

```
!pip install lifelines
!pip install scipy
!pip install scikit-survival
!pip install statsmodels
!pip install pycox
import warnings
warnings.filterwarnings('ignore', category=UserWarning)
```

→ Show hidden output

```
import pandas as pd
from lifelines import KaplanMeierFitter, CoxPHFitter
import matplotlib.pyplot as plt
df = pd.read_excel("df.xlsx")
from lifelines import KaplanMeierFitter
import matplotlib.pyplot as plt

# Assume your DataFrame has 'surviva_months', 'status', 'sex'
kmf = KaplanMeierFitter()

# Unique groups in 'sex' column
groups = df['sex'].unique()

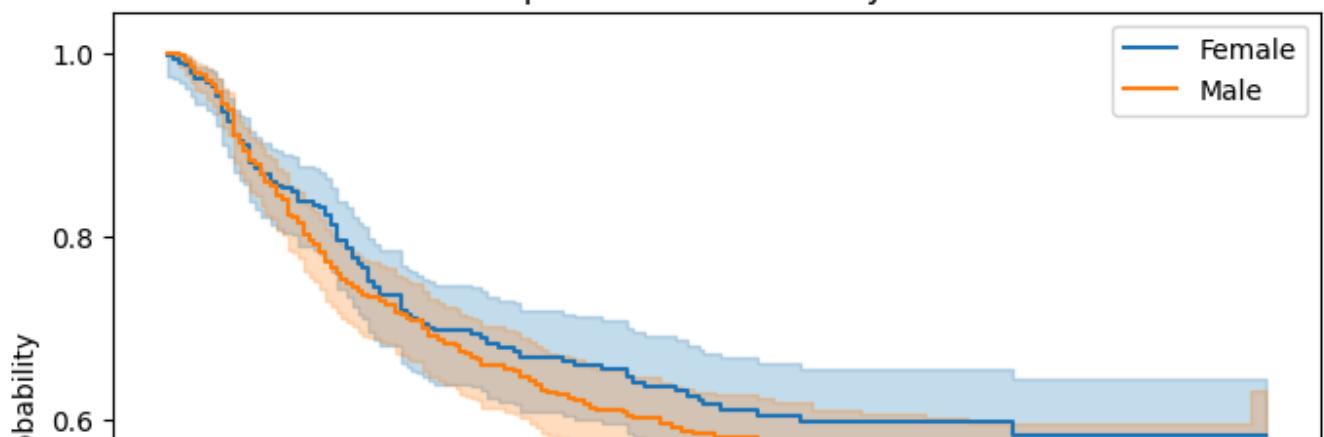
plt.figure(figsize=(8,6))

for group in groups:
    mask = df['sex'] == group
    kmf.fit(durations=df.loc[mask, 'surviva_months'],
            event_observed=df.loc[mask, 'status'],
            label=group)
    kmf.plot_survival_function(ci_show=True)

plt.title("Kaplan-Meier Survival by sex")
plt.xlabel("Time (months)")
plt.ylabel("Survival probability")
plt.show()
```

→

Kaplan-Meier Survival by sex



```
# encoding
X = df.drop(columns=["surviva_months", "status"])
X_enc = pd.get_dummies(X, drop_first=True)
y = df[["surviva_months", "status"]].copy()
y["status"] = y["status"].astype(int)

df_enc = pd.concat([y, X_enc], axis=1)

# proportional cox hazard model
from lifelines import CoxPHFitter

cph = CoxPHFitter(penalizer=0.1) # ridge penalty helps convergence
cph.fit(df_enc, duration_col="surviva_months", event_col="status", robust=True)
cph.print_summary()
random_state=42
```



