 (64.6%) met inclusion criteria and had sufficiently complete data at baseline and follow-up.

| Variable | Mean or % | SD | Median | SE |
|---|---|---|---|---|
| Total surgical time (min) | 368.4 | 132.7 | 364.0 | 7.7 |
| Estimated blood loss (cc) | 1572.5 | 1491.6 | 1200.0 | 85.8 |
| Number of fused vertebral levels | 10.5 | 4.3 | 10.0 | 0.3 |
| Use of pelvic fixation (%) | 60.8 | | | |
| Use of interbody fusion (%) | 62.1 | | | |
| Use of Smith-Petersen osteotomy (%) | 49.5 | | | |
| Use of pedicle subtraction osteotomy (%) | 14.6 | | | |
| Use of vertebral column resection (%) | 4.2 | | | |
| Length of hospitalization (days) | 8.25 | 5.84 | 7.0 | 0.2 |
| Occurrence of perioperative complication (%) | 9.98 | | | |



Age: 54.4
Gender: 75.9% women
Previous spine surgery: 44.6%
Smoker 10.3%

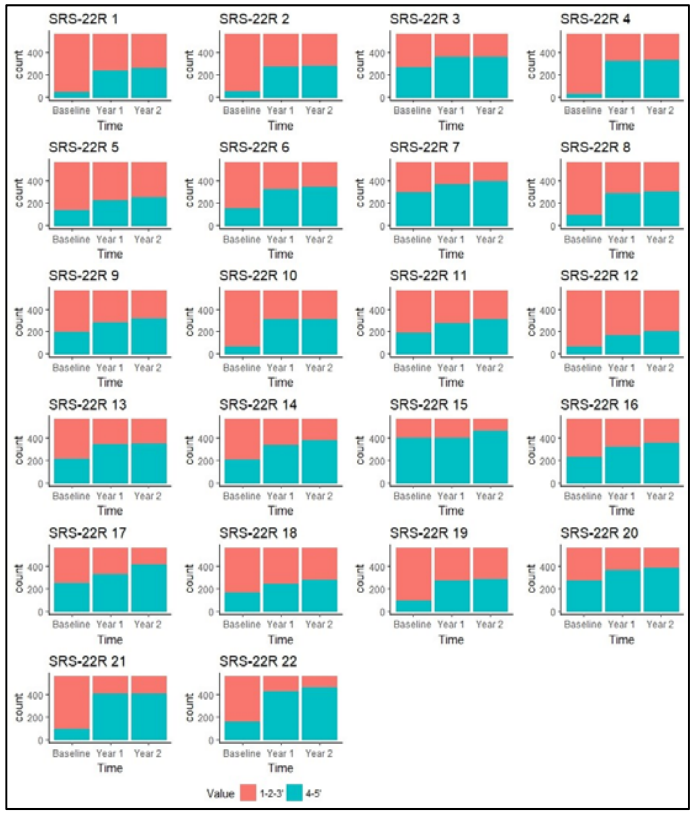
| Variable | Mean | SD | Median | SE |
|---|---|---|---|---|
| **Pre-operative Baseline** | | | | |
| Sagittal alignment (SVA, mm) | 52.6 | 71.6 | 41.8 | 3.1 |
| Coronal alignment (GCA, mm) | 31.6 | 31.8 | 23.8 | 1.4 |
| Major curve Cobb angle (°) | 42.2 | 21.4 | 41.1 | 0.9 |
| Pelvic tilt (°) | 22.3 | 11.1 | 22 | 0.5 |
| **1-Year Post-operative** | | | | |
| Sagittal alignment (SVA, cm) | 22.06 | 54.4 | 16 | 2.4 |
| Coronal alignment (GCA, cm) | 3.96 | 31.4 | 6.5 | 1.4 |
| Major curve Cobb angle (°) | 8.82 | 25.76 | 10.9 | 1.2 |
| Pelvic tilt (°) | 20.5 | 9.7 | 20.6 | 0.4 |
| **2-Years Post-operative** | | | | |
| Sagittal alignment (SVA, mm) | 26.3 | 54.1 | 22.7 | 2.4 |
| Coronal alignment (GCA, mm) | 23.77 | 20.16 | 18.74 | 0.9 |
| Major curve Cobb angle (°) | 21.21 | 16.11 | 17.9 | 0.72 |
| Pelvic tilt (°) | 20.25 | 10.08 | 20.07 | 0.45 |

