



## Targets for maximum waiting times and patient prioritization: Evidence from England

[Link to publication record in Manchester Research Explorer](#)

### Citation for published version (APA):

Sinko, A., Nikolova, S., & Sutton, M. (2013). *Targets for maximum waiting times and patient prioritization: Evidence from England*.

### Citing this paper

Please note that where the full-text provided on Manchester Research Explorer is the Author Accepted Manuscript or Proof version this may differ from the final Published version. If citing, it is advised that you check and use the publisher's definitive version.

### General rights

Copyright and moral rights for the publications made accessible in the Research Explorer are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

### Takedown policy

If you believe that this document breaches copyright please refer to the University of Manchester's Takedown Procedures [<http://man.ac.uk/04Y6Bo>] or contact [uml.scholarlycommunications@manchester.ac.uk](mailto:uml.scholarlycommunications@manchester.ac.uk) providing relevant details, so we can investigate your claim.



# Targets for maximum waiting times and patient prioritisation: evidence from England

Arthur Sinko, Silviya Nikolova, Matt Sutton

## 1 Introduction

Waiting lists and waiting times are of central importance to the experience and perception of health care in the National Health Service (NHS) in England. The aim of this paper is to explore how the implementation of progressively tight and stringently enforced waiting times targets over the period 2000-2008 in the English NHS and their subsequent relaxing in 2010 affected patient prioritisation for elective treatment. We add to the literature by including the period after targets were lifted. We evaluate the effect of government policies for targets for maximum waiting times in England by comparing average waiting times for patient groups defined by patient's age category, number of co-morbidities, and disease chapter in three periods of the NHS reform. We use the Conditional Density Estimation (CDE) approach. We interpret our results within a framework adopted from queuing and scheduling theory.

## 2 Literature Review

Research on patient prioritisation in England has been inconclusive. Propper et al. [2010] addressed possible re-prioritisation concerns by examining urgent cases and complication rates. However, their findings were inconclusive as their difference-in-difference analysis of England and Scotland did not satisfy the commonality in pre-intervention trends assumption. Appleby

et al. [2003] investigate whether there were any changes in the order of admitting patients from waiting lists for orthopaedic surgery. They are able to demonstrate that although admission patterns changed, it is unclear whether any significant and clinically relevant distortions took place. Applying a novel Conditional Density Estimation technique to waiting times data for Scotland in 2002 and 2007 Nikolova et al. [2012] found that health providers reduced the waiting times for long-wait patients at the expense of short-wait patients.

Waiting time distributions are skewed and multi-peaked. These features make the Conditional Density Estimation approach adopted here especially useful in modelling waiting times. The CDE approach was introduced in Gilleskie and Mroz [2004]. It has been previously applied to the evaluation of Scottish waiting time targets in Nikolova et al. [2012]. The method uses flexible functional form to estimate conditional probabilities. Consequently, the conditional density function and expected value of the outcome conditional on covariates are also flexibly specified.

The issue of controlling maximum waiting times is conceptually linked to the the issue of queuing. The queuing concept was first developed by Erlang [1909] to analyze public telephone networks. Several assumptions are applicable to the analysis of maximum waiting time targets in the English NHS. The first assumption is that queuing is non-preemptive. This implies that, under normal conditions, once a treatment begins, it cannot be interrupted to service a higher priority patient. Second, the number of “impatient” patients that can willingly leave the queue is negligible. This means that for practically all patients NHS treatment is the only available option. The third assumption relates to the properties of customer arrival, service time, and number of servers employed. Namely we assume that patient arrivals are determined by a Poisson process, patient treatment times have an exponential distribution, and there are  $n$  units that treat patients simultaneously, that is M/M/n queue is assumed. This implies that distribution of hospital service time across patients with different characteristics is the same *and/or* hospitals do not discriminate between patients’ groups based on their treatment time. Under this set of assumptions Little [1961] and Kingman [1962] found that average waiting time

for the entire population does not depend on the rule for allocating treatment across patient groups. This, however, does not imply that expected waiting times as well as the distributions of maximum waiting time are the same for groups with different priority. Kingman [1962] showed that minimum variance of waiting time is achieved using First Come First Served rules, i.e. when patients are treated in the order they arrived. Tambouratzis [1968] found that maximum variance of waiting time is achieved using Last Come First Served rule where the last patient is treated first. Finally, under the assumption of exponentially distributed treatment times, the only way to increase the number of patients treated per period is to increase the capacity of the system, that is the number of effective hours worked and/or number of hospital units since expected waiting times depend only on the intensity of patient arrival and departure processes. In a more general framework, waiting times can also be decreased through a reduction in variance of hospital treatment for a given average treatment time. For example, reducing its variability to 0 decreases average waiting times by a factor of 2 [Kleinrock, 1975, p.98, p.191].

## **3 Data**

### **3.1 Hospital Episode Statistics (HES)**

Hospital Episode Statistics for three periods 1998–2004, 2004–2008, and 2008–2011 were analysed. 1998–2004 is the first period when maximum waiting time targets were introduced. 1998 is the last year before targets were introduced and 2004 is the year when the 9 month target first had to be achieved. 2004–2008 is the 18 week Referral to Treatment period. 2008–2011 is the period of financial constraint. 2011 is the most recent year available and a year after targets were lifted. HES data cover all episodes of care for English NHS-funded hospital patients provided in NHS hospitals or elsewhere. The data are collected by financial years which run from 1st April to 31st March.