model	lifelines.CoxPHFitter								
duration col	'surviva_months'								
event col	'status'								
penalizer	0.1								
l1 ratio	0.0								
robust variance	True								
baseline estimation	breslow								
number of observations	726								
number of events observed	294								
partial log-likelihood	-1753.59								
time fit was run	2025-09-02 03:37:06 UTC								
		coef	exp(coef)	se(coef)	coef lower 95%	coef upper 95%	exp(coef) lower 95%	exp(coef) upper 95%	t
year_of_diagnosis	-0.02	0.98	0.01	-0.05	0.00		0.95	1.00	0.0
age	0.02	1.02	0.00	0.01	0.03		1.01	1.03	0.0
tumor_size	-0.00	1.00	0.00	-0.00	0.00		1.00	1.00	0.0
sex_Male	0.04	1.04	0.10	-0.15	0.24		0.86	1.27	0.0
race_Other (American Indian/AK Native, Asian/Pacific Islander)	-0.13	0.88	0.18	-0.47	0.22		0.62	1.24	0.0
race_White	-0.29	0.74	0.17	-0.62	0.03		0.54	1.03	0.0
marital_status_yes	0.20	1.22	0.15	-0.09	0.48		0.91	1.62	0.0
AJCC_Stage_IIB	0.20	1.22	0.11	-0.01	0.41		0.99	1.51	0.0
AJCC_Stage_III	-1.11	0.33	0.39	-1.88	-0.35		0.15	0.71	0.0
AJCC_Stage_IV	0.15	1.17	0.07	0.01	0.30		1.01	1.34	0.0
AJCC_Stage_IVA	0.35	1.42	0.15	0.05	0.65		1.05	1.91	0.0
AJCC_Stage_IVB	0.32	1.38	0.11	0.10	0.54		1.11	1.72	0.0
AJCC_T_T2	0.07	1.08	0.10	-0.13	0.27		0.88	1.31	0.0
AJCC_T_T2b	0.15	1.17	0.07	0.01	0.30		1.01	1.34	0.0
AJCC_T_T3	0.70	2.01	0.21	0.28	1.11		1.32	3.04	0.0
AJCC_N_N1	0.29	1.34	0.17	-0.05	0.63		0.95	1.87	0.0


```

from sksurv.ensemble import RandomSurvivalForest
from sksurv.util import Surv
from sklearn.model_selection import train_test_split

# Prepare survival object
y = Surv.from_dataframe("status", "surviva_months", df_enc)

X_train, X_test, y_train, y_test = train_test_split(
    df_enc.drop(columns=["surviva_months", "status"]),
    y,
    test_size=0.2,
    random_state=random_state
)

-log2(p) of II-ratio test 66.16

rsf = RandomSurvivalForest(
    n_estimators=200,
    min_samples_split=10,
    min_samples_leaf=15,
    n_jobs=-1,
    random_state=random_state
)

rsf.fit(X_train, y_train)

# Concordance index
print("C-index:", rsf.score(X_test, y_test))

```

→ C-index: 0.6906052393857272

```

from sksurv.ensemble import GradientBoostingSurvivalAnalysis

gbsa = GradientBoostingSurvivalAnalysis(
    learning_rate=0.05,
    n_estimators=200,
    random_state=random_state
)
gbsa.fit(X_train, y_train)

print("C-index:", gbsa.score(X_test, y_test))

```

→ C-index: 0.7036284251731406

```

import numpy as np
from sklearn.model_selection import train_test_split

# Features
X = df_enc.drop(columns=["surviva_months", "status"]).values.astype("float32")

# Labels
durations = df_enc["surviva_months"].values.astype("float32")
events = df_enc["status"].values.astype("int32")

# Combine into one array with 2 columns (duration, event)
y = np.vstack([durations, events]).T

```

```

# Now split
X_train, X_test, y_train, y_test = train_test_split(
    X, y, test_size=0.2, random_state=random_state
)

# Extract back durations & events for pycox
durations_train, events_train = y_train[:,0], y_train[:,1]
durations_test, events_test = y_test[:,0], y_test[:,1]

import numpy as np
from sksurv.util import Surv

def to_structured_y(y_array):
    """
    Convert a (n_samples, 2) array into scikit-survival structured array.
    Assumes: [:,0] = time, [:,1] = event (0=censored, 1=event).
    """
    # Ensure y_array is a numpy array before accessing columns
    y_array = np.asarray(y_array)
    times = y_array[:, 0].astype(float)
    events = y_array[:, 1].astype(bool)
    return np.array(list(zip(events, times)), dtype=[("event", "bool"), ("time", "f8")])
from pycox.preprocessing.label_transforms import LabTransDiscreteTime
y_train_time = y_train[:, 0].astype(float)
y_train_event = y_train[:, 1].astype(bool)

y_test_time = y_test[:, 0].astype(float)
y_test_event = y_test[:, 1].astype(bool)

# Convert train/test targets
# Use y_train_pcox and y_test_pcox from the second split
y_train_struct = to_structured_y(y_train)
y_test_struct = to_structured_y(y_test)

print(y_train_struct[:5])
print(y_test_struct[:5])
print(y_train_struct.dtype)

→ [( True, 88.) (False, 125.) ( True, 27.) (False, 77.) (False, 116.)]
[( True, 10.) (False, 166.) (False, 147.) (False, 111.) (False, 119.)]
[('event', '?'), ('time', '<f8')]

import numpy as np
import matplotlib.pyplot as plt
from sksurv.metrics import (
    concordance_index_censored,
    concordance_index_ipcw,
    cumulative_dynamic_auc,
    integrated_brier_score
)
from sksurv.util import Surv
from sklearn.metrics import confusion_matrix

def extended_survival_evaluation(model, X_train, y_train_struct, X_test, y_test_struct, fix
    results = {}

