

National Diabetes Audit, 2015-16 Report 2b: Complications and Mortality (associations between disease outcomes and preceding care)

England and Wales 13 July 2017

Information and technology for better health and care

Prepared in collaboration with:



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Diabetes UK is the largest organisation in the UK working for people with diabetes, funding research, campaigning and helping people live with the condition.

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Introduction

This report from the National Diabetes Audit (NDA), for the first time, investigates the associations between disease outcomes and preceding care. Limited resources and time mean that these investigations are constrained to just a few areas. In this Report 2b, the disease outcomes Heart Failure, Kidney Failure and Death have been studied.

The NICE care standards against which the NDA reports annually (Report 1) comprise opinion based care processes and evidence based (RCT) treatment targets. A theme of this report is that it is easier to understand the relationships between outcomes and preceding care processes than between outcomes and preceding glucose, blood pressure and cholesterol treatment targets.

Such differences between observational data and the evidence from prospective RCT data are well recognised. This is because during the years immediately preceding severe health events, treatment and disease factors often modify well established risk factors.

For example, people at higher cardiovascular risk are more likely to have a cardiovascular event or die but they are also more likely to be taking statins and to have inflammation, both of which lower cholesterol levels. So observational data may show people with the lowest cholesterol levels having the highest risk of heart attacks or strokes i.e. the reverse of what has been found in countless RCTs. This is called 'Reverse Causality' (Sattar N, Preiss D, 2017).

Sattar N, Preiss D. Reverse Causality in Cardiovascular Epidemiological Research: More Common Than Imagined? Circulation. 2017 Jun 13;135(24):2369-2372

Aims and Objectives

- To start to investigate long term associations between disease outcomes and the NICE specified diabetes care processes and treatment targets to see if there are implications for service provision.
- The report has been divided into 3 sections:
 - 1. Cardiovascular Complications;
 - Heart Failure and Care Processes;
 - Heart Failure and Treatment Targets;
 - 2. Diabetes Specific Complications;
 - Renal Replacement Therapy (RRT) and Care Processes;
 - RRT and Treatment Targets;
 - 3. Mortality;
 - Mortality and Care Processes;
 - Mortality and Treatment Targets
- Each section aims to explore whether there are associations between the chosen disease outcomes and preceding measures of care. Overall complication rates, time trends and geographical variation can be found in Report 2a: Complications and Mortality (complications of diabetes, <u>http://www.digital.nhs.uk/pubs/ndauditcm1315</u>)

Key Findings

- Care Processes and Outcomes
 - This seven year longitudinal analysis of NDA data has found an association between consistent healthcare attendance and better outcomes
 - Iower mortality
 - reduced progression to Heart Failure
 - reduced progression to Renal Replacement Therapy.
 - The analysis cannot determine causality. For example the findings could be due to such factors as well organised accessible services, more frequent care planning consultations or an association between poor attendance and hazardous behaviours.

Treatment targets and Outcomes

- One year and seven year follow up associations between outcomes and HbA1c, blood pressure and serum Cholesterol are complex.
- Interpretation needs caution. At this stage, when viewing the results, our analysis suggests that, as a minimum, account should be taken of:
 - age,
 - consistency of treatment target achievement and
 - the influence of 'reverse causality' (in which the disease process or its treatment modifies a well established risk factor).

Recommendations

- Providers of diabetes care and people with diabetes should be aware of the correlation between regular review and good long term health.
- Providers of diabetes care should monitor poor attendance and make extra efforts to re-engage non-attenders
- The high cardiovascular risks of all types of diabetes should be
 - fully recognised
 - regularly assessed and managed using all the effective prevention interventions such as diet, exercise, weight management, early sustained glucose control, blood pressure, statins
- Providers of diabetes care should ensure that cardiovascular risk reduction especially includes people of working age and younger (about 1 in 3 people with diabetes) they have the greatest relative risks including premature death.