We extract a subset of patients from the full-year population who were admitted for elective

procedure. We have omitted as well external causes of morbidity and mortality and codes for special purposes (ICD-10 chapters 20 and 22) We also drop all patients who are less than 1 year old.

Each year's data consist of all admissions within that financial year and records the date of admission for each patient. The date on which the patient was placed on the waiting list is also recorded. As a result, we have waiting times for all of the admissions recorded in each year. The HES data also collect information on age and the number and type of diagnoses which we use as indicators of patient severity of illness. We study in detail circulatory system diseases<sup>1</sup>.

## 4 Results

### 4.1 Descriptive Analysis

We first study the conditional expected values based on observed and model-implied data for the four years of our analysis (Table 1). The table has three horizontal panels: age categories, number of comorbidities, and disease type. There are four vertical sets of results, one for each year, and each set consists of the following three columns: estimated conditional means, observed averages, and number of patients. Conditional expectations are constructed using a weighted average of the estimated conditional distributions. The weights are constructed using data-implied conditional group probabilities. We compare summary statistics for each two consecutive years. The first panel shows that patients across all age categories waited, on average, less in 2004. We observe similar pattern when we compare data for 2004 and 2008. However, 2011 results show a stark change from previous years; there was an uniform increase in waiting times across all disease categories. The second horizontal panel shows the same pattern of change in average waiting times across co-morbidity groups as well as across age categories. The third panel reports estimated and data-implied numbers for the ICD-10

---

<sup>1</sup>Results for all chapters are available upon request

categories we analyze. Comparing 2004 to 1998 we observe that waiting times, on average, declined across most disease chapters. The pattern is similar when 2008 is compared to 2004. Finally, waiting times in 2011 are higher across most disease categories. We find that waiting times for infectious diseases and unclassified conditions decreased slightly on average. The averages for all types of patients show that elective waits gradually decreased from 101 days in 1998 to 83 days in 2004 to 47 in 2008 before climbing up to 51 days in 2011. The model captures the data quite well. All model-implied results are within 4 days of the observed value. We extend our exploratory analysis in Table 1 by plotting the unconditional distribution of waiting times  $y_t$  in bin units. We define  $y_t$  as

$$y_t = CDF^{Y_2} - CDF^{Y_1}$$

where  $CDF$  is constructed using real data for number of patients still on the waiting list and  $Y_1$  precedes  $Y_2$  in time.

The upper half of Figure 1 shows the difference in the share of patients across all disease categories who are still waiting for treatment at a certain day for the three periods that we consider. The lower three plots present respective differences in shares for cardiovascular patients. The share of untreated patients across all disease categories was uniformly smaller in 2004 compared to 1998 with the difference between the two years peaking at nine months which is the waiting times target for the period. For the 2004/2008 period we observe that the share of untreated patients with very short waiting times was slightly larger in 2008 up to week 2. Overall, however, the share of patients on the waiting list was smaller in 2008. The difference between CDFs for 2008 and 2011 shows that there were more patients waiting for treatment at each time period in 2011 across all disease categories. The lower three plots show that the pattern of results for cardiovascular patients is similar to the pattern for all disease chapters across the three periods of our analysis.

## 4.2 Patient prioritization results

### 4.2.1 Conditional means and their change

Table 2 shows that, for 1998–2004 period, children in the first two age categories with up to 3 co-morbidities experience declines in their waits, while children with 3–5 additional health problems wait longer. Waiting times declined for most patient groups age 18–84. We find that elderly patients age 85+ waited longer in 2004. It appears that, over the 1998–2004 period, the shortest 1998 average waiting times increased while the longest decreased. The policy over the 2004–2008 period led to declines in waiting times for most groups except for children age 1–6 with 3–5 co-morbidities who experience an increase of 1, 6, 15 days, respectively, and children age 7–17 with 5 co-morbidities who waited approximately 4 days more. Similarly to the 1998/2004 period the shortest waiting times increased while the longest waits went down. Relaxing government’s commitment to explicit waiting time targets (2008–2011) resulted in uniform increase in waiting times for all patient groups with the largest increases concentrated among the youngest patients with the largest number of health problems. Finally, we compare 1998 to 2011 to understand how well the NHS performs in 2011 compared to the start of reforms in 1998 in terms of waiting times. We observe that patients younger than 18 years with 3–5 co-morbidities fare worse in 2011 compared to 1998.

### 4.2.2 Effects for changes in age

Table 3 shows that the order of prioritizing cardiovascular patients based on their age remained relatively unchanged in 2004. Although waiting times declined for most patient groups, the overall relative ordering was preserved. The 2004/2008 reforms reorganized the way cardiovascular patients were taken off the waiting list. We find that, in 2008, waiting times decreased progressively with age category. No similar pattern is observed in 2004 when most patient groups up to 55 years old waited progressively longer, while those in the above age

categories experienced declines. This could be explained with the fact that patients age 1–6 are waiting the most. The consequent large increase in waiting times over the 2008–2011 period did not change the established pattern of clinical ordering for treatment.