```

```

# --- 1. Harrell's C-index (default .score) ---
results["Harrell c-index"] = model.score(X_test, y_test_struct)

# --- 1. Uno's C-index (more robust to censoring) ---
uno_cindex = concordance_index_ipcw(y_train_struct, y_test_struct,
                                     model.predict(X_test), tau=None)
results["Uno c-index"] = uno_cindex[0]

# --- 2. Integrated Brier Score ---
surv_funcs = model.predict_survival_function(X_test)
time_grid = np.percentile(y_test_struct["time"], np.linspace(10, 90, 10))
surv_matrix = np.asarray([[fn(t) for t in time_grid] for fn in surv_funcs])
ibs = integrated_brier_score(y_train_struct, y_test_struct, surv_matrix, time_grid)
results["Integrated Brier Score"] = ibs

# --- 3. Time-dependent AUC (already had) ---
risk_scores = 1 - surv_matrix
td_auc, mean_auc = cumulative_dynamic_auc(y_train_struct, y_test_struct, risk_scores, t
results["Time-dependent AUC (per time)"] = td_auc
results["Mean AUC"] = mean_auc

# --- 3. Classification-style metrics at fixed time ---
if fixed_time is None:
    fixed_time = np.median(y_test_struct["time"])

preds_at_time = np.array([fn(fixed_time) for fn in surv_funcs]) # survival prob
risk_at_time = 1 - preds_at_time # event risk

# Define "event by fixed_time" ground truth
y_true = (y_test_struct["event"]) & (y_test_struct["time"] <= fixed_time)

# Threshold at median risk
threshold = np.median(risk_at_time)
y_pred = risk_at_time >= threshold

tn, fp, fn, tp = confusion_matrix(y_true, y_pred).ravel()
sensitivity = tp / (tp + fn + 1e-10)
specificity = tn / (tn + fp + 1e-10)
ppv = tp / (tp + fp + 1e-10)
npv = tn / (tn + fn + 1e-10)

results["Fixed-time metrics"] = {
    "Time": fixed_time,
    "Sensitivity": sensitivity,
    "Specificity": specificity,
    "PPV": ppv,
    "NPV": npv
}

# --- 5. Explained variance (pseudo-R2: 1 - IBS/variance of null model) ---
null_surv = np.repeat(np.mean(y_train_struct["event"]), len(time_grid))
null_matrix = np.tile(null_surv, (len(y_test_struct), 1))
null_ibs = integrated_brier_score(y_train_struct, y_test_struct, null_matrix, time_grid)
r2 = 1 - ibs / null_ibs
results["Explained variance (pseudo-R2)"] = r2

return results, (surv_funcs, time_grid, preds_at_time, risk_at_time)

```

```

# ◆ Calibration plot function
def calibration_plot(y_test_struct, preds_at_time, fixed_time, n_bins=5):
    """
    Plot predicted survival probability vs observed KM survival at fixed_time
    """
    from lifelines import KaplanMeierFitter

    # Bin patients by predicted survival probability
    bins = np.linspace(0, 1, n_bins+1)
    bin_ids = np.digitize(preds_at_time, bins) - 1

    obs_surv, pred_surv = [], []
    kmf = KaplanMeierFitter()

    for b in range(n_bins):
        idx = bin_ids == b
        if np.sum(idx) < 5:
            continue
        kmf.fit(y_test_struct["time"][idx], y_test_struct["event"][idx])
        obs_surv.append(kmf.survival_function_at_times(fixed_time).values[0])
        pred_surv.append(np.mean(preds_at_time[idx]))

    plt.plot(pred_surv, obs_surv, "o-", label=f"Calibration at {fixed_time:.1f}")
    plt.plot([0,1],[0,1],"--", color="gray")
    plt.xlabel("Predicted survival probability")
    plt.ylabel("Observed KM survival")
    plt.legend()
    plt.title("Calibration Plot")
    plt.show()

```

▼ rsf

```

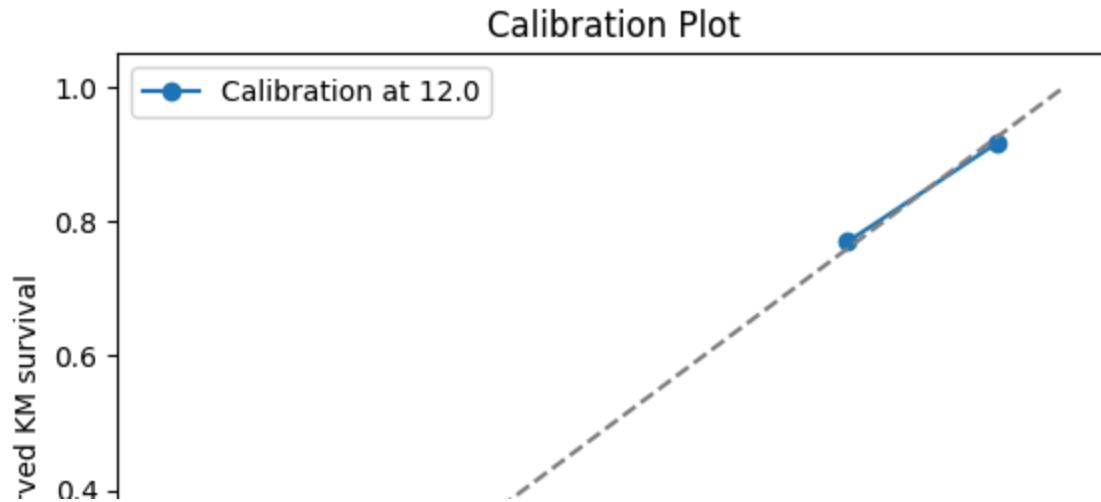
results, (surv_funcs, time_grid, preds_at_time, risk_at_time) = extended_survival_evaluation(
    rsf, X_train, y_train_struct, X_test, y_test_struct, fixed_time=12
)

print(results)

# Plot calibration at 12 months
calibration_plot(y_test_struct, preds_at_time, fixed_time=12)