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1.1 Heart Failure and Care Processes

Heart Failure and Care Processes^a - Cohort

Two cohorts of people with diabetes, aged 20 years and over and alive as at 31st March 2013 were chosen to evaluate how, over the preceding seven years, full care process completion (all 21 checks, 'Complete') and significantly reduced care process completion (only 12 checks or fewer, 'Incomplete') are associated with the outcomes of people with diabetes. Only three care processes, measurement of HbA1c, blood pressure and serum cholesterol, were included in this analysis.

The cohorts of people and their care process completion were tracked over the seven years between the 2006-07 and 2012-13 audit periods. Only new heart failure admissions experienced by the Complete and Incomplete groups during 2013-15 were analysed. Anyone who had been admitted with heart failure between 2006-07 and 2012-13 was excluded

Table 1: Care process completion cohort sizes for heart failure

England and Wales

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	Туре 1	Type 2 and Other
Complete Care Processes	22,949	229,739
Incomplete Care Processes	16,230	75,131

^a All people with diabetes aged 12 years and over should receive all of the nine NICE recommended care processes. For information on this and performance in England and Wales see *National Diabetes Audit – 2015-2016: Report 1, Care Processes and Treatment Targets <u>http://content.digital.nhs.uk/catalogue/PUB23241</u>.*

Heart Failure, Care Processes and Age

Age is a major risk factor for heart failure.

In the younger population (age 20-64 years), fewer people with Complete attendance developed heart failure (slides 10 & 11). In the older population (age 65 years and over), the opposite was found (slides 10 & 11).

This age difference may be because in elderly age groups those destined to be admitted with heart failure have more ill health and higher attendance rates in the years leading up to their admission or the elderly may be less likely to have survived for the full follow up period (future analysis might investigate this).

These age related associations were similar in people with Type 1 diabetes and Type 2 and other diabetes.

Figures 1 and 2 in the following two slides (10,11) show the population broken down into two age groups, younger (20–64 years) and older (65 years and over), and also shows the relative positioning of these two cohorts on the overall graph for their respective diabetes type.

Heart Failure and Care Processes Rates by Age, Type 1



Heart Failure and Care Processes Rates by Age, Type 2



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1.2 Heart Failure and Treatment Targets

Heart Failure and Treatment Targets^a - Cohort

The cohort used in this section differs from the cohort used in the Heart Failure and Care Processes section. A cohort of people with diabetes, aged 20 years and over and alive as at 31st March 2013 was taken from the 2006-07 audit period. For this cohort, measurements of HbA1c, systolic blood pressure and cholesterol were then taken from the 2006-07 and 2012-13 audit period and divided into five groups for each measure. Corresponding long (7 year) and short (1 year) follow up periods were used to identify if the patient was admitted to hospital with heart failure during 2013-14 or 2014-15.

The groups were defined differently for the different diabetes types; the boundaries being dictated by the volumes of data in each group to get an even spread of records across the groups, rather than by clinical significance.

Anyone who was admitted with heart failure between 2006-07 and 2012-13 was excluded from the analysis.

Table 5: Treatment target cohort sizes for heart failure

England and Wales

	Туре 1	Type 2 and Other
Treatment Targets	109,267	811,841

^a NICE recommends treatment targets for HbA1c (glucose control), blood pressure and serum cholesterol. For information on this and performance in England and Wales see *National Diabetes Audit – 2015-2016: Report 1, Care Processes and Treatment Targets <u>http://content.digital.nhs.uk/catalogue/PUB23241</u>.*

Heart Failure and Treatment Targets – Rates by Blood Pressure Group, Type 1

For both long (7 year) and short (1 year) follow up, more people in the highest systolic blood pressure group were admitted with heart failure than in the lowest blood pressure group.

Figure 8: Percentage of people with Type 1 diabetes who were admitted with heart failure in the follow up period, by systolic blood pressure group



	Group 1	Group 2	Group 3	Group 4	Group 5
Systolic Blood PressuremmHg	0-118	119-127	128-133	134-140	141+

Heart Failure and Treatment Targets – Rates by HbA1c Group, Type 1

HbA1c groups 1 (lowest) and 4, 5 (highest) had higher heart failure rates than those in groups 2 and 3 in both long (7 year) and short (1 year) follow up periods.