### **4.2.3 Effects for changes in the number of co-morbidity conditions**

Table 4 shows that, for the initial 1998/2004 period, the overall reduction in waiting times was accompanied by several changes in the pattern for treatment. In particular, in 2004, patients with 2 additional health problems and older than 55 waited relatively longer. Similarly, for patients with 3 co-morbidities and between 18-55 years old. However, in 2004, all patients with 5 co-morbidities waited less compared to patients with 4 additional health problems; this pattern was not present in 1998. The progressive tightening in the waiting times target over the 2004/2008 period affected the existing ordering for treatment. Table 4 results actually point to faster processing of most patients with 2 co-morbidities. However, patients with 5 co-morbidities who are more than 40 years old waited more in 2008. Relaxing government commitment to waiting times target changed the 2008 treatment schedule. We find that patients with 1 co-morbidity who are less than 18 years old and older than 75 waited longer. We also observe that more patient groups with 3 and 4 co-morbidities wait relatively shorter periods in 2011. Finally, all patients with 5 co-morbidities waited longer in 2011.

## **4.3 Scheduling for treatment. A queuing theory framework**

In 1998 there was a large variability in waiting times between different groups of patients within the same disease category. The results are consistent for all three disease chapters for years 1998–2004 (Tables 2). The average waiting times for 2004 show a different picture. On average, waiting times decreased by 20 days across all patient group (Table 1). For some disease categories this decline was accompanied by a decline in the number of patients treated. Waiting times increased for patients with mental diseases or diseases of the nervous system.



However, the variability in waiting times decreased. The implications of these results, using the queuing theory framework outlined in Section 2, are that (1) patient prioritization for treatment was in place in 1998, (2) hospital Trusts adopted a different rule by year 2004. The new scheduling appears closer to First Come, First Served. This policy implies similar waiting times for different patient groups. As a result, the number of patients with very short wait decreased. In addition, there was an increase in NHS capacity over the 1998–2004 period as overall number of treated patients increased. Increases in capacity while preserving existing ordering for treatment should have shifted the entire distribution towards 0. However, our results in Fig 1 provide different evidence. They point to the fact that the target was achieved partially through changing scheduling rule, and partially through increase in capacity.

Comparison of findings for the three disease chapters in 2004 and 2008 shows a different pattern (Tables 2). Over the period there was a large decrease in aggregate waiting times (35 days). The total number of treated patients in 2004 is significantly smaller than in 2008. The variability of average waiting times across different groups of patients further decreased. Figure 1 supports this finding. Altogether these results reflect a significant increase in health care spending and heavy investment in infrastructure that led to decreases in waiting times.

The scheduling rule changed one more time over the 2008–2011 period. First, waiting times increased for almost all disease chapters and patient categories. Second, it increased differently across different patient groups. We can only hope that the implied change in priorities reflects medical need. However, given that we observe the largest increases among the youngest patients with the largest number of co-morbidities, need-based prioritisation for treatment is unlikely.

## 5 Discussion and Conclusions

The high profile waiting times reforms implemented in England since 2000 were a unique experiment in how to alter the performance of a large State bureaucracy. The paper documents

that one of the mechanisms to achieve the maximum waiting times target is by increasing the waiting times for patients who used to wait less. It also detects statistically significant changes in prioritisation between different groups of patients. Children and teenagers with cardiovascular disease problems and large number of co-morbidities waited relatively longer in 2011 compared to 1998. The paper also provides a simple explanation for the observed prioritisation patterns based on well-established scheduling concepts.

A limitation of our analysis is that we do not have information on patients who leave the waiting list due to death, out-migration, or a change in their health condition. We also can not directly control for the severity of patient's condition and instead use as a proxy the number of co-morbidities.

Our findings point to a difficult trade-off that policy-makers face in reducing waiting times through the imposition of maximum threshold. That is successful at reducing the average waiting times and long waiting times, but it occurs at the expense of patients who were more highly prioritised when there was no maximum cap. While we can observe changes in scheduling rules, we do not know how these changes have affected patient health. Further research is needed to answer this question and therefore to assess the overall effect of maximum waiting times targets on social welfare.

## References

- J. Appleby, S. Boyle, N. Devlin, M. Harley, A. Harrison, and L. Locock. Sustaining reduction in waiting times: identifying successful strategies. Report commissioned by the Department of Health Policy Directorate. King's Fund. London, 2003.
- A. K. Erlang. The theory of probabilities and telephone conversations. *Nyt Tidsskrift For Matematik*, 20:33–39, 1909.
- D. Gilleskie and T. Mroz. A flexible approach for estimating the effects of covariates on health expenditures. *Journal of Health Economics*, 23:391–418, 2004.