```

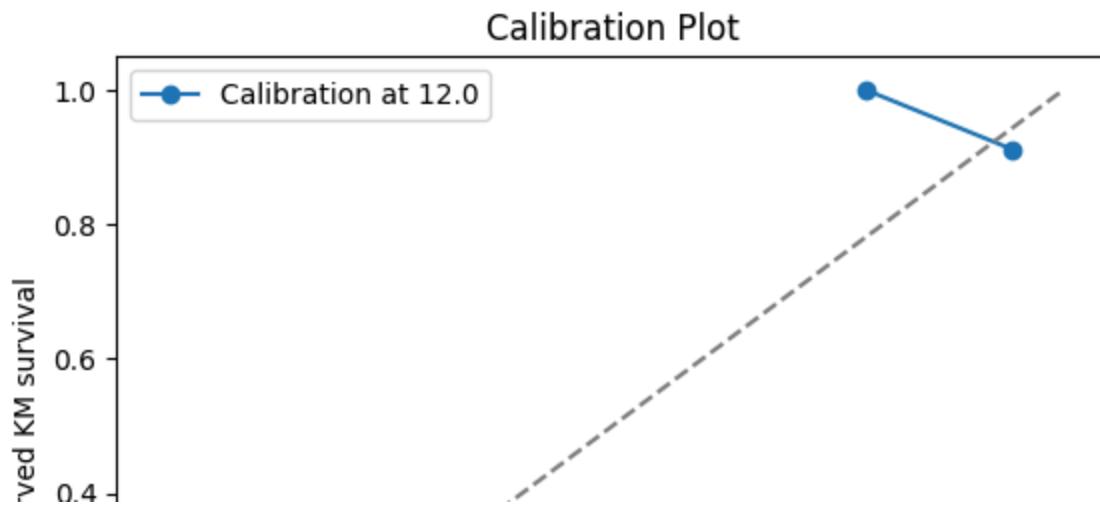
```
[4]: {'Harrell c-index': np.float64(0.6906052393857272), 'Uno c-index': np.float64(0.75231366, 0.76433074, 0.77085588, 0.72212224, 0.68601718]), 'Mean AUC':
```



