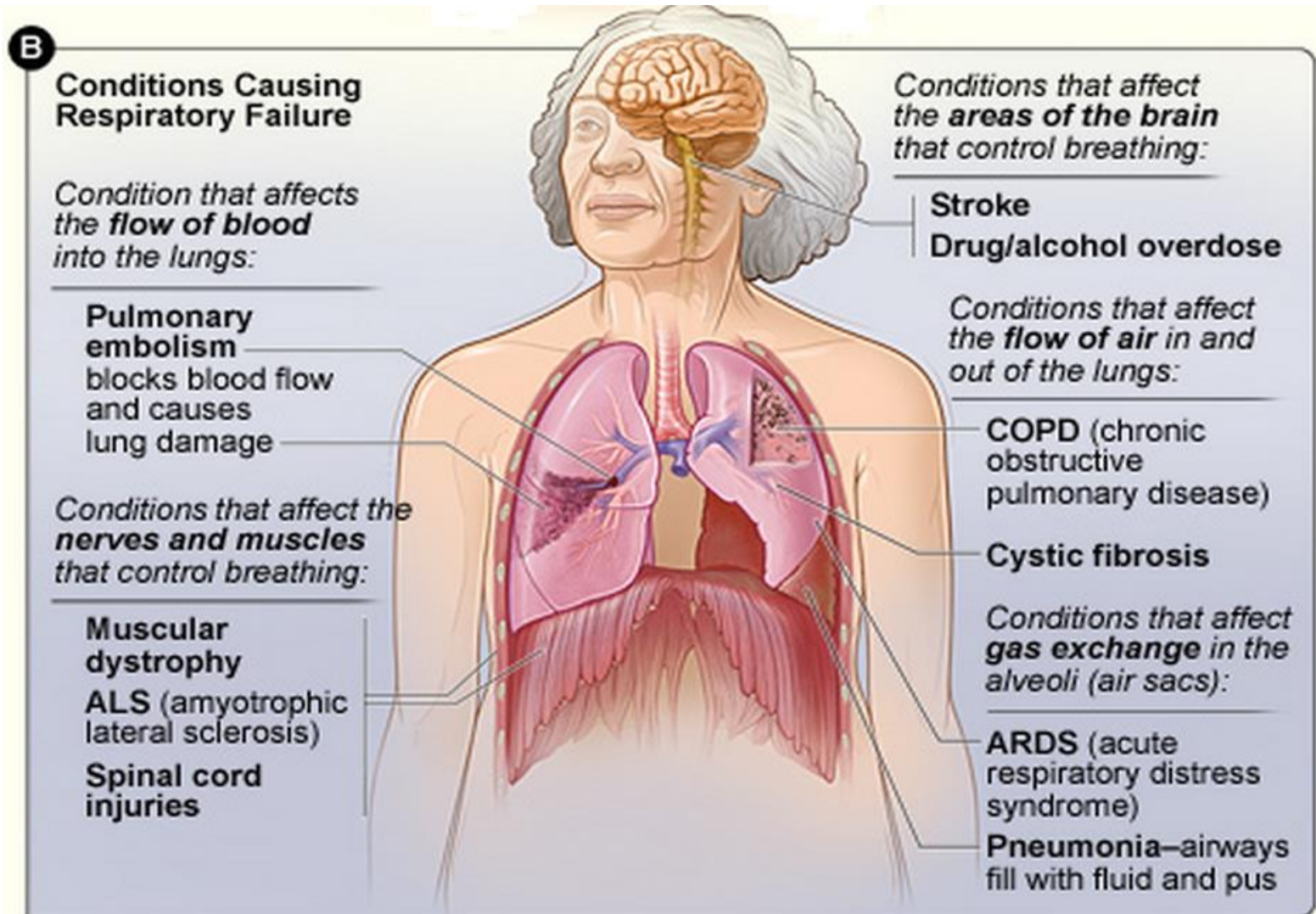


# **The application of a piezo-resistive cardiorespiratory sensor system in an automobile