- J. F. C. Kingman. The effect of queue discipline on waiting time variance. *Mathematical Proceedings of the Cambridge Philosophical Society*, 58(1):163–164, 1962.
- L. Kleinrock. *Queueing Systems*, volume I: Theory. Wiley Interscience, 1975. (Published in Russian, 1979. Published in Japanese, 1979. Published in Hungarian, 1979. Published in Italian 1992.).
- J. D. C. Little. A proof for the queuing formula:  $L = \lambda W$ . *Operations Research*, 9(3):pp. 383–387, 1961. ISSN 0030364X. URL <http://www.jstor.org/stable/167570>.
- S. Nikolova, A. Sinko, and M. Sutton. Do maximum waiting times guarantees change clinical priorities? A Conditional Density Estimation approach. Working Paper, 2012.
- C. Propper, M. Sutton, C. Whitnall, and F. Windmeijer. Incentives and targets in hospital care: Evidence from a natural experiment. *Journal of Public Economics*, 94:318–335, 2010.
- D. G. Tambouratzis. On a property of the variance of the waiting time of a queue. *Journal of Applied Probability*, 5(3):pp. 702–703, 1968. ISSN 00219002. URL <http://www.jstor.org/stable/3211932>.

**Table 1: ACTUAL AND IMPLIED AVERAGE WAITING TIMES.**

Comparison between average waiting times computed directly from the data and their empirical estimates implied by the model.

	1998			2004			2008			2011		
	emp.	data	N	emp.	data	N	emp.	data	N	emp.	data	N
<b>Age Categories</b>												
Age 1-6	93.18	95.05	173111	77.69	78.10	144015	52.55	52.50	137758	64.58	65.15	147188
Age 7-17	109.50	113.04	199528	88.17	90.82	181669	54.00	56.14	177877	62.73	66.79	176268
Age 18-39	109.88	111.58	842447	91.89	92.14	686991	51.74	50.51	766348	56.10	54.14	767117
Age 40-54	101.31	97.73	800228	87.70	86.40	763854	48.47	48.26	961685	51.90	52.24	1048195
Age 55-64	94.92	93.94	576507	82.38	81.69	655374	45.65	45.31	825632	48.78	48.44	883590
Age 65-74	92.02	95.17	610467	76.89	78.16	681825	43.90	44.20	851447	46.96	47.03	971315
Age 75-84	101.75	103.34	438855	74.22	74.63	531304	43.74	44.33	661721	46.39	46.49	741517
Age 85+	116.18	109.75	116936	73.36	70.41	124977	44.39	44.04	183318	45.96	45.83	215848
<b>Number of Co-morbidities</b>												
Co-morbidities 0	105.54	105.99	2142079	87.25	87.46	1802257	48.94	48.87	1875520	51.23	51.01	1318100
Co-morbidities 1	95.89	95.65	926486	79.35	78.60	968555	46.17	45.81	1148033	50.78	50.73	1201324
Co-morbidities 2	96.44	97.18	378548	79.27	80.70	470520	46.00	46.38	658726	50.72	50.69	854503
Co-morbidities 3	96.07	95.49	164265	80.19	79.44	242327	46.04	45.87	377468	50.55	50.49	578894
Co-morbidities 4	94.68	93.83	76777	79.13	77.46	132535	45.86	45.29	220437	50.31	50.05	382149
Co-morbidities 5	89.80	90.33	69930	71.65	72.05	153822	44.37	44.36	285860	49.78	49.74	616163
<b>Disease types</b>												
I. Infections	54.67	55.64	13365	53.89	52.97	11553	31.58	31.65	11032	30.59	30.15	12014
II. Cancer2	48.38	48.04	485025	40.60	40.21	524477	30.06	30.05	559334	33.02	32.95	638738
III. Blood	27.78	27.39	41984	27.70	27.95	45478	20.77	20.68	67800	23.14	23.37	75000
IV. Metabolic	56.79	56.53	41733	52.89	52.97	38603	40.22	40.23	45592	53.34	52.82	49407
V. Mental	32.90	32.67	14521	37.72	37.52	7051	40.65	40.38	4992	41.62	40.99	5180
VI. Nervous	96.00	95.39	77144	97.55	97.33	90741	53.40	53.35	112887	55.73	55.75	122503
VII. Eye	176.29	177.57	292736	87.93	88.01	364124	56.62	56.69	436424	60.00	60.02	471841
VIII. Ear	116.25	117.06	81884	100.76	101.41	61574	60.34	60.03	63418	71.54	71.53	59559
IX. Cardiovascular	122.01	121.84	242866	85.07	84.20	284419	43.55	43.21	322481	47.62	47.19	329445
X. Respiratory	164.39	166.03	151500	117.72	118.23	126676	58.00	58.01	124827	62.05	62.20	126282
XI. Digestive	90.24	90.33	656190	82.15	82.22	589176	41.11	40.76	893048	43.47	43.21	1042119
XII. Skin	91.81	91.53	125939	80.56	80.87	122769	46.28	46.33	125834	48.70	48.62	113935
XIII. Musculoskeletal	156.02	156.45	399570	140.14	140.45	482042	71.60	71.65	661979	77.95	77.97	722209
XIV. Genitourinary	91.29	91.23	466887	76.86	76.63	434466	48.90	48.76	454221	55.53	55.41	447259
XVII. Congenital	120.02	125.60	51231	106.92	109.58	51606	66.20	66.43	52744	78.47	78.53	57232
XVIII. Undiagnosed	59.67	59.37	280249	60.18	60.14	272217	31.65	31.46	343948	30.73	30.58	354343
XIX. External Injury	67.93	68.52	61226	60.63	60.80	68955	37.00	37.31	91972	38.34	38.47	109651
XXI. Health Status Factors	97.46	97.74	274035	79.15	79.39	194089	45.85	45.96	193511	48.94	48.94	214416
<b>Total</b>												
All	101.32	101.56	3758085	82.85	82.84	3770016	47.14	47.04	4566044	50.70	50.59	4951133

**Table 2:** CONDITIONAL MEANS FOR CARDIOVASCULAR DISEASES AND THEIR CHANGE B/N 1998–2011

CDE-implied conditional mean waiting times for different patient groups that vary by age category and number of co-morbidity conditions in 1998, 2004, 2008, and 2011 (first two panel). Change in conditional mean waiting times between years 1998 and 2004, 2004 and 2008, and 2008 and 2011 (the last three panels). Statistically significant results for the 95% two-sided confidence interval are underlined. Statistically significant results for the 99% two-sided confidence interval are in bold font.

Age	1998						2004					
	Number of co-morbidities						Number of co-morbidities					
	0	1	2	3	4	5	0	1	2	3	4	5
0-6	<b>137.29</b>	<b>84.60</b>	<b>53.69</b>	<b>36.07</b>	<b>24.37</b>	<b>18.41</b>	<b>112.56</b>	<b>70.50</b>	<b>54.52</b>	<b>48.32</b>	<b>40.16</b>	<b>24.14</b>
7-17	<b>159.61</b>	<b>106.74</b>	<b>75.37</b>	<b>56.98</b>	<b>44.44</b>	<b>38.03</b>	<b>117.77</b>	<b>75.75</b>	<b>64.15</b>	<b>60.15</b>	<b>55.81</b>	<b>38.36</b>
18-39	<b>175.38</b>	<b>135.77</b>	<b>111.90</b>	<b>100.08</b>	<b>96.45</b>	<b>97.86</b>	<b>121.55</b>	<b>83.92</b>	<b>79.10</b>	<b>82.37</b>	<b>82.92</b>	<b>67.38</b>
40-54	<b>161.89</b>	<b>134.86</b>	<b>120.01</b>	<b>114.43</b>	<b>116.18</b>	<b>124.60</b>	<b>116.29</b>	<b>84.79</b>	<b>83.46</b>	<b>89.75</b>	<b>91.36</b>	<b>79.18</b>
55-64	<b>134.38</b>	<b>117.24</b>	<b>108.93</b>	<b>107.60</b>	<b>112.11</b>	<b>122.25</b>	<b>104.06</b>	<b>78.57</b>	<b>79.52</b>	<b>86.98</b>	<b>89.99</b>	<b>80.10</b>
65-74	<b>103.59</b>	<b>93.18</b>	<b>89.34</b>	<b>90.29</b>	<b>96.41</b>	<b>106.35</b>	<b>88.51</b>	<b>68.21</b>	<b>70.75</b>	<b>79.28</b>	<b>83.43</b>	<b>74.91</b>
75-84	<b>72.84</b>	<b>66.74</b>	<b>65.31</b>	<b>67.59</b>	<b>72.87</b>	<b>80.97</b>	<b>71.04</b>	<b>55.52</b>	<b>58.54</b>	<b>67.80</b>	<b>73.05</b>	<b>64.64</b>
85+	<b>42.40</b>	<b>38.96</b>	<b>37.71</b>	<b>39.23</b>	<b>41.36</b>	<b>44.53</b>	<b>51.75</b>	<b>39.33</b>	<b>42.88</b>	<b>51.53</b>	<b>57.00</b>	<b>48.00</b>
	2008						2011					
0-6	<b>73.44</b>	<b>61.12</b>	<b>53.11</b>	<b>48.98</b>	<b>45.69</b>	<b>38.74</b>	<b>74.01</b>	<b>76.92</b>	<b>72.25</b>	<b>65.39</b>	<b>60.78</b>	<b>62.07</b>
7-17	<b>68.59</b>	<b>56.47</b>	<b>50.08</b>	<b>47.12</b>	<b>45.44</b>	<b>42.11</b>	<b>69.01</b>	<b>70.00</b>	<b>64.79</b>	<b>58.56</b>	<b>55.38</b>	<b>58.04</b>
18-39	<b>61.19</b>	<b>50.98</b>	<b>45.97</b>	<b>44.02</b>	<b>43.61</b>	<b>43.07</b>	<b>63.36</b>	<b>62.43</b>	<b>56.69</b>	<b>51.11</b>	<b>48.12</b>	<b>50.46</b>
40-54	<b>54.98</b>	<b>46.61</b>	<b>42.94</b>	<b>41.83</b>	<b>41.98</b>	<b>42.54</b>	<b>58.18</b>	<b>56.67</b>	<b>51.62</b>	<b>46.82</b>	<b>44.71</b>	<b>46.98</b>
55-64	<b>49.11</b>	<b>42.78</b>	<b>40.47</b>	<b>40.26</b>	<b>40.99</b>	<b>42.14</b>	<b>52.51</b>	<b>51.77</b>	<b>47.91</b>	<b>44.28</b>	<b>42.91</b>	<b>45.73</b>
65-74	<b>44.09</b>	<b>39.20</b>	<b>37.98</b>	<b>38.63</b>	<b>40.02</b>	<b>41.72</b>	<b>47.21</b>	<b>47.17</b>	<b>44.48</b>	<b>41.91</b>	<b>41.30</b>	<b>44.69</b>