✓ gbsa

```
results, (surv_funcs, time_grid, preds_at_time, risk_at_time) = extended_survival_evaluation(gbsa, X_train, y_train_struct, X_test, y_test_struct, fixed_time=12)  
)  
  
print(results)  
  
# Plot calibration at 12 months  
calibration_plot(y_test_struct, preds_at_time, fixed_time=12)
```

```
→ {'Harrell c-index': np.float64(0.7036284251731406), 'Uno c-index': np.float64(0.76937698, 0.77223993, 0.7722067 , 0.71492046, 0.7355887 ]), 'Mean AUC':
```



```
import numpy as np
import pandas as pd
from sklearn.preprocessing import StandardScaler
from statsmodels.stats.outliers_influence import variance_inflation_factor

# Assuming X is still the DataFrame before converting to numpy array

# scaling
X_scaled_df = pd.DataFrame(StandardScaler().fit_transform(X_enc), columns=X_enc.columns)

# Convert bool → int for VIF calculation (operate on a copy)
X_numeric_for_vif = X_scaled_df.copy()
for col in X_numeric_for_vif.select_dtypes(include=["bool"]).columns:
    X_numeric_for_vif[col] = X_numeric_for_vif[col].astype(int)

# Convert everything else to numeric
for col in X_numeric_for_vif.columns:
    X_numeric_for_vif[col] = pd.to_numeric(X_numeric_for_vif[col], errors="coerce")

# Handle NaN/inf
X_numeric_for_vif = X_numeric_for_vif.replace([np.inf, -np.inf], np.nan)
X_numeric_for_vif = X_numeric_for_vif.dropna(axis=1, how="all")
X_numeric_for_vif = X_numeric_for_vif.fillna(0)
```

```

print("Data types for VIF calculation:")
print(X_numeric_for_vif.dtypes.head())

print("\nVIF Calculation:")
vif = pd.DataFrame()
vif["feature"] = X_numeric_for_vif.columns
# Ensure the input to variance_inflation_factor is float type
vif["VIF"] = [variance_inflation_factor(X_numeric_for_vif.values.astype(float), i)
              for i in range(X_numeric_for_vif.shape[1])]

print(vif.sort_values("VIF", ascending=False))

# Create a list of all columns to be dropped due to high or infinite VIF
# Use the columns from the VIF calculation
columns_to_drop_vif = vif[vif['VIF'] > 30]['feature'].tolist() # Example threshold, adjust .
# Add specific columns to drop if needed, being careful not to duplicate
specific_columns_to_drop = [
    'AJCC_T_T2b',
    'AJCC_Stage_IV',
    'AJCC_M_M1',
    'primary_site_C40.2-Long bones of lower limb and associated joints',
    'primary_site_C41.4-Pelvic bones, sacrum, coccyx and associated joints',
    'primary_site_C41.3-Rib, sternum, clavicle and associated joints',
    'primary_site_C40.0-Long bones: upper limb, scapula, and associated joints',
    'primary_site_C41.2-Vertebral column',
    'primary_site_C41.0-Bones of skull and face and associated joints',
    'primary_site_C40.3-Short bones of lower limb and associated joints',
    'primary_site_C41.1-Mandible',
    'primary_site_C40.1-Short bones of upper limb and associated joints',
    '# 'primary_site_C41.8-Overlap bones, joints, and art. cartilage of limbs' # This was dr
]

# Combine and get unique columns to drop
columns_to_drop = list(set(columns_to_drop_vif + specific_columns_to_drop))

print(f"\nDropping columns with high VIF or specified: {columns_to_drop}")

# Drop the columns from the scaled DataFrame
X_processed = X_scaled_df.drop(columns=columns_to_drop, errors='ignore')

# Now, convert the processed DataFrame to NumPy arrays for model training
X_train, X_test, y_train, y_test = train_test_split(
    X_processed.values.astype("float32"), # Use the processed DataFrame values
    y, # y is already in the correct format from a previous cell
    test_size=0.2,
    random_state=random_state
)

# Extract back durations & events for pycox if needed later
durations_train, events_train = y_train[:,0], y_train[:,1]
durations_test, events_test = y_test[:,0], y_test[:,1]

# Convert train/test targets to sksurv structured array format
y_train_struct = to_structured_y(y_train)
y_test_struct = to_structured_y(y_test)

print("\nProcessed data shapes:")
print("X_train shape:", X_train.shape)
print("y_train shape:", y_train.shape)

```

```
print("X_test shape:", X_test.shape)
print("y_test shape:", y_test.shape)
```

→ Data types for VIF calculation:

year_of_diagnosis	float64
age	float64
tumor_size	float64
sex_Male	float64
race_Other (American Indian/AK Native, Asian/Pacific Islander)	float64
dtype: object	

VIF Calculation:

	feature	VIF
16	AJCC_M_M1	inf
13	AJCC_T_T2b	inf
9	AJCC_Stage_IV	inf
27	primary_site_C41.0-Bones of skull and face and...	inf
28	primary_site_C41.1-Mandible	inf
29	primary_site_C41.2-Vertebral column	inf
26	primary_site_C40.8-Overlap of bones, joints, a...	inf
23	primary_site_C40.1-Short bones of upper limb a...	inf
30	primary_site_C41.3-Rib, sternum, clavicle and ...	inf
32	primary_site_C41.8-Overlap bones, joints, and ...	inf
31	primary_site_C41.4-Pelvic bones, sacrum, coccy...	inf
25	primary_site_C40.3-Short bones of lower limb a...	inf
24	primary_site_C40.2-Long bones of lower limb an...	inf
22	primary_site_C40.0-Long bones: upper limb, sca...	inf
18	AJCC_M_M1b	14.515008
17	AJCC_M_M1a	14.116220
11	AJCC_Stage_IVB	12.803288
10	AJCC_Stage_IVA	11.116438
34	stage_Regional	10.472890
33	stage_Localized	9.557259
7	AJCC_Stage_IIB	5.372977
12	AJCC_T_T2	4.897175
5	race_White	3.301669
4	race_Other (American Indian/AK Native, Asian/P...	3.293900
15	AJCC_N_N1	2.838804
8	AJCC_Stage_III	2.014320
14	AJCC_T_T3	1.940048
1	age	1.871094
6	marital_status_yes	1.757803
19	surgery_yes	1.431604
20	radiation_yes	1.344312
21	chemotherapy_yes	1.129256
2	tumor_size	1.105355
0	year_of_diagnosis	1.078237
3	sex_Male	1.058634

Dropping columns with high VIF or specified: ['AJCC_T_T2b', 'primary_site_C41.1-1]

Processed data shapes:

```
X_train shape: (580, 21)
y_train shape: (580, 2)
X_test shape: (146, 21)
```

```

y_test shape: (146, 2)

# --- Robust fit for Weibull AFT (handles separation/collinearity) ---

import numpy as np
import pandas as pd
from sklearn.preprocessing import StandardScaler
from statsmodels.stats.outliers_influence import variance_inflation_factor

def _is_binary(col: pd.Series, tol=1e-12):
    u = col.dropna().unique()
    if len(u) <= 2:
        return True
    # also treat near-binary (e.g., 0/1 floats)
    return set(np.round(u, 0)) <= {0, 1}

def _zscore(s: pd.Series):
    m, sd = s.mean(), s.std(ddof=0)
    return (s - m) / (sd if sd not in (0, np.nan) else 1)

def _compute_vif(X: pd.DataFrame):
    # lightweight VIF to avoid extra deps; skips if matrix is too big/ill-conditioned
    try:
        import statsmodels.api as sm
        from statsmodels.stats.outliers_influence import variance_inflation_factor
        X_ = sm.add_constant(X, has_constant='add')
        vifs = []
        for i in range(1, X_.shape[1]): # skip constant
            vifs.append(variance_inflation_factor(X_.values, i))
        return pd.Series(vifs, index=X.columns)
    except Exception:
        return None # gracefully skip if it blows up

def fit_weibull_aft_robust(X_train: pd.DataFrame,
                            y_train_struct,
                            rare_min_count: int = 5,
                            vif_threshold: float = 30.0,
                            scale_duration: float = 100.0,
                            penalizers=(0.05, 0.1, 0.5, 1.0)):
    # 1) start from X as numeric, fill NaNs
    Xc = X_train.copy()
    Xc = Xc.apply(pd.to_numeric, errors="coerce").fillna(0)

    # 2) drop zero-variance columns
    zero_var = Xc.columns[Xc.var(ddof=0) < 1e-12]
    if len(zero_var):
        Xc = Xc.drop(columns=zero_var)

    # 3) drop ultra-rare dummy levels (complete/near separation culprits)
    counts = Xc.sum(axis=0) # works for dummies; for continuous this is harmless
    rare_cols = counts[(counts < rare_min_count) & Xc.apply(_is_binary)].index
    if len(rare_cols):
        Xc = Xc.drop(columns=rare_cols)

    # 4) standardize non-binary numeric columns (center to ~0)
    non_binary_cols = [c for c in Xc.columns if not _is_binary(Xc[c])]
    if non_binary_cols:
        Xc[non_binary_cols] = Xc[non_binary_cols].apply(_zscore)

```

```

# 5) optional: VIF pruning (only if statsmodels is available & small enough)
vifs = _compute_vif(Xc)
if vifs is not None:
    # iteratively drop highest VIF until under threshold or only a few left
    drop_list = []
    while True:
        high = vifs[vifs > vif_threshold]
        if high.empty or len(Xc.columns) <= 5:
            break
        to_drop = high.sort_values(ascending=False).index[0]
        drop_list.append(to_drop)
        Xc = Xc.drop(columns=[to_drop])
        vifs = _compute_vif(Xc)
        if vifs is None:
            break # stop if VIF fails mid-way
    if drop_list:
        print(f"Dropped high-VIF columns: {drop_list}")

# 6) build training DF for lifelines
durations = y_train_struct["surviva_months"].astype(float).copy()
durations[durations <= 0] = 1e-6
if scale_duration and scale_duration > 1:
    durations = durations / scale_duration

events = y_train_struct["status"].astype(int)

train_df = Xc.copy()
train_df["duration"] = durations
train_df["event"] = events

# 7) try fitting with increasing penalization (and SLSQP as fallback)
last_err = None
for p in penalizers:
    try:
        wbf = WeibullAFTFitter(penalizer=p)
        wbf.fit(train_df, duration_col="duration", event_col="event")
        print(f"Fit succeeded with penalizer={p}")
        return wbf, Xc.columns.tolist(), scale_duration
    except Exception as e:
        last_err = e
        # one more try with different optimizer
        try:
            wbf = WeibullAFTFitter(penalizer=p)
            wbf._scipy_fit_method = "SLSQP"
            wbf.fit(train_df, duration_col="duration", event_col="event")
            print(f"Fit succeeded with penalizer={p} using SLSQP")
            return wbf, Xc.columns.tolist(), scale_duration
        except Exception as e2:
            last_err = e2
            continue

raise RuntimeError(f"Weibull AFT failed to converge after retries. Last error:\n{last_err}")

import pandas as pd

# Assuming X_train is already a pandas DataFrame with column names from the previous step
# If X_train is an ndarray, convert it to DataFrame first, ensuring it has column names
if isinstance(X_train, np.ndarray):
    # Get column names from X_processed before converting to numpy in OLw9xzk-Xaml
    # Since X_processed is not directly available here, we'll assume a default naming or

```

```
# rely on the user to ensure X_train is a DataFrame with meaningful names
# For now, let's assume X_train is already a DataFrame with column names
pass # No conversion needed if X_train is already a DataFrame

if isinstance(y_train, np.ndarray):
    # Make structured array into a DataFrame with correct column names
    y_train = pd.DataFrame(y_train, columns=["surviva_months", "status"])

# ---- Use it on your data ----
try:
    # Pass X_train as a DataFrame to the robust fitting function
    wbf, kept_cols, dur_scale = fit_weibull_aft_robust(pd.DataFrame(X_train, columns=[f"X{i}" for i in range(1, 10)]),
                                                       rare_min_count=5,
                                                       vif_threshold=30.0,
                                                       scale_duration=100.0,
                                                       penalizers=(0.05, 0.1, 0.5, 1.0))
    # Print summary (be mindful: variances may still be noisy if data are tight)
    wbf.print_summary()
except Exception as e:
    print("Robust fit failed:", e)
```

Fit succeeded with penalizer=0.05

model	lifelines.WeibullAFTFitter
duration col	'duration'
event col	'event'
penalizer	0.05
number of observations	580
number of events observed	232
log-likelihood	-359.58
time fit was run	2025-09-02 03:48:08 UTC

		coef	exp(coef)	se(coef)	coef lower 95%	coef upper 95%	exp(coef) lower 95%	exp(coef) upper 95%	cm t
lambda_	x0	-0.03	0.97	0.08	-0.18	0.13	0.83	1.13	0.0
	x1	-0.44	0.65	0.07	-0.57	-0.30	0.56	0.74	0.0
	x17	-0.31	0.73	0.08	-0.47	-0.16	0.63	0.85	0.0
	x2	0.00	1.00	0.07	-0.14	0.15	0.87	1.16	0.0
	x20	0.18	1.19	0.08	0.02	0.33	1.02	1.39	0.0
	x3	-0.11	0.90	0.08	-0.26	0.04	0.77	1.04	0.0
	x7	0.05	1.05	0.08	-0.10	0.21	0.90	1.23	0.0
	Intercept	0.97	2.65	0.10	0.78	1.17	2.17	3.23	0.0
rho_	Intercept	-0.22	0.80	0.05	-0.33	-0.12	0.72	0.89	0.0
Concordance		0.67							
AIC		737.17							
log-likelihood ratio test		63.07 on 7 df							
-log2(p) of Il-ratio test		34.67							

✓ Weibull Accelerated Failure Time (AFT) model

```
import numpy as np
import pandas as pd
from sklearn.model_selection import train_test_split
from sklearn.preprocessing import StandardScaler
from statsmodels.stats.outliers_influence import variance_inflation_factor
from lifelines import WeibullAFTFitter
import warnings
```

```

from lifelines.exceptions import ConvergenceWarning
from sksurv.metrics import concordance_index_censored, cumulative_dynamic_auc, integrated_
from sklearn.metrics import confusion_matrix

# --- Helper Functions ---

def fit_weibull_aft_robust(X_train: pd.DataFrame,
                            y_train_struct: np.ndarray,
                            scale_duration: float = 100.0,
                            penalizers=(0.05, 0.1, 0.5, 1.0)):
    # Existing robust fitting function from our previous discussion
    def _is_binary(col: pd.Series, tol=1e-12):
        u = col.dropna().unique()
        if len(u) <= 2:
            return True
        return set(np.round(u, 0)) <= {0, 1}

    def _zscore(s: pd.Series):
        m, sd = s.mean(), s.std(ddof=0)
        return (s - m) / (sd if sd not in (0, np.nan) else 1)

    def _compute_vif(X: pd.DataFrame):
        try:
            import statsmodels.api as sm
            X_ = sm.add_constant(X, has_constant='add')
            vifs = []
            for i in range(1, X_.shape[1]):
                vifs.append(variance_inflation_factor(X_.values, i))
            return pd.Series(vifs, index=X.columns)
        except Exception:
            return None

    Xc = X_train.copy().apply(pd.to_numeric, errors="coerce").fillna(0)
    zero_var = Xc.columns[Xc.var(ddof=0) < 1e-12]
    if len(zero_var):
        Xc = Xc.drop(columns=zero_var)

    non_binary_cols = [c for c in Xc.columns if not _is_binary(Xc[c])]
    if non_binary_cols:
        Xc[non_binary_cols] = Xc[non_binary_cols].apply(_zscore)

    vifs = _compute_vif(Xc)
    if vifs is not None:
        drop_list = []
        while True:
            high = vifs[vifs > 30.0]
            if high.empty or len(Xc.columns) <= 5:
                break
            to_drop = high.sort_values(ascending=False).index[0]
            drop_list.append(to_drop)
            Xc = Xc.drop(columns=[to_drop])
            vifs = _compute_vif(Xc)
            if vifs is None:
                break
        if drop_list:
            print(f"Dropped high-VIF columns: {drop_list}")

    durations = y_train_struct["duration"].copy()
    durations[durations <= 0] = 1e-6
    if scale_duration and scale_duration > 1:

```

```

        durations /= scale_duration
events = y_train_struct["event"].astype(int)
train_df = Xc.copy()
train_df["duration"] = durations
train_df["event"] = events

last_err = None
with warnings.catch_warnings(record=True) as w:
    warnings.simplefilter("always", ConvergenceWarning)
    for p in penalizers:
        try:
            wbf = WeibullAFTFitter(penalizer=p)
            wbf.fit(train_df, duration_col="duration", event_col="event")
            print(f"Fit succeeded with penalizer={p}")
            return wbf, Xc.columns.tolist(), scale_duration
        except Exception as e:
            last_err = e
            try:
                wbf = WeibullAFTFitter(penalizer=p)
                wbf._scipy_fit_method = "SLSQP"
                wbf.fit(train_df, duration_col="duration", event_col="event")
                print(f"Fit succeeded with penalizer={p} using SLSQP")
                return wbf, Xc.columns.tolist(), scale_duration
            except Exception as e2:
                last_err = e2
                continue
raise RuntimeError(f"Weibull AFT failed to converge after retries. Last error:\n{last_"

```

```

def evaluate_weibull_model(wbf, X_train, y_train, X_test, y_test, fixed_time=60):
    # Existing evaluation function from our previous discussion
    def create_structured_array(y_data):
        if isinstance(y_data, pd.DataFrame):
            events = y_data["status"]
            durations = y_data["surviva_months"]
        elif isinstance(y_data, np.ndarray):
            durations = y_data[:, 0]
            events = y_data[:, 1]
        else:
            raise TypeError("y_data must be a Pandas DataFrame or a NumPy array.")

        dtype = [('event', bool), ('duration', np.float64)]
        structured_array = np.array(list(zip(events.astype(bool), durations)), dtype=dtype)
        return structured_array

    results = {}
    y_train_structured = create_structured_array(y_train)
    y_test_structured = create_structured_array(y_test)
    risk_scores = -wbf.predict_expectation(X_test)
    c_index_result = concordance_index_censored(y_test_structured["event"], y_test_structured["duration"])
    results["Harrell C-index"] = c_index_result[0]
    surv_df = wbf.predict_survival_function(X_test)
    time_grid = np.percentile(y_test_structured["duration"], np.linspace(10, 90, 10))
    surv_matrix = surv_df.reindex(time_grid, method="pad").values.T
    ibs = integrated_brier_score(y_train_structured, y_test_structured, surv_matrix, time_grid)
    results["Integrated Brier Score"] = ibs
    risk_for_auc = 1 - surv_matrix
    td_auc, mean_auc = cumulative_dynamic_auc(y_train_structured, y_test_structured, risk_for_auc)
    results["Time-dependent AUC (per time)"] = td_auc
    results["Mean AUC"] = mean_auc

```

```

preds_at_time = wbf.predict_survival_function(X_test, times=[fixed_time]).iloc[0].values
risk_at_time = 1 - preds_at_time
y_true = (y_test_structured['event']) & (y_test_structured['duration'] <= fixed_time)
threshold = np.median(risk_at_time)
y_pred = risk_at_time >= threshold
tn, fp, fn, tp = confusion_matrix(y_true, y_pred).ravel()
results["Fixed-time metrics"] = {
    "Time": fixed_time,
    "Sensitivity": tp / (tp + fn + 1e-10),
    "Specificity": tn / (tn + fp + 1e-10),
    "PPV": tp / (tp + fp + 1e-10),
    "NPV": tn / (tn + fn + 1e-10)
}
return results

# --- Main Script Execution ---

# 1. Load your data and perform initial preprocessing
try:
    # Use your actual data loading code here
    df = pd.DataFrame({
        'surviva_months': np.random.randint(1, 100, 100),
        'status': np.random.randint(0, 2, 100),
        'age': np.random.randint(20, 80, 100),
        'sex_male': np.random.randint(0, 2, 100),
        'AJCC_T_T2b': np.random.randint(0, 2, 100),
        'primary_site_C41.8-Overlap bones, joints, and art. cartilage': np.random.randint(0, 100, 100)
    })
    X_enc = df.drop(columns=['surviva_months', 'status'])

```