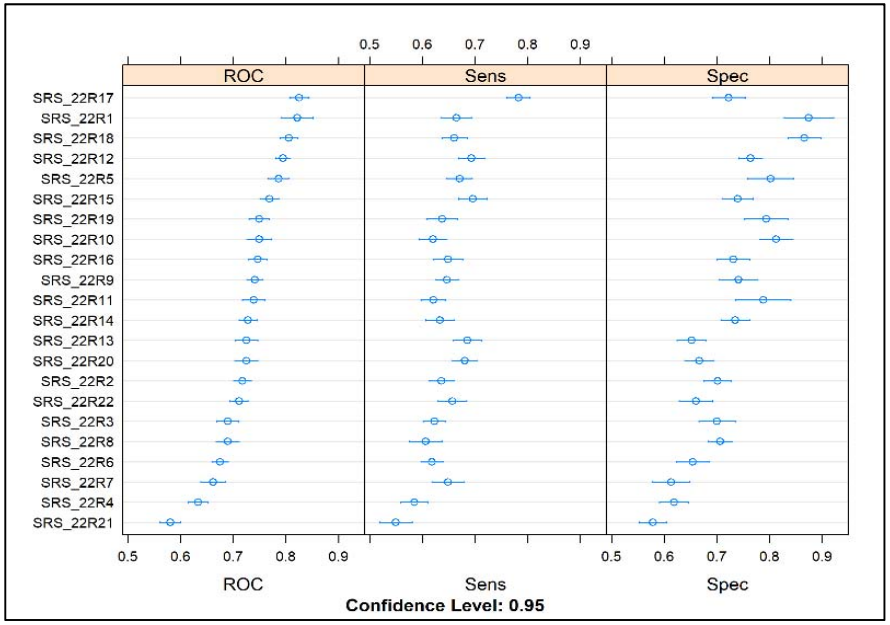
| Variable | Mean | SD | Median | SE |
|---|---|---|---|---|
| **Pre-operative Baseline** | | | | |
| Oswestry Disability Index | 40.3 | 19.3 | 40 | 0.8 |
| SRS-22R function score | 3.08 | 0.91 | 3 | 0.04 |
| SRS-22R mental health score | 3.4 | 0.9 | 3.4 | 0.04 |
| SRS-22R pain score | 2.55 | 0.91 | 2.4 | 0.04 |
| SRS-22R self-image score | 2.49 | 0.74 | 2.4 | 0.03 |
| SRS-22R subtotal score | 2.88 | 0.67 | 2.91 | 0.03 |
| SF36v2 MCS score | 45.3 | 13.4 | 46.3 | 0.58 |
| SF36v2 PCS score | 33.89 | 10.22 | 32.91 | 0.44 |
| **1-Year Post-operative** | | | | |
| Oswestry Disability Index | 24.9 | 17.9 | 22 | 0.8 |
| SRS-22R function score | 3.61 | 0.88 | 3.6 | 0.04 |
| SRS-22R mental health score | 3.86 | 0.83 | 4.00 | 0.04 |
| SRS-22R pain score | 3.55 | 0.97 | 3.60 | 0.04 |
| SRS-22R self-image score | 3.71 | 0.83 | 3.80 | 0.04 |
| SRS-22R subtotal score | 3.74 | 0.71 | 3.83 | 0.03 |
| SF36v2 MCS score | 50.5 | 11.7 | 53.9 | 0.5 |
| SF36v2 PCS score | 42.1 | 9.9 | 42.6 | 0.4 |
| **2-Years Post-operative** | | | | |
| Oswestry Disability Index | 25.4 | 19.4 | 22 | 0.8 |
| SRS-22R function score | 3.62 | 0.94 | 3.8 | 0.04 |
| SRS-22R mental health score | 3.83 | 0.85 | 4.00 | 0.04 |
| SRS-22R pain score | 3.52 | 1.06 | 3.6 | 0.04 |
| SRS-22R self-image score | 3.66 | 0.87 | 3.8 | 0.04 |
| SRS-22R subtotal score | 3.7 | 0.77 | 3.8 | 0.03 |
| SF36v2 MCS score | 49.81 | 11.98 | 51.09 | 0.5 |
| SF36v2 PCS score | 41.34 | 10.98 | 41.95 | 0.5 |

Outcomes and answers of the SRS22r were dichotomized as

a) “good” (4, 5)

b) “bad” (1-3)






The AUROC of most models were approximately 75-80% indicating successful fits.

Items regarding back pain in the last 6 months (q1), level of activity (q5), domestic activity (q12) and feeling attractive with the current back condition (q19) of the SRS22 questionnaire were most accurately predicted.

The models were less sensitive to questions regarding financial difficulties (q15), depression (q16) and days of sick leave or ceasing domestic activity in the last 3 months (q17).

Preop models to predict answers to each of the SRS-22 questions at 2-year followup were created with 75-80% accuracy. Items related to pain, function, and self-image were most accurately predicted.

The ability to predict individual question responses may be useful in preoperative counseling of patients in the age of individualized medicine.

| | |
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