75-84	<b>38.72</b>	<b>35.21</b>	<b>35.07</b>	<b>36.62</b>	<b>38.74</b>	<b>40.96</b>	<b>41.07</b>	<b>41.82</b>	<b>40.48</b>	<b>39.02</b>	<b>39.27</b>	<b>43.32</b>
85+	<b>33.07</b>	<b>30.49</b>	<b>31.34</b>	<b>33.86</b>	<b>36.70</b>	<b>39.33</b>	<b>35.08</b>	<b>36.57</b>	<b>36.18</b>	<b>35.77</b>	<b>36.77</b>	<b>41.34</b>
	Change in conditional means between 1998 and 2004											
0-6							<b>-24.73</b>	<b>-14.10</b>	0.83	<b>12.25</b>	<b>15.79</b>	5.73
7-17							<b>-41.84</b>	<b>-30.99</b>	<b>-11.22</b>	3.17	<b>11.37</b>	0.32
18-39							<b>-53.84</b>	<b>-51.84</b>	<b>-32.80</b>	<b>-17.70</b>	<b>-13.53</b>	<b>-30.48</b>
40-54							<b>-45.60</b>	<b>-50.07</b>	<b>-36.55</b>	<b>-24.68</b>	<b>-24.82</b>	<b>-45.41</b>
55-64							<b>-30.31</b>	<b>-38.67</b>	<b>-29.41</b>	<b>-20.61</b>	<b>-22.12</b>	<b>-42.15</b>
65-74							<b>-15.08</b>	<b>-24.97</b>	<b>-18.59</b>	<b>-11.01</b>	<b>-12.98</b>	<b>-31.44</b>
75-84							<i>-1.80</i>	<b>-11.22</b>	<b>-6.76</b>	0.21	0.18	<b>-16.34</b>
85+							<b>9.35</b>	0.38	<b>5.17</b>	<b>12.29</b>	<b>15.64</b>	<i>3.47</i>
	Change in conditional means between 2004 and 2008											
0-6							<b>-39.12</b>	<b>-9.38</b>	-1.41	0.66	5.53	<b>14.60</b>
7-17							<b>-49.18</b>	<b>-19.28</b>	<b>-14.07</b>	<b>-13.03</b>	<b>-10.38</b>	3.75
18-39							<b>-60.35</b>	<b>-32.94</b>	<b>-33.13</b>	<b>-38.35</b>	<b>-39.30</b>	<b>-24.31</b>
40-54							<b>-61.31</b>	<b>-38.18</b>	<b>-40.52</b>	<b>-47.92</b>	<b>-49.38</b>	<b>-36.64</b>
55-64							<b>-54.96</b>	<b>-35.79</b>	<b>-39.06</b>	<b>-46.72</b>	<b>-48.99</b>	<b>-37.96</b>
65-74							<b>-44.42</b>	<b>-29.01</b>	<b>-32.78</b>	<b>-40.65</b>	<b>-43.41</b>	<b>-33.18</b>
75-84							<b>-32.32</b>	<b>-20.31</b>	<b>-23.47</b>	<b>-31.18</b>	<b>-34.31</b>	<b>-23.67</b>
85+							<b>-18.68</b>	<b>-8.84</b>	<b>-11.54</b>	<b>-17.67</b>	<b>-20.30</b>	<b>-8.67</b>
	Change in conditional means between 2008 and 2011											
0-6							0.57	<b>15.80</b>	<b>19.14</b>	<b>16.41</b>	<b>15.09</b>	<b>23.33</b>
7-17							0.42	<b>13.53</b>	<b>14.72</b>	<b>11.44</b>	<b>9.94</b>	<b>15.93</b>
18-39							<b>2.16</b>	<b>11.44</b>	<b>10.72</b>	<b>7.09</b>	<b>4.50</b>	<b>7.39</b>
40-54							<b>3.20</b>	<b>10.06</b>	<b>8.68</b>	<b>5.00</b>	<b>2.72</b>	<b>4.44</b>
55-64							<b>3.40</b>	<b>8.99</b>	<b>7.45</b>	<b>4.02</b>	<b>1.91</b>	<b>3.58</b>
65-74							<b>3.12</b>	<b>7.97</b>	<b>6.50</b>	<b>3.28</b>	<b>1.28</b>	<b>2.97</b>
75-84							<b>2.35</b>	<b>6.61</b>	<b>5.41</b>	<b>2.40</b>	<i>0.53</i>	<b>2.36</b>
85+							<b>2.02</b>	<b>6.08</b>	<b>4.84</b>	<b>1.91</b>	0.07	<b>2.01</b>

**Table 3: MARGINAL EFFECTS FOR AGE: CARDIOVASCULAR**

CDE results for circulatory system diseases. Each number is the difference b/w two consecutive age groups. Statistically significant results for the 95% two-sided confidence interval are underlined. Statistically significant results for the 99% two-sided confidence interval are in bold font.