Figure 9: Percentage of people with Type 1 diabetes who were admitted with heart failure in the follow up period, by HbA1c group



2006/07 groups,

2012/13 groups, 2013-15 follow up (short)



	Group 1	Group 2	Group 3	Group 4	Group 5
HbA1c mmol/mol	0-54	55-62	63-72	73-94	95+

Heart Failure and Treatment Targets – Rates by Cholesterol Group, Type 1

The rates of heart failure were highest in the group with lowest cholesterol levels in both the long (7 year) and short (1 year) follow up periods. This probably reflects the use of extra interventions such as statins in those with evident risk cardiovascular factors who would be more likely to develop heart failure.

Figure 10: Percentage of people with Type 1 diabetes who were admitted with heart failure in the follow up period, by cholesterol group



2012/13 gr	oup	DS,
2013-15 follow	up	(short)



	Group 1	Group 2	Group 3	Group 4	Group 5
Cholesterol mmol/L	0-3.7	3.8-4.1	4.2-4.6	4.7-5.4	5.5+

Heart Failure and Treatment Targets – Rates by Blood Pressure Group, Type 2

Unsurprisingly, given the age profile of people with Type 2 and other diabetes, the heart failure rates were higher than for Type 1.

There was less association between heart failure rates and blood pressure than there was for Type 1. The rate for group 5 (highest) systolic blood pressure was only one and a half times the rate for group 1 (lowest).

Figure 11: Percentage of people with Type 2 diabetes who were admitted with heart failure in the follow up period, by systolic blood pressure group





	Group 1	Group 2	Group 3	Group 4	Group 5
Systolic Blood PressuremmHg	0-121	122-131	132-139	140-145	146+

Heart Failure and Treatment Targets – Rates by HbA1c Group, Type 2

Over the longer (7 year) follow up, there was a small association between HbA1c and likelihood of admission with heart failure. In the short (1 year) follow up period, the finding of higher heart failure rates in those with the lowest HbA1c may reflect treatment intensification in response to deteriorating health.

Figure 12: Percentage of people with Type 2 diabetes who were admitted with heart failure in the follow up period, by HbA1c group



2012/13 groups, 2013-15 follow up (short)



	Group 1	Group 2	Group 3	Group 4	Group 5
HbA1c mmol/mol	0-45	46-51	52-58	59-74	75+

Rates by Cholesterol Level – Type 2

For cholesterol groups, the rates of heart failure were highest in the group with lowest cholesterol levels, in both long (7 year) and short (1 year) follow up, probably reflecting extra interventions such as statins in those with evident cardiovascular risk factors.

Figure 13: Percentage of people with Type 2 diabetes who were admitted with heart failure in the follow up period, by cholesterol group



2006/07 groups,

Group 1: Lowest cholesterol, 5: Highest cholesterol

2012/13 groups, 2013-15 follow up (short)



Group 1: Lowest cholesterol, 5: Highest cholesterol

	Group 1	Group 2	Group 3	Group 4	Group 5
Cholesterol mmol/L	0-3.3	3.4-3.9	4.0-4.4	4.5-5.4	5.5+

Associations with Consistently Low or Consistently High Treatment Target Levels

The following analysis compares two cohorts of people with Type 2 and other diabetes:

- Group 1 Consistently low treatment target levels between 2006-07 and 2012-13
- Group 5 Consistently high treatment target levels between 2006-07 and 2012-13.

People with Type 1 diabetes were not included in this analysis due to insufficient numbers in the two cohorts.

Association of Consistently Low and High HbA1c with Heart Failure Rates – Type 2, by Age

HbA1c sustained at lower levels is associated with appreciably reduced rates of heart failure at all ages, compared with those whose HBA1c was consistently high.

Figure 14: Percentage of people with Type 2 and other diabetes with consistently low/high HbA1c who were admitted with heart failure in the follow up period, by age



Association of Consistently Low and High Blood Pressure Levels on Heart Failure Rates – Type 2, by Age

- For systolic blood pressure, there is no difference between groups with consistently lower or higher blood pressure in older age groups. In younger age groups, consistently low blood pressure is associated with reduced rates of heart failure. Overall, age is the dominant association.
- Figure 15: Percentage of people with Type 2 and other diabetes with consistently low/high blood pressure who were admitted with heart failure in the follow up period, by age



Association of Consistently Low and High Cholesterol Levels on Heart Failure Rates – Type 2, by Age

Sustained lower cholesterol levels are associated with higher rates of heart failure in older age groups while the reverse is found under the age of 55 years. This may reflect greater clinically evident cardiovascular risk and consequent greater use of statins in older people.

Figure 16: Percentage of people with Type 2 and other diabetes and consistently low/high cholesterol who were admitted with heart failure in the follow up period, by age



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2.1 RRT and Care Processes

Renal Replacement Therapy (RRT) and Care Processes^a - Cohort

Two cohorts of people with diabetes, aged 20 years and over and alive as at 31st March 2013 were chosen to evaluate how full care process completion (all 21 checks, 'Complete') and significantly reduced care process completion (12 checks or less, 'Incomplete') are associated with the outcomes of people with diabetes. Only three care processes, measurement of HbA1c, blood pressure and serum cholesterol, were included in this analysis.

The cohorts of people and their care process completion were tracked over a period of seven years between the 2006-07 and 2012-13 audit periods. Only new RRT recorded for the Complete and Incomplete groups during 2013-15 were analysed. Anyone who was admitted for RRT between 2006-07 and 2012-13 was excluded from the analysis.

Table 15: Care process completion cohort sizes for RRT

England and Wales

	Туре 1	Type 2 and Other
Complete Care Processes	23,579	241,028
Incomplete Care Processes	16,350	78,955

^a All people with diabetes aged 12 years and over should receive all of the nine NICE recommended care processes. For information on this and performance in England and Wales see National Diabetes Audit – 2015-2016: Report 1, Care Processes and Treatment Targets <u>http://content.digital.nhs.uk/catalogue/PUB23241</u>.

RRT and Care Processes - Rates by Age, Type 1

The percentage of people with Type 1 diabetes progressing to RRT is lower in the Complete cohort of the younger population. This was not found in the older population.

Figure 22: Percentage of people with Type 1 diabetes who were admitted for RRT in the follow up period, by age

England and Wales



RRT and Care Processes - Rates by Age, Type 2

The percentage of people with Type 2 and other diabetes progressing to RRT is lower in the Complete cohort of the younger population. There was less difference in the older population.

Figure 23: Percentage of people with Type 2 diabetes who were admitted for RRT in the follow up period, by age

England and Wales



Younger age groups

Older age groups

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2.2 RRT and Treatment Targets

RRT and Treatment Targets^a - Cohort

The cohort used in this section differs from the cohort used in the RRT and Care Processes section. A cohort of people with diabetes, aged 20 years and over and alive as at 31st March 2013 was taken from the 2006-07 audit period. For this cohort, measurements of HbA1c, systolic blood pressure and cholesterol were then taken from the 2006-07 and 2012-13 audit period and divided into five groups for each measure. Corresponding long (7 year) and short (1 year) follow up periods were used to identify if the patient was admitted for RRT during 2013-14 or 2014-15.

The groups were defined differently for the different diabetes types; the boundaries being dictated by the volumes of data in each group to get an even spread of records across the groups, rather than by clinical significance.

Anyone who was admitted for RRT between 2006-07 and 2012-13 was excluded from the analysis.

Table 16: Treatment target cohort sizes for people with diabetes who were admitted for RRT in the follow up period

England and Wales

	Туре 1	Type 2 and Other
Treatment Targets	111,226	855,371

^a NICE recommends treatment targets for HbA1c (glucose control), blood pressure and serum cholesterol. For information on this and performance in England and Wales see National Diabetes Audit – 2015-2016: Report 1, ²⁹ Care Processes and Treatment Targets <u>http://content.digital.nhs.uk/catalogue/PUB23241</u>.

RRT and Treatment Targets – Rates by Blood Pressure Group, Type 1

As would be expected, there are close long (7 year) and short (1 year) term associations between blood pressure and progression to RRT since early Chronic Kidney Disease (CKD) increases blood pressure and blood pressure lowering slows progression of CKD.

Figure 24: Percentage of people with Type 1 diabetes who were admitted for RRT in the follow up period, by systolic blood pressure group





	Group 1	Group 2	Group 3	Group 4	Group 5
Systolic Blood PressuremmHg	0-118	119-127	128-133	134-140	141+

RRT and Treatment Targets – Rates by HbA1c Group, Type 1

There are both long (7 year) and short (1 year) term associations between the highest levels of HbA1c and progression to RRT.

Figure 25: Percentage of people with Type 1 diabetes who were admitted for RRT in the follow up period, by HbA1c group



2006/07 groups,

2013-15 follow up (long)



	Group 1	Group 2	Group 3	Group 4	Group 5
HbA1c mmol/mol	0-54	55-62	63-72	73-94	95+

RRT and Treatment Targets – Rates by Cholesterol Group, Type 1

As per the picture for associations between cholesterol levels and other complications, the complex pattern is likely to be related to a mixture of disease and drug influences (reverse causality – see slide 3).

Figure 26: Percentage of people with Type 1 diabetes who were admitted for RRT in the follow up period, by cholesterol group





	Group 1	Group 2	Group 3	Group 4	Group 5
Cholesterol mmol/L	0-3.7	3.8-4.1	4.2-4.6	4.7-5.4	5.5+

RRT and Treatment Targets – Rates by Blood Pressure Group, Type 2

As would be expected, there are close long (7 year) and short (1 year) term associations between blood pressure and progression to RRT since early CKD increases blood pressure and blood pressure lowering slows progression of CKD.

Figure 27: Percentage of people with Type 2 diabetes who were admitted for RRT in the follow up period, by systolic blood pressure group





Group 1: Lowest systolic	BP,	5: Highest	systolic	BF
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	Group 1	Group 2	Group 3	Group 4	Group 5
Systolic Blood PressuremmHg	0-121	122-131	132-139	140-145	146+

RRT and Treatment Targets – Rates by HbA1c Group, Type 2

There are clear long term (7 year) associations between the highest levels of HbA1c and progression to RRT. There is no real short term (1 year) pattern.

Figure 28: Percentage of people with Type 2 diabetes who were admitted for RRT in the follow up period, by HbA1c group



2006/07 groups,

2012/13 groups, 2013-15 follow up (short)



	Group 1	Group 2	Group 3	Group 4	Group 5
HbA1c mmol/mol	0-45	46-51	52-58	59-74	75+

RRT and Treatment Targets – Rates by Cholesterol Level – Type 2

As per the picture for associations between cholesterol levels and other complications, the complex picture is likely to be related to a mixture of disease and drug influences (reverse causality – see slide 3).

Figure 29: Percentage of people with Type 2 diabetes who were admitted for RRT in the follow up period, by cholesterol group



	Group 1	Group 2	Group 3	Group 4	Group 5
Cholesterol mmol/L	0-3.3	3.4-3.9	4.0-4.4	4.5-5.4	5.5+

Associations with Consistently Low or Consistently High Treatment Target Levels

The following analysis compares two cohorts of people with Type 2 and other diabetes:

- Group 1 Consistently low treatment target levels between 2006-07 and 2012-13
- Group 5 Consistently high treatment target levels between 2006-07 and 2012-13.

People with Type 1 diabetes were not included in this analysis due to insufficient numbers in the two cohorts.

Associations of Consistently Low and High HbA1c Levels with RRT Rates – Type 2, by Age

In all age groups, consistently high HbA1c levels are associated with an approximately threefold increase in the chance of progressing to RRT.

Figure 30: Percentage of people with Type 2 diabetes with consistently low/high HbA1c who were admitted for RRT in the follow up period, by age



Associations of Consistently Low and High Blood Pressure Levels with RRT Rates – Type 2, by Age

Sustained lower blood pressure levels are associated with lower rates of RRT (ESKD). This is what would be expected from the known relationships between CKD and blood pressure i.e. CKD raises blood pressure and controlling that rise slows progression of CKD.

Figure 31: Percentage of people with Type 2 diabetes and consistently low/high blood pressure who were admitted for RRT in the follow up period, by age



Associations of Consistently Low and High Cholesterol Levels with RRT Rates – Type 2, by Age

The different patterns in those under 60 years (consistently low cholesterol associated with lower rates of RRT) and over 60 years (consistently low cholesterol associated with slightly higher rates of RRT than consistently high cholesterol) are unexplained but may reflect greater use of statins in younger people with early CKD.

Figure 32: Percentage of people with Type 2 diabetes and consistently low/high cholesterol who were admitted for RRT in the follow up period, by age



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3.1 Mortality and Care Processes

Mortality and Care Processes^a - Cohort

Two cohorts of people with diabetes, aged 20 years and over and alive as at 31st March 2013 were chosen to evaluate how full care process completion (all 21 checks, 'Complete') and significantly reduced care process completion (12 checks or less, 'Incomplete') are associated with the outcomes of people with diabetes. Only three care processes, measurement of HbA1c, blood pressure and serum cholesterol, were included in this analysis.

The cohorts of people and their care process completion were tracked over a period of seven years between the 2006-07 and 2012-13 audit periods. A follow up period was used to identify if the patient died during 2013-14 or 2014-15.

Table 20: Care process completion cohort sizes for mortality

England and Wales

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	Туре 1	Type 2 and Other
Complete Care Processes	23,928	242,829
Incomplete Care Processes	16,823	79,924

^a All people with diabetes aged 12 years and over should receive all of the nine NICE recommended care processes. For information on this and performance in England and Wales see *National Diabetes Audit* – 2015-2016: Report 1, Care Processes and Treatment Targets <u>http://content.digital.nhs.uk/catalogue/PUB23241</u>.

Mortality and Care Processes - Rates by Age, Type 1

For all age groups, the death rate during the follow up period was higher for the group whose care process completion during the preceding seven years was incomplete – twice as high for most age groups.

This suggests that regular healthcare contacts in people with Type 1 diabetes are associated with reduced additional mortality.

Figure 39: Percentage of people with Type 1 diabetes who died during the follow up period, by age



England and Wales

Mortality and Care Processes - Rates by Age, Type 2

For all age groups, the death rate during the follow up period was higher for the group whose care process completion during the preceding seven years was incomplete – twice as high for most age groups.

This suggests that regular healthcare contacts in people with Type 2 diabetes are associated with reduced additional mortality.

Figure 40: Percentage of people with Type 2 diabetes who died during the follow up period, by age



England and Wales

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3.2 Mortality and Treatment Targets

Mortality and Treatment Targets^a - Cohort

The cohort used in this section differs from the cohort used in the Mortality and Care Processes section. A cohort of people with diabetes, aged 20 years and over and alive as at 31st March 2013 was taken from the 2006-07 audit period. For this cohort, measurements of HbA1c, systolic blood pressure and cholesterol were then taken from the 2006-07 and 2012-13 audit period and divided into five groups for each measure. A follow up period was used to identify if the patient died during 2013-14 or 2014-15.

The groups were defined differently for the different diabetes types and the boundaries were dictated by the volumes of data in each group to get an even spread of records across the groups, rather than by clinical significance.

Table 21: Treatment target cohort sizes for mortality

England and Wales

	Туре 1	Type 2 and Other
Treatment Targets	113,748	863,850

^a NICE recommends treatment targets for HbA1c (glucose control), blood pressure and serum cholesterol. For information on this and performance in England and Wales see *National Diabetes Audit – 2015-2016: Report 1, Care Processes and Treatment Targets <u>http://content.digital.nhs.uk/catalogue/PUB23241</u>.*

Mortality and Treatment Targets – Rates by Blood **Pressure Group, Type 1**

Blood pressure is clearly associated with mortality seven years later but there is an inconsistent relationship between blood pressure and one year mortality, probably due to confounding by treatment of blood pressure or changes in blood pressure as people become severely ill (see slide 3).

Figure 40: