



Bloodlink

# The impact of guideline-based decision support on general practitioners' test ordering

Marc van Wijk

Mees Mosseveld

Arthur Bohnen

Johan van der Lei

Department of Medical Informatics, Erasmus University

<http://www.eur.nl/FGG/MI/>

# Outline

- **Introduction**
- **Research in the Netherlands**
- **Analysis of guidelines of Dutch College of General Practitioners (DCGP)**
- **Randomized trial with BloodLink a computer-based decision support system on blood test ordering**
- **Conclusions**

# Introduction

- 3-4 % of patient's encounters with GP result in test ordering
- Annually: over \$ 40.000.000
- Large diversity in test-ordering behavior
- Difficult to influence



# Research in the Netherlands with proven effect on test ordering behavior

## Restricted Order Form

Indikatie

vooraf geschatte kans op afwijking in %

0-10	10-20	20-30	30-40	40-50
50-60	60-70	70-80	80-90	90-100

bevestigen/uitsluiten specifieke hypothese

screening onduidelijke pathologie

controle bekende aandoening

verzoek patiënt

<b>ANEMIE</b>	<b>PFEIFFER</b>	<b>FAECES</b>
hemoglobine	microstroom	occult bloed
<b>SCREENING</b>	<b>LEVERFUNCTIE</b>	
Bezinking	zonder icterus	<b>URINE</b>
	ALAT	glucose
<b>DIABETES</b>	Gamma-GT	ketonen
diagnose	met icterus	eiwit
glucose 2 uur na maaltijd	ALAT	sediment
controle diabetes	ASAT	
glucose nuchter	Gamma-GT	<b>DIVERSEN</b>
HbA <sub>1c</sub>	bilirubine totaal	
<b>NIERFUNCTIE</b>	<b>CONTROLE THERAPIE</b>	
creatinine	diuretica	
	kaliüm	
<b>SCHILDKLIJER</b>	<b>RISICOFACTOREN</b>	
diagnostiek	cholesterol	
TSH		
controle		
T4		

## Problem oriented Order Form

The image shows a highly detailed and complex order form. It features multiple columns and rows of text, likely representing different clinical problems or test categories. The form is densely packed with information, including what appears to be a header with logos, various checkboxes, and a grid-like structure for data entry. The text is small and difficult to read, but the overall layout is organized into distinct vertical sections.

# DCGP-Guidelines

- DCGP-guidelines difficult to access
- Analysis DCGP-guidelines (M1 - M64)
  - 23 guidelines include recommendations for test ordering
- Ordering protocols based on DCGP-guidelines



# Objective

To evaluate which method is most effective on test-ordering behavior

- BloodLink-Guideline
- BloodLink-Restricted



voornaam		
voort gezette naam en afkorting n. v.		
D 10	10-20	20-30
30-40	40-50	50-60
60-70	70-80	80-90
90-100	100-110	110-120
120-130	130-140	140-150
150-160	160-170	170-180
180-190	190-200	200-210
210-220	220-230	230-240
240-250	250-260	260-270
270-280	280-290	290-300
300-310	310-320	320-330
330-340	340-350	350-360
360-370	370-380	380-390
390-400	400-410	410-420
420-430	430-440	440-450
450-460	460-470	470-480
480-490	490-500	500-510
510-520	520-530	530-540
540-550	550-560	560-570
570-580	580-590	590-600
600-610	610-620	620-630
630-640	640-650	650-660
660-670	670-680	680-690
690-700	700-710	710-720
720-730	730-740	740-750
750-760	760-770	770-780
780-790	790-800	800-810
810-820	820-830	830-840
840-850	850-860	860-870
870-880	880-890	890-900
900-910	910-920	920-930
930-940	940-950	950-960
960-970	970-980	980-990
990-1000	1000-1010	1010-1020
1020-1030	1030-1040	1040-1050
1050-1060	1060-1070	1070-1080
1080-1090	1090-1100	1100-1110
1110-1120	1120-1130	1130-1140
1140-1150	1150-1160	1160-1170
1170-1180	1180-1190	1190-1200
1200-1210	1210-1220	1220-1230
1230-1240	1240-1250	1250-1260
1260-1270	1270-1280	1280-1290
1290-1300	1300-1310	1310-1320
1320-1330	1330-1340	1340-1350
1350-1360	1360-1370	1370-1380
1380-1390	1390-1400	1400-1410
1410-1420	1420-1430	1430-1440
1440-1450	1450-1460	1460-1470
1470-1480	1480-1490	1490-1500
1500-1510	1510-1520	1520-1530
1530-1540	1540-1550	1550-1560
1560-1570	1570-1580	1580-1590
1590-1600	1600-1610	1610-1620
1620-1630	1630-1640	1640-1650
1650-1660	1660-1670	1670-1680
1680-1690	1690-1700	1700-1710
1710-1720	1720-1730	1730-1740
1740-1750	1750-1760	1760-1770
1770-1780	1780-1790	1790-1800
1800-1810	1810-1820	1820-1830
1830-1840	1840-1850	1850-1860
1860-1870	1870-1880	1880-1890
1890-1900	1900-1910	1910-1920
1920-1930	1930-1940	1940-1950
1950-1960	1960-1970	1970-1980
1980-1990	1990-2000	2000-2010
2010-2020	2020-2030	2030-2040
2040-2050	2050-2060	2060-2070
2070-2080	2080-2090	2090-2100
2100-2110	2110-2120	2120-2130
2130-2140	2140-2150	2150-2160
2160-2170	2170-2180	2180-2190
2190-2200	2200-2210	2210-2220
2220-2230	2230-2240	2240-2250
2250-2260	2260-2270	2270-2280
2280-2290	2290-2300	2300-2310
2310-2320	2320-2330	2330-2340
2340-2350	2350-2360	2360-2370
2370-2380	2380-2390	2390-2400
2400-2410	2410-2420	2420-2430
2430-2440	2440-2450	2450-2460
2460-2470	2470-2480	2480-2490
2490-2500	2500-2510	2510-2520
2520-2530	2530-2540	2540-2550
2550-2560	2560-2570	2570-2580
2580-2590	2590-2600	2600-2610
2610-2620	2620-2630	2630-2640
2640-2650	2650-2660	2660-2670
2670-2680	2680-2690	2690-2700
2700-2710	2710-2720	2720-2730
2730-2740	2740-2750	2750-2760
2760-2770	2770-2780	2780-2790
2790-2800	2800-2810	2810-2820
2820-2830	2830-2840	2840-2850
2850-2860	2860-2870	2870-2880
2880-2890	2890-2900	2900-2910
2910-2920	2920-2930	2930-2940
2940-2950	2950-2960	2960-2970
2970-2980	2980-2990	2990-3000
3000-3010	3010-3020	3020-3030
3030-3040	3040-3050	3050-3060
3060-3070	3070-3080	3080-3090
3090-3100	3100-3110	3110-3120
3120-3130	3130-3140	3140-3150
3150-3160	3160-3170	3170-3180
3180-3190	3190-3200	3200-3210
3210-3220	3220-3230	3230-3240
3240-3250	3250-3260	3260-3270
3270-3280	3280-3290	3290-3300
3300-3310	3310-3320	3320-3330
3330-3340	3340-3350	3350-3360
3360-3370	3370-3380	3380-3390
3390-3400	3400-3410	3410-3420
3420-3430	3430-3440	3440-3450
3450-3460	3460-3470	3470-3480
3480-3490	3490-3500	3500-3510
3510-3520	3520-3530	3530-3540
3540-3550	3550-3560	3560-3570
3570-3580	3580-3590	3590-3600
3600-3610	3610-3620	3620-3630
3630-3640	3640-3650	3650-3660
3660-3670	3670-3680	3680-3690
3690-3700	3700-3710	3710-3720
3720-3730	3730-3740	3740-3750
3750-3760	3760-3770	3770-3780
3780-3790	3790-3800	3800-3810
3810-3820	3820-3830	3830-3840
3840-3850	3850-3860	3860-3870
3870-3880	3880-3890	3890-3900
3900-3910	3910-3920	3920-3930
3930-3940	3940-3950	3950-3960
3960-3970	3970-3980	3980-3990
3990-4000	4000-4010	4010-4020
4020-4030	4030-4040	4040-4050
4050-4060	4060-4070	4070-4080
4080-4090	4090-4100	4100-4110
4110-4120	4120-4130	4130-4140
4140-4150	4150-4160	4160-4170
4170-4180	4180-4190	4190-4200
4200-4210	4210-4220	4220-4230
4230-4240	4240-4250	4250-4260
4260-4270	4270-4280	4280-4290
4290-4300	4300-4310	4310-4320
4320-4330	4330-4340	4340-4350
4350-4360	4360-4370	4370-4380
4380-4390	4390-4400	4400-4410
4410-4420	4420-4430	4430-4440
4440-4450	4450-4460	4460-4470
4470-4480	4480-4490	4490-4500
4500-4510	4510-4520	4520-4530
4530-4540	4540-4550	4550-4560
4560-4570	4570-4580	4580-4590
4590-4600	4600-4610	4610-4620
4620-4630	4630-4640	4640-4650
4650-4660	4660-4670	4670-4680
4680-4690	4690-4700	4700-4710
4710-4720	4720-4730	4730-4740
4740-4750	4750-4760	4760-4770
4770-4780	4780-4790	4790-4800
4800-4810	4810-4820	4820-4830
4830-4840	4840-4850	4850-4860
4860-4870	4870-4880	4880-4890
4890-4900	4900-4910	4910-4920
4920-4930	4930-4940	4940-4950
4950-4960	4960-4970	4970-4980
4980-4990	4990-5000	5000-5010
5010-5020	5020-5030	5030-5040
5040-5050	5050-5060	5060-5070
5070-5080	5080-5090	5090-5100
5100-5110	5110-5120	5120-5130
5130-5140	5140-5150	5150-5160
5160-5170	5170-5180	5180-5190
5190-5200	5200-5210	5210-5220
5220-5230	5230-5240	5240-5250
5250-5260	5260-5270	5270-5280
5280-5290	5290-5300	5300-5310
5310-5320	5320-5330	5330-5340
5340-5350	5350-5360	5360-5370
5370-5380	5380-5390	5390-5400
5400-5410	5410-5420	5420-5430
5430-5440	5440-5450	5450-5460
5460-5470	5470-5480	5480-5490
5490-5500	5500-5510	5510-5520
5520-5530	5530-5540	5540-5550
5550-5560	5560-5570	5570-5580
5580-5590	5590-5600	5600-5610
5610-5620	5620-5630	5630-5640
5640-5650	5650-5660	5660-5670
5670-5680	5680-5690	5690-5700
5700-5710	5710-5720	5720-5730
5730-5740	5740-5750	5750-5760
5760-5770	5770-5780	5780-5790
5790-5800	5800-5810	5810-5820
5820-5830	5830-5840	5840-5850
5850-5860	5860-5870	5870-5880
5880-5890	5890-5900	5900-5910
5910-5920	5920-5930	5930-5940
5940-5950	5950-5960	5960-5970
5970-5980	5980-5990	5990-6000
6000-6010	6010-6020	6020-6030
6030-6040	6040-6050	6050-6060
6060-6070	6070-6080	6080-6090
6090-6100	6100-6110	6110-6120
6120-6130	6130-6140	6140-6150
6150-6160	6160-6170	6170-6180
6180-6190	6190-6200	6200-6210
6210-6220	6220-6230	6230-6240
6240-6250	6250-6260	6260-6270
6270-6280	6280-6290	6290-6300
6300-6310	6310-6320	6320-6330
6330-6340	6340-6350	6350-6360
6360-6370	6370-6380	6380-6390
6390-6400	6400-6410	6410-6420
6420-6430	6430-6440	6440-6450
6450-6460	6460-6470	6470-6480
6480-6490	6490-6500	6500-6510
6510-6520	6520-6530	6530-6540
6540-6550	6550-6560	6560-6570
6570-6580	6580-6590	6590-6600
6600-6610	6610-6620	6620-6630
6630-6640	6640-6650	6650-6660
6660-6670	6670-6680	6680-6690
6690-6700	6700-6710	6710-6720
6720-6730	6730-6740	6740-6750
6750-6760	6760-6770	6770-6780
6780-6790	6790-6800	6800-6810
6810-6820	6820-6830	6830-6840
6840-6850	6850-6860	6860-6870
6870-6880	6880-6890	6890-6900
6900-6910	6910-6920	6920-6930
6930-6940	6940-6950	6950-6960
6960-6970	6970-6980	6980-6990
6990-7000	7000-7010	7010-7020
7020-7030	7030-7040	7040-7050
7050-7060	7060-7070	7070-7080
7080-7090	7090-7100	7100-7110
7110-7120	7120-7130	7130-7140
7140-7150	7150-7160	7160-7170
7170-7180	7180-7190	7190-7200
7200-7210	7210-7220	7220-7230
7230-7240	7240-7250	7250-7260
7260-7270	7270-7280	7280-7290
7290-7300	7300-7310	7310-7320
7320-7330	7330-7340	7340-7350
7350-7360	7360-7370	7370-7380
7380-7390	7390-7400	7400-7410
7410-7420	7420-7430	7430-7440
7440-7450	7450-7460	7460-7470
7470-7480	7480-7490	7490-7500
7500-7510	7510-7520	7520-7530
7530-7540	7540-7550	7550-7560
7560-7570	7570-7580	7580-7590
7590-7600	7600-7610	7610-7620
7620-7630	7630-7640	7640-7650
7650-7660	7660-7670	7670-7680
7680-7690	7690-7700	7700-7710
7710-7720	7720-7730	7730-7740
7740-7750	7750-7760	7760-7770
7770-7780	7780-7790	7790-7800
7800-7810	7810-7820	7820-7830
7830-7840	7840-7850	7850-7860
7860-7870	7870-7880	7880-7890
7890-7900	7900-7910	7910-7920
7920-7930	7930-7940	7940-7950
7950-7960	7960-7970	7970-7980
7980-7990		

# Methods

- **Randomized controlled trial**
- **Two versions of module BloodLink**
  - **BloodLink-Guideline**
    - ♦ **indication-oriented (based on DCGP-guidelines)**

# BloodLink-Guideline

BloodLink Problemoriented Laboratory Request.

Naam M.A.M. Wijk van Grabijnhof 2A 46 jr. Man

230 P

## Guideline

Anaemia  
Angina pectoris  
Atopic syndrome  
Bleeding tendency  
Dementia syndrome  
Diabetes mellitus  
HIV-infection  
Heart Failure  
Hypercholesterolaemia  
Hypertension  
Liver disorders  
Mononucleosis infectiosa  
Pregnancy  
Prostate complaints  
Rheumatoid arthritis  
TIA  
Thyreoid dysfunctions  
Vague Complaints

MEER

# BloodLink-Guideline

BloodLink Problemoriented Laboratory Request.

Naam **M.A.M. Wijk van** Grabijnhof 2A 46 jr. Man

230 P

Guideline

**Liver disorders**

Drug-induced liver damage

Hepatitis A

**Hepatitis B**

Hepatitis C

Icterus

Icterus neonatorum

Livercirrhosis

Suspicion alcohol-hepatitis

**Liver disorders**

Mononucleosis infectiosa

Pregnancy

Prostate complaints

Rheumatoid arthritis

TIA

Thyreoid dysfunctions

Vague Complaints

MEER

# BloodLink-Guideline

BloodLink Problemoriented Laboratory Request.

Naam **M.A.M. Wijk van** Grabijnhof 2A 46 jr. Man

230 P

Guideline

Liver disorders

**Hepatitis B**

Control course (every 4 weeks)

Exclusion HBsAg-carrier

Exclusion chronic hepatitis

**Recent infection hepatitis B**

Livercirrhosis

Suspicion alcohol-hepatitis

**Liver disorders**

Mononucleosis infectiosa

Pregnancy

Prostate complaints

Rheumatoid arthritis

TIA

Thyreoid dysfunctions

Vague Complaints

MEER

# BloodLink-Guideline

BloodLink Problemoriented Laboratory Request.

Naam M.A.M. Wijk van Grabijnhof 2A 46 jr. Man 230 P

---

Guideline : Liver disorders  
Disease : Hepatitis B  
Indication : Recent infection hepatitis B

**Protocol**

ALAT(PT)	: Yes
HBC-AS	: Yes
HBSAG	: Yes
Other test	: No

<Enter> = Switch Yes/No  
<F3> = Help information

-> = Fasting value/Urgent  
∨ = Fasting value/Urgent

<F1> = Exit this screen

Fasting value:	No
Urgent	: No



# Methods

- **Randomized controlled trial**
- **Two versions of module BloodLink**
  - **BloodLink-Guideline**
    - ◆ **indication-oriented (based on DCGP-guidelines)**
  - **BloodLink-Restricted**
    - ◆ **restricted order form**

# BloodLink-Restricted

BloodLink Restricted Laboratory Request.

Naam **M.A.M. Wijk van** Grabijnhof 2A 46 jr. Man 230 P

---

**Protocol**

ALAT(PT)	: Yes
ASAT(OT)	: No
BILIRUBINE TOT	: No
BSE	: No
CHOLESTEROL	: No
GAMMA GT	: Yes
GLUC BL	: No
GLUC BL N	: No
HB	: Yes
HBA1C	: No
K	: No
KREAT	: No
MCV	: No
PAULBUNNELL	: No
TSH	: No
VRIJE T4	: No
<b>Other test</b>	<b>: No</b>

Fasting value: No  
Urgent : No

<Enter> = Switch Yes/No  
<F3> = Help information  
-> = Fasting value/Urgent  
∨ = Fasting value/Urgent  
<F1> = Exit this screen

# BloodLink-Restricted

BloodLink Restricted Laboratory Request.

Naam **M.A.M. Wijk van** Grabijnhof 2A 46 jr. Man 230 P

---

<p>Protocol</p> <p>ALAT(PT) : Yes</p> <p>ASAT(OT) : No</p> <p>BILIRUBINE TOT : No</p> <p>BSE : No</p> <p>CHOLESTEROL : No</p> <p>GAMMA GT : Yes</p> <p>GLUC BL : No</p> <p>GLUC BL N : No</p> <p>HB : Yes</p> <p>HBA1C : No</p> <p>K : No</p> <p>KREAT : No</p> <p>MCV : No</p> <p>PAULBUNNELL : No</p> <p>TSH : No</p> <p>VRIJE T4 : No</p> <p>Other test : Yes</p>	<p>Bepaling: <b>al</b></p> <div style="border: 1px solid black; height: 100px; width: 100%;"></div> <p>Fasting value: No</p> <p>Urgent : No</p>	<p>Which test?</p> <table border="1" style="width: 100%; border-collapse: collapse;"> <tr><td>ALAT</td><td>ALAT (PT)</td></tr> <tr><td>ALB</td><td>ALBUMINE</td></tr> <tr><td>ALBUMEN</td><td>EIWIT KW URINE</td></tr> <tr><td>ALCOHOL</td><td>ETHANOL</td></tr> <tr><td>ALDOLASE</td><td>ALDOLASE</td></tr> <tr><td>ALDOSTERON</td><td>ALDOSTERON</td></tr> <tr><td>ALFA 1</td><td>ALPHA1FOET</td></tr> <tr style="background-color: #e0e0e0;"><td><b>ALK FOS</b></td><td><b>ALK FOS</b></td></tr> <tr><td>ALK FOS ISOENZYMEN</td><td>ALK FOS ISOENZYMEN</td></tr> <tr><td>ALUMINIUM</td><td>ALUMINIUM</td></tr> </table> <p style="text-align: right;">MEER</p> <p>∨ = Fasting value/Urgent</p> <p>&lt;F1&gt; = Exit this screen</p>	ALAT	ALAT (PT)	ALB	ALBUMINE	ALBUMEN	EIWIT KW URINE	ALCOHOL	ETHANOL	ALDOLASE	ALDOLASE	ALDOSTERON	ALDOSTERON	ALFA 1	ALPHA1FOET	<b>ALK FOS</b>	<b>ALK FOS</b>	ALK FOS ISOENZYMEN	ALK FOS ISOENZYMEN	ALUMINIUM	ALUMINIUM
ALAT	ALAT (PT)																					
ALB	ALBUMINE																					
ALBUMEN	EIWIT KW URINE																					
ALCOHOL	ETHANOL																					
ALDOLASE	ALDOLASE																					
ALDOSTERON	ALDOSTERON																					
ALFA 1	ALPHA1FOET																					
<b>ALK FOS</b>	<b>ALK FOS</b>																					
ALK FOS ISOENZYMEN	ALK FOS ISOENZYMEN																					
ALUMINIUM	ALUMINIUM																					

# Method

- **Randomized controlled trial**
- **Two versions of module BloodLink**
  - **BloodLink-Guideline**
  - **indication-oriented (based on DCGP-guidelines)**
  - **BloodLink-Restricted**
    - ◆ **restricted form (Zaat 1991)**
- **Integrated in EPR**
- **Delft Region, general practitioners, R. de Graaf Hospitals**

# Study

- **Period: March 1st 96 through March 1st 97**
- **Population: 60 gp's, 44 practices**
- **Randomization at the level of practice**
- **Paperform available during study period**
- **Comparing average number of test per order form**

# Total number of tests

<b>Module</b>	<b>Total Number of order forms</b>	<b>Total Number of requested tests</b>	<b>Average number of test per order form</b>
<b>BloodLink Restricted</b>	<b>12.786</b>	<b>87.634</b>	<b>6.9</b>
<b>BloodLink Guideline</b>	<b>12.700</b>	<b>70.479</b>	<b>5.5</b>

( Mann-Whitney test  $p=0.003$ ,  $N=44$ )



# Number of ordered test per module

Test	BloodLink Guideline	Difference	BloodLink Restricted
ESR	5612	-29%	7932
Hemoglobin	6061	-17%	7332
WBC	3719	-26%	5039
Hematocrite	3611	-25%	4830
Creatinine	3314	-34%	5024
Erythrocytes	3360	-28%	4690
MCV	3159	-32%	4642
WBC count	3060	-26%	4151
Cholesterol	3413	-1%	4354
TSH	3213	9%	2954
<b>Gamma-GT</b>	<b>2004</b>	<b>-42%</b>	<b>3466</b>
Glucose in serum	2964	19%	2501
ALAT (SGPT)	1892	-34%	2850
Potassium	1096	-53%	2320
ASAT (SGOT)	959	-58%	2269
Glucose fasting	1286	-20%	1611
Triglycerides	1398	1%	1380
HDL cholesterol	1350	-2%	1382
Sodium	745	-30%	1070
Free T4	618	-47%	1163

# Number of ordered test per module

Test	BloodLink Guideline	Difference	BloodLink Restricted
ESR	5612	-29%	7932
Hemoglobin	6061	-17%	7332
WBC	3719	-26%	5039
Hematocrite	3611	-25%	4830
Creatinine	3314	-34%	5024
Erythrocytes	3360	-28%	4690
MCV	3159	-32%	4642
WBC count	3060	-26%	4151
Cholesterol	3413	-1%	4354
<b>TSH</b>	<b>3213</b>	<b>9%</b>	<b>2954</b>
Gamma-GT	2004	-42%	3466
Glucose in serum	2964	19%	2501
ALAT (SGPT)	1892	-34%	2850
Potassium	1096	-53%	2320
ASAT (SGOT)	959	-58%	2269
Glucose fasting	1286	-20%	1611
Triglycerides	1398	1%	1380
HDL cholesterol	1350	-2%	1382
Natrium	745	-30%	1070
<b>Free T4</b>	<b>618</b>	<b>-47%</b>	<b>1163</b>



## Other conclusion

Effective introduction of DCGP Guidelines in daily practice