safety belt**

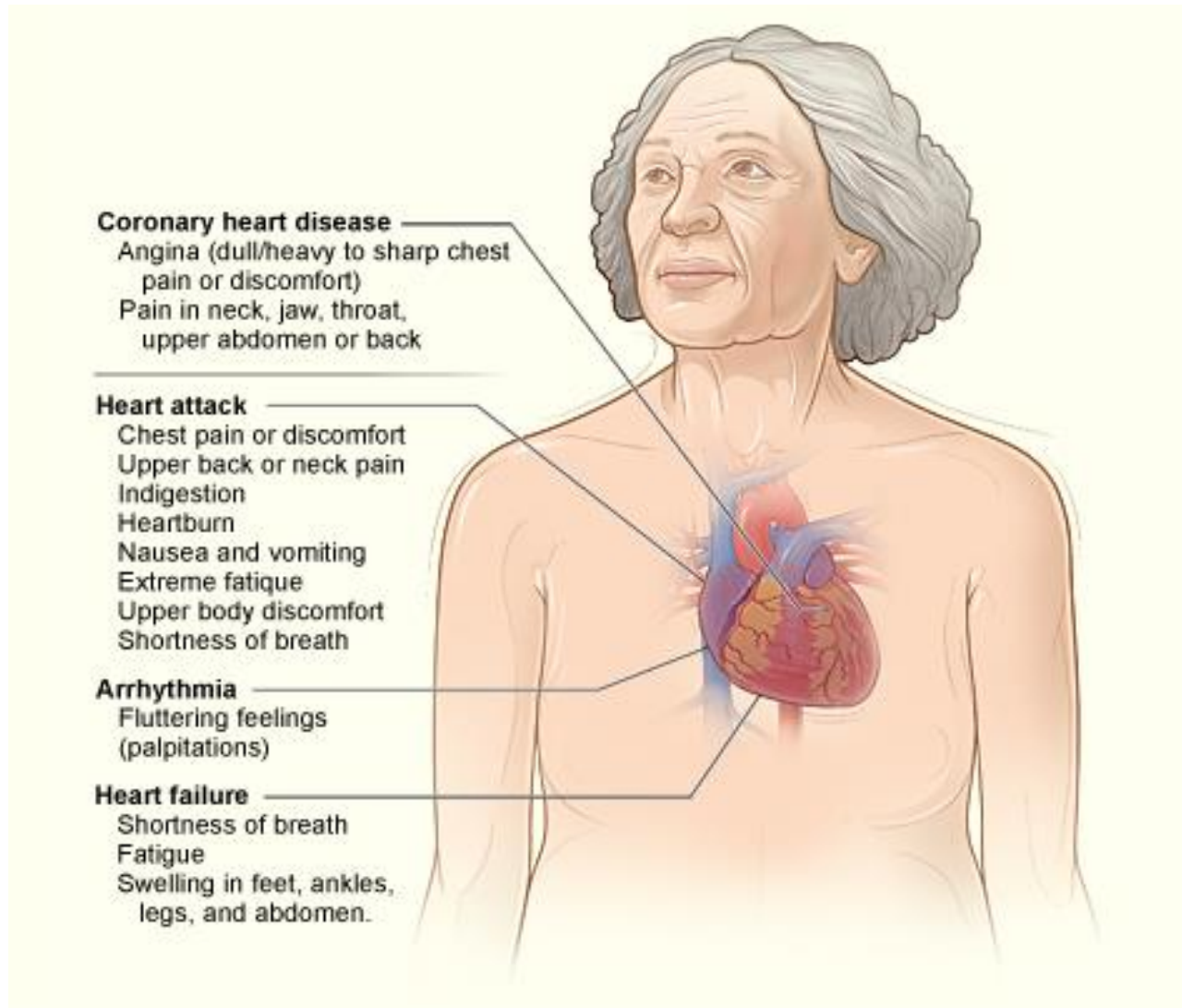
Author(s): Syed Talha Ali Hamdani, Prasad Potluri and Anura Fernando

School of Materials  
University of Manchester, UK

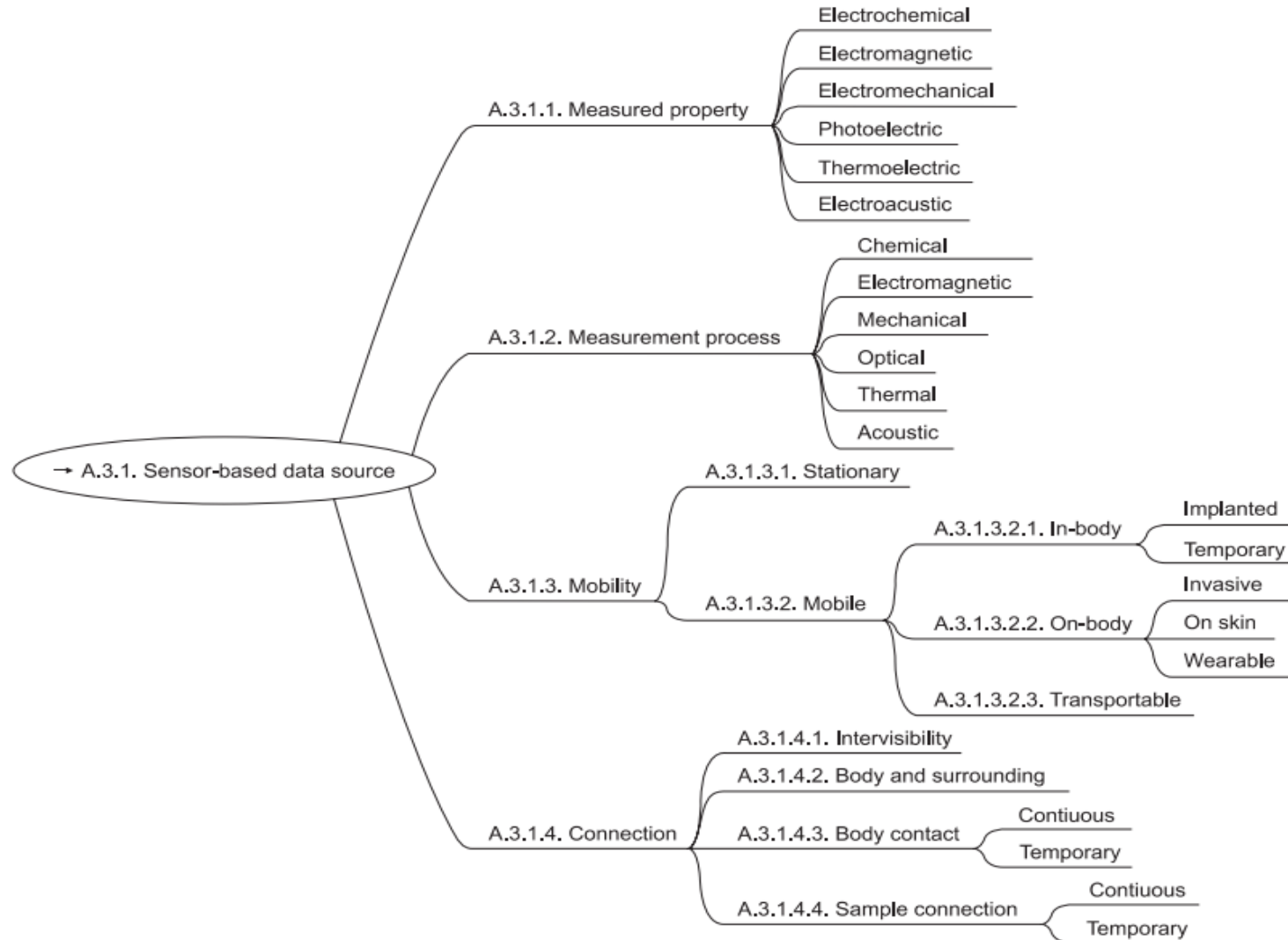
# Conditions Causing Respiratory Failure



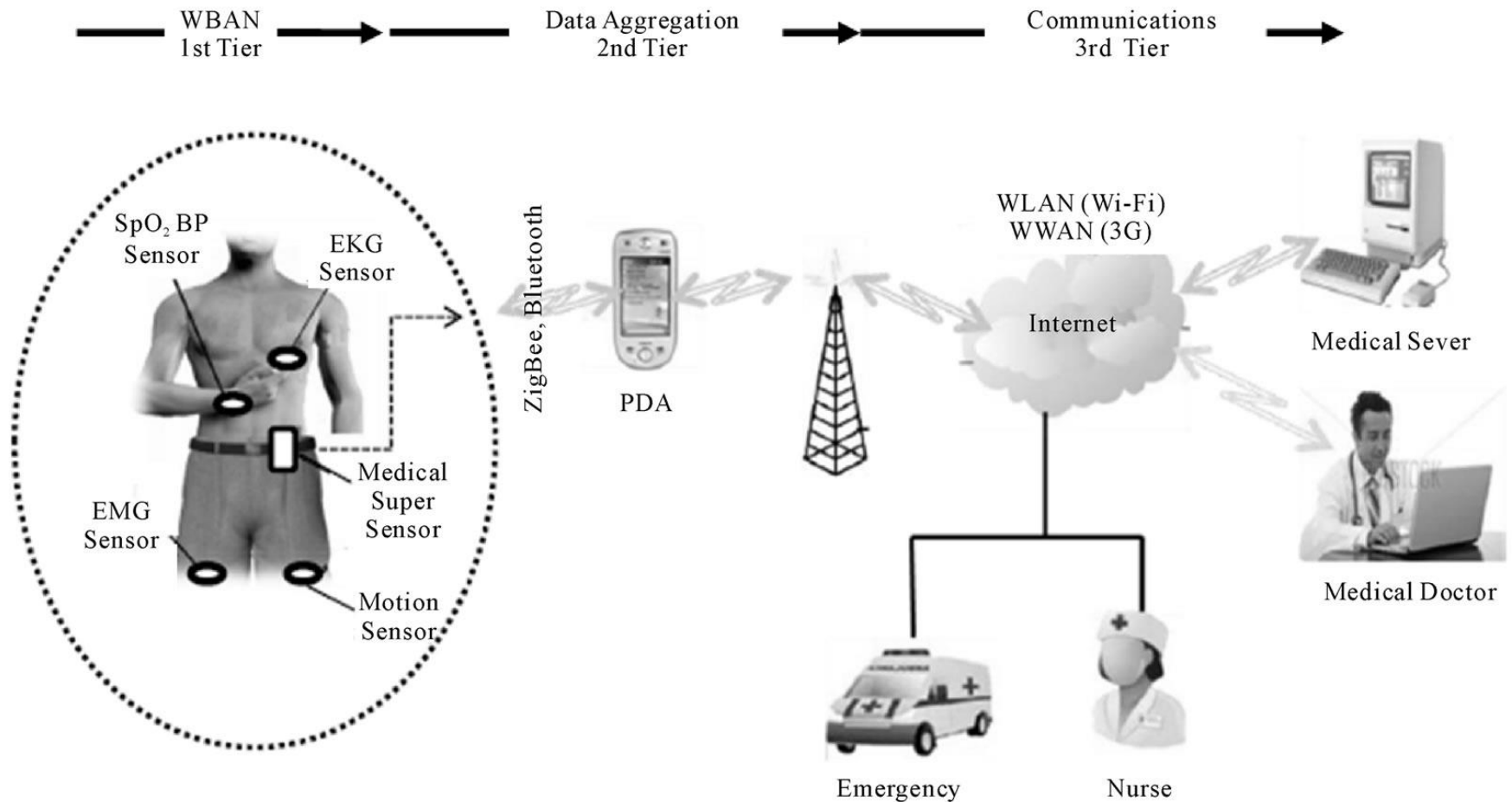
# Heart Disease Signs and Symptoms



# Sensor-based data sources



# Wearable Sensors for Remote Healthcare Monitoring System

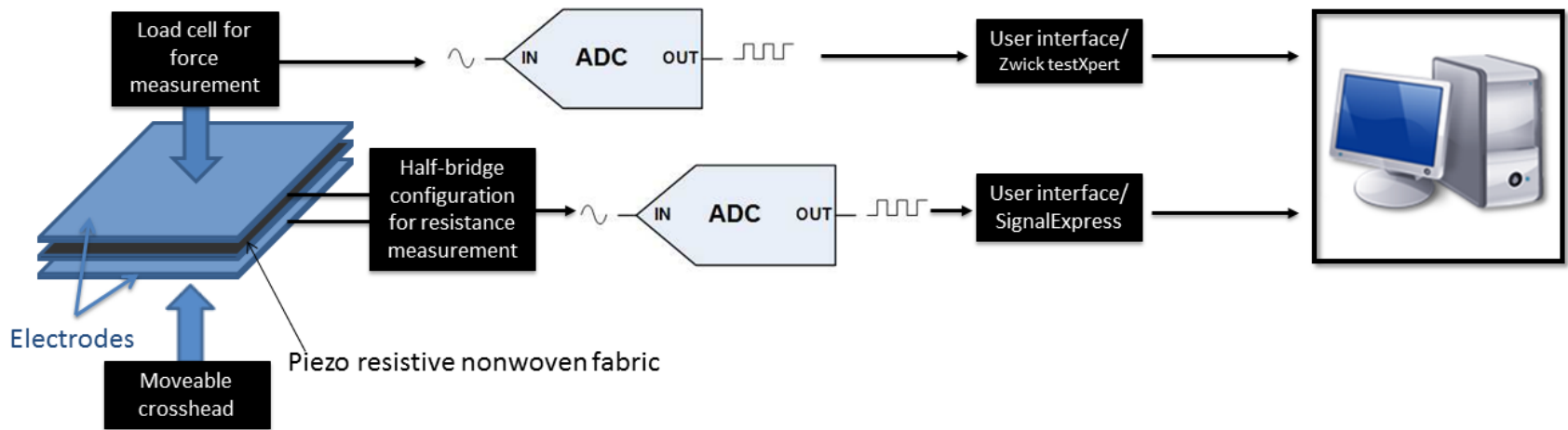


# Motor vehicles (per 1,000 people)

Country Name	2004	2005	2006	2007	2008	2009	2010	2011
World	145.12	153.52	159.99	180.18	165.94	168.58		
Australia	652.68	661.85	671.35	678.91	688.77	691.05	697.97	702.82
Austria	547.19	549.85	553.73	557.48	560.83	568.72	577.78	585.31
Belgium	530.05	533.65	538.19	543.70	547.43	551.21	559.41	562.27
Cayman Islands	529.13			606.83	629.77	622.28	612.75	589.45
Cyprus	449.55	461.67	469.24	500.20	528.04	539.26	531.64	529.31
Finland	515.18	530.93	545.50	542.58	534.38	532.05	612.01	550.83
France	574.77	574.59	576.29	578.84	578.12	578.41	580.02	581.61
Germany	536.80	543.28	549.37	553.14	556.37	563.59	572.42	587.59
Greece	475.46	496.80	519.34	543.35	564.26	572.71	580.00	579.80
Iceland	685.52	724.17	748.30	772.07	767.18	747.72	745.47	746.97
Ireland	462.24	476.13	500.30	520.28	523.43	512.71	500.06	490.51
Italy		666.98	676.55	662.87	668.65	672.43	679.41	682.32
Japan	580.84	587.17	592.19	593.51	592.19	590.31	589.85	587.95
Kuwait	466.23	501.18	516.38	516.71	519.44	522.54	527.57	538.62
Liechtenstein						802.56	830.84	826.36
Lithuania	421.02	466.59	513.66	518.27	546.44	555.47	559.52	614.86
Luxembourg	719.18	727.05	733.82	740.65	746.94	739.02	738.76	741.03
Malta	636.10	633.57	547.98	664.06	673.69	680.88	692.99	708.75
Monaco			793.52	807.45	799.07	841.71	843.03	842.30
Netherlands	493.73	496.81	503.90	513.59	521.69	523.36	526.67	530.78
New Zealand	696.54	713.65	724.33	729.29	732.99	717.53	711.55	708.28
Norway	535.36	545.74	557.80	571.88	575.31	577.58	583.99	591.40
Poland	378.43	385.78	415.83	451.12	495.25	508.15	532.12	554.22
Portugal			508.60				578.31	583.57
Slovenia	504.20	518.33	528.92	547.03	565.30	567.14	566.51	568.23
Spain	566.91	579.71	590.60	605.51	606.14	592.10	592.87	593.41
Sweden	508.03	512.56	517.14	522.63	520.75	519.15	519.74	525.29
Switzerland	558.56	562.97	565.54	569.26	566.73	562.50	566.12	572.60
United Kingdom	510.02	517.22	516.82	522.03	521.60	518.31	518.29	515.55
United States	810.24	816.18	818.30	820.85	816.08	802.82	782.48	785.57

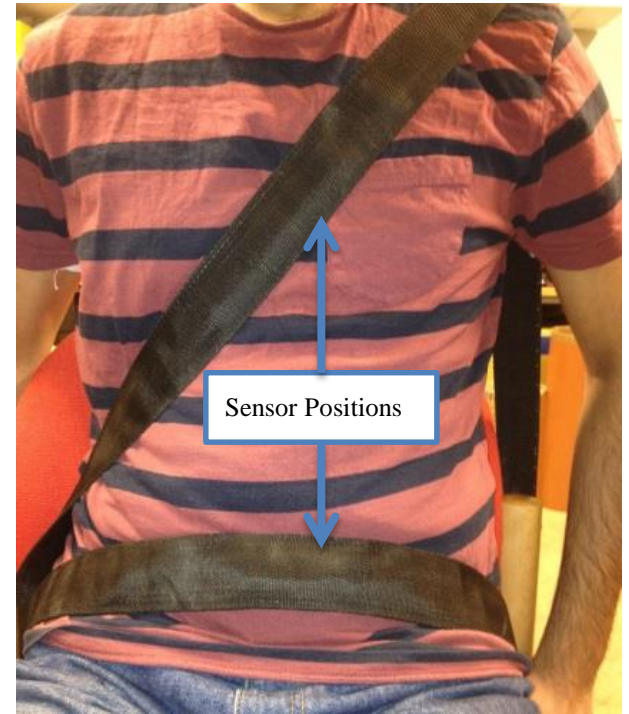
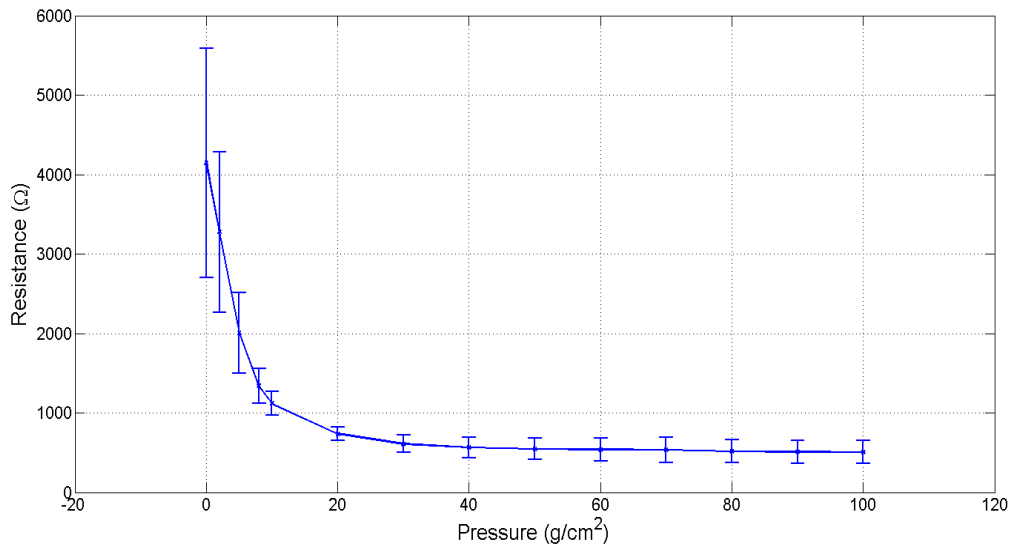
<http://data.worldbank.org/indicator/IS.VEH.NVEH.P3>

# Experimental setup



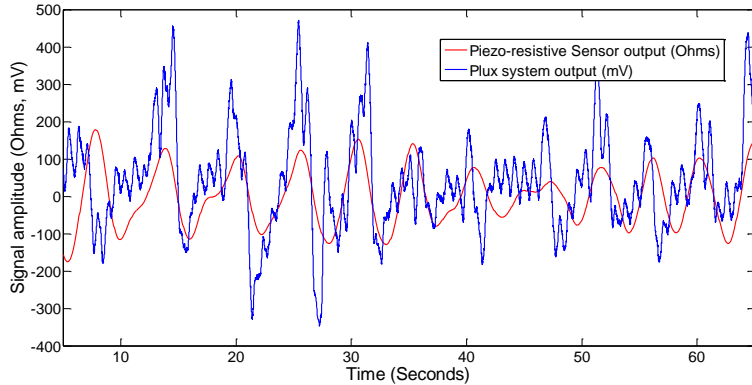


# Sensors characteristic curve

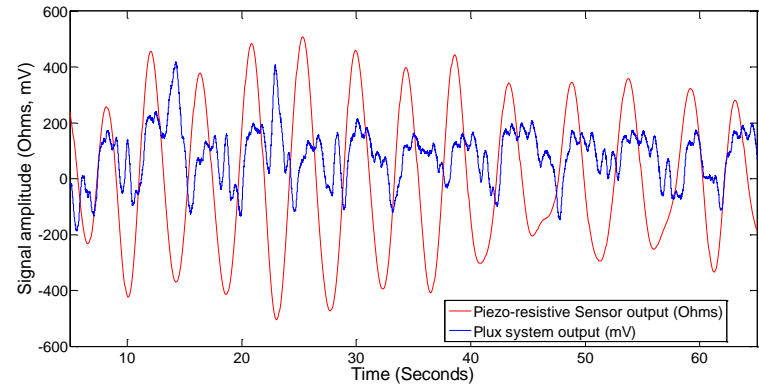




# Results from prototype of safety belt

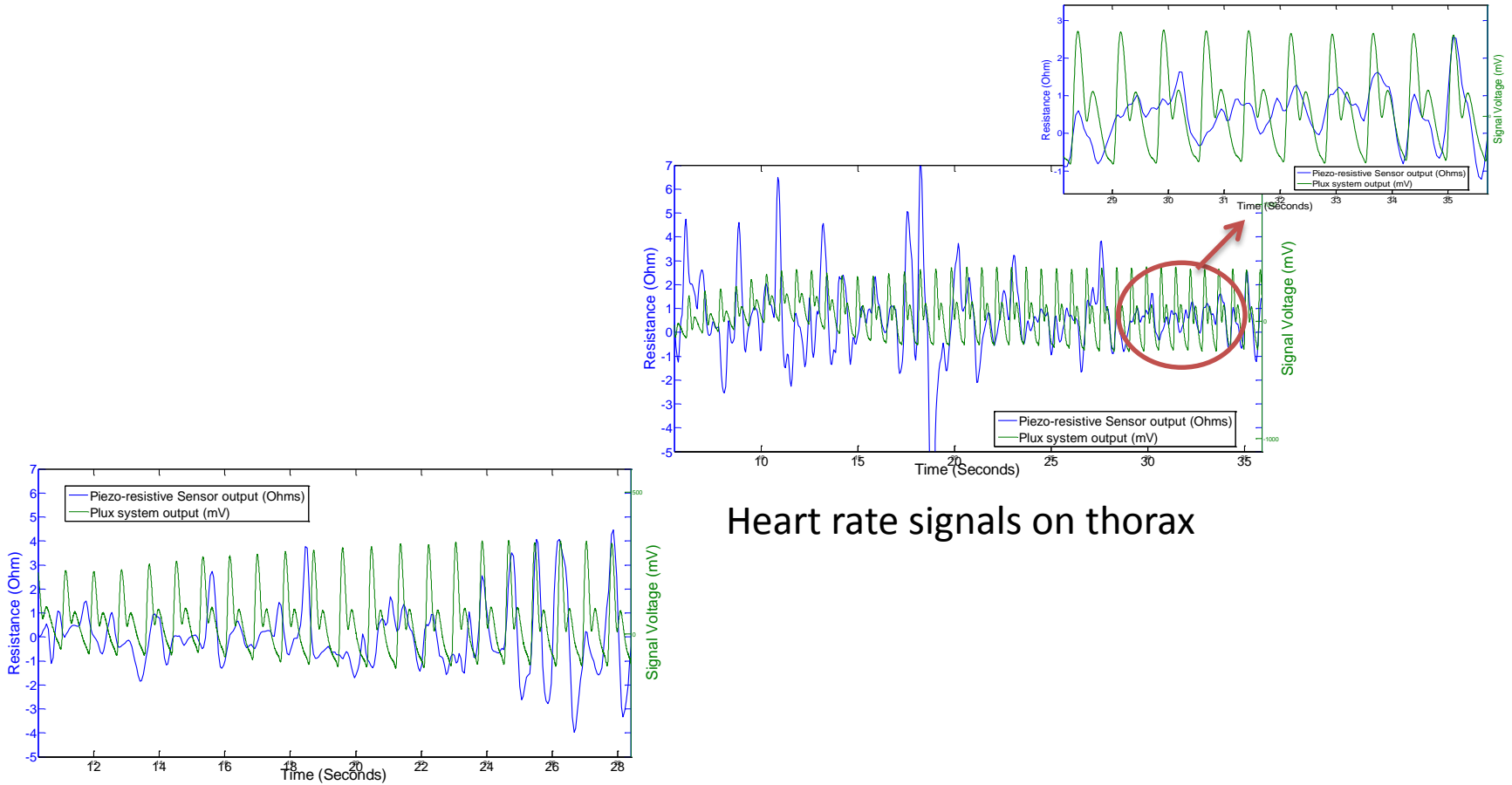


Breathing signals on thorax



Breathing signals on abdomen

*continued*



Heart rate signals on thorax

Heart rate signals on abdomen

# Conclusion

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Position of sensor	Breathing signals ( $\Omega$ )	Heart signals ( $\Omega$ )
Thorax	200-400	2-6
Abdomen	700-900	n/a

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