Age	Number of co-morbidities						Number of co-morbidities					
	0	1	2	3	4	5	0	1	2	3	4	5
	1998						2004					
0-6												
7-17	<b>22.33</b>	<b>22.14</b>	<b>21.68</b>	<b>20.91</b>	<b>20.07</b>	<b>19.63</b>	<u>5.21</u>	<u>5.25</u>	<u>9.63</u>	<u>11.83</u>	<u>15.65</u>	<u>14.22</u>
18-39	<b>15.77</b>	<b>29.02</b>	<b>36.53</b>	<b>43.09</b>	<b>52.01</b>	<b>59.83</b>	<i>3.78</i>	<u>8.17</u>	<u>14.95</u>	<u>22.22</u>	<u>27.10</u>	<u>29.03</u>
40-54	<b>-13.49</b>	-0.91	<u>8.11</u>	<u>14.36</u>	<u>19.73</u>	<u>26.73</u>	<b>-5.26</b>	<i>0.87</i>	<u>4.36</u>	<u>7.38</u>	<u>8.45</u>	<u>11.80</u>
55-64	<b>-27.51</b>	<b>-17.62</b>	<b>-11.08</b>	<b>-6.84</b>	<b>-4.07</b>	<b>-2.35</b>	<b>-12.22</b>	<b>-6.22</b>	<b>-3.94</b>	<b>-2.77</b>	<b>-1.38</b>	<u>0.92</u>
65-74	<b>-30.79</b>	<b>-24.06</b>	<b>-19.59</b>	<b>-17.31</b>	<b>-15.70</b>	<b>-15.90</b>	<b>-15.56</b>	<b>-10.36</b>	<b>-8.77</b>	<b>-7.70</b>	<b>-6.55</b>	<b>-5.19</b>
75-84	<b>-30.75</b>	<b>-26.44</b>	<b>-24.03</b>	<b>-22.70</b>	<b>-23.55</b>	<b>-25.38</b>	<b>-17.47</b>	<b>-12.69</b>	<b>-12.21</b>	<b>-11.48</b>	<b>-10.38</b>	<b>-10.27</b>
85+	<b>-30.44</b>	<b>-27.78</b>	<b>-27.60</b>	<b>-28.36</b>	<b>-31.50</b>	<b>-36.44</b>	<b>-19.29</b>	<b>-16.19</b>	<b>-15.67</b>	<b>-16.27</b>	<b>-16.05</b>	<b>-16.64</b>
	2008						2011					
0-6												
7-17	<i>-4.85</i>	<b>-4.65</b>	<b>-3.04</b>	-1.86	-0.25	3.37	<b>-5.00</b>	<b>-6.92</b>	<b>-7.46</b>	<b>-6.83</b>	<b>-5.40</b>	<i>-4.03</i>
18-39	<b>-7.39</b>	<b>-5.49</b>	<b>-4.11</b>	<b>-3.10</b>	-1.82	0.96	<b>-5.65</b>	<b>-7.57</b>	<b>-8.11</b>	<b>-7.46</b>	<b>-7.26</b>	<b>-7.59</b>
40-54	<b>-6.22</b>	<b>-4.38</b>	<b>-3.03</b>	<b>-2.19</b>	<b>-1.63</b>	-0.53	<b>-5.18</b>	<b>-5.76</b>	<b>-5.07</b>	<b>-4.28</b>	<b>-3.41</b>	<b>-3.48</b>
55-64	<b>-5.87</b>	<b>-3.83</b>	<b>-2.47</b>	<b>-1.57</b>	<b>-0.99</b>	-0.40	<b>-5.67</b>	<b>-4.90</b>	<b>-3.70</b>	<b>-2.54</b>	<b>-1.80</b>	<b>-1.25</b>
65-74	<b>-5.02</b>	<b>-3.58</b>	<b>-2.49</b>	<b>-1.63</b>	<b>-0.97</b>	<b>-0.42</b>	<b>-5.30</b>	<b>-4.60</b>	<b>-3.43</b>	<b>-2.37</b>	<b>-1.61</b>	<b>-1.04</b>
75-84	<b>-5.37</b>	<b>-3.99</b>	<b>-2.91</b>	<b>-2.01</b>	<b>-1.28</b>	<b>-0.76</b>	<b>-6.14</b>	<b>-5.35</b>	<b>-4.01</b>	<b>-2.89</b>	<b>-2.03</b>	<b>-1.37</b>
85+	<b>-5.65</b>	<b>-4.72</b>	<b>-3.73</b>	<b>-2.76</b>	<b>-2.04</b>	<b>-1.63</b>	<b>-5.98</b>	<b>-5.25</b>	<b>-4.29</b>	<b>-3.26</b>	<b>-2.50</b>	<b>-1.98</b>

**Table 4: MARGINAL EFFECTS FOR NUMBER OF CO-MORBIDITY CONDITIONS: CARDIOVASCULAR**

CDE results for circulatory system diseases. Each number is the difference b/w consecutive comorbidities. Statistically significant results for the 95% two-sided confidence interval are underlined. Statistically significant results for the 99% two-sided confidence interval are in bold font.

Age	Number of co-morbidities					Number of co-morbidities						
	0	1	2	3	4	5	0	1	2	3	4	5
	1998					2004						
0-6												
7-17	-52.69	<b>-30.91</b>	<b>-17.62</b>	<b>-11.70</b>	<b>-5.96</b>	<b>-42.06</b>	<b>-15.98</b>	<b>-6.20</b>	<b>-8.16</b>	<b>-16.02</b>		
18-39	-52.87	<b>-31.37</b>	<b>-18.38</b>	<b>-12.54</b>	<b>-6.41</b>	<b>-42.02</b>	<b>-11.60</b>	<b>-4.00</b>	<b>-4.34</b>	<b>-17.46</b>		
40-54	-39.62	<b>-23.87</b>	<b>-11.82</b>	<b>-3.63</b>	<u>1.42</u>	<b>-37.62</b>	<b>-4.82</b>	<u>3.27</u>	<u>0.54</u>	<b>-15.53</b>		
55-64	-27.03	<b>-14.85</b>	<b>-5.57</b>	<u>1.74</u>	<u>8.42</u>	<b>-31.50</b>	<b>-1.33</b>	<u>6.29</u>	<u>1.61</u>	<b>-12.18</b>		
65-74	-17.14	<b>-8.31</b>	<b>-1.34</b>	<i>4.51</i>	<u>10.14</u>	<b>-25.50</b>	<u>0.96</u>	<u>7.46</u>	<u>3.00</u>	<b>-9.88</b>		
75-84	-10.41	<b>-3.84</b>	<u>0.95</u>	<u>6.13</u>	<u>9.94</u>	<b>-20.30</b>	<u>2.55</u>	<u>8.52</u>	<u>4.15</u>	<b>-8.53</b>		
85+	-6.10	<b>-1.43</b>	<u>2.28</u>	<u>5.28</u>	<u>8.10</u>	<b>-15.52</b>	<u>3.02</u>	<u>9.26</u>	<u>5.25</u>	<b>-8.41</b>		
	2008					2011						
0-6												
7-17	-3.44	<b>-1.25</b>	<u>1.53</u>	<u>2.13</u>	<u>3.17</u>	<b>-12.42</b>	<u>3.54</u>	<u>8.65</u>	<u>5.47</u>	<b>-9.00</b>		
18-39	-12.32	<b>-8.00</b>	<b>-4.13</b>	<b>-3.29</b>	<b>-6.95</b>	2.92	<b>-4.67</b>	<b>-6.86</b>	<b>-4.61</b>	1.29		
40-54	-12.11	<b>-6.39</b>	<b>-2.95</b>	<b>-1.69</b>	<b>-3.32</b>	0.99	<b>-5.21</b>	<b>-6.23</b>	<b>-3.19</b>	2.67		
55-64	-10.21	<b>-5.02</b>	<b>-1.95</b>	<b>-0.41</b>	-0.54	-0.93	<b>-5.74</b>	<b>-5.58</b>	<b>-2.99</b>	<u>2.34</u>		
65-74	-8.37	<b>-3.66</b>	<b>-1.12</b>	<u>0.16</u>	0.56	<b>-1.51</b>	<b>-5.05</b>	<b>-4.79</b>	<b>-2.12</b>	<u>2.27</u>		
75-84	-6.33	<b>-2.31</b>	<b>-0.21</b>	<u>0.74</u>	<u>1.15</u>	<b>-0.74</b>	<b>-3.86</b>	<b>-3.64</b>	<b>-1.37</b>	<u>2.82</u>		
85+	-4.89	<b>-1.22</b>	<u>0.65</u>	<u>1.39</u>	<u>1.70</u>	-0.04	<b>-2.69</b>	<b>-2.57</b>	<b>-0.61</b>	<u>3.39</u>		
	-3.50	<b>-0.15</b>	<u>1.55</u>	<u>2.12</u>	<u>2.22</u>	<u>0.75</u>	<b>-1.34</b>	<b>-1.45</b>	<u>0.25</u>	<u>4.05</u>		
	-2.58	<b>0.85</b>	<u>2.52</u>	<u>2.84</u>	<u>2.63</u>	<u>1.49</u>	<i>-0.39</i>	<b>-0.42</b>	<u>1.01</u>	<u>4.57</u>		

**Figure 1:** DEPENDENCE OF  $CDF_t^{year1} - CDF_t^{year2}$  ON WAITING TIME FOR ALL DISEASES AND CARDIOVASCULAR DISEASES.

Dependence of  $CDF_t^{1998} - CDF_t^{2004}$ ,  $CDF_t^{2004} - CDF_t^{2008}$ ,  $CDF_t^{2008} - CDF_t^{2011}$  on waiting time for all diseases and cardiovascular diseases (ICD-10 Chapter 9). Results are constructed using real data. The three vertical red lines for the last two columns correspond to 18 weeks, 26 weeks and 52 weeks. The red line for the first column correspond to 9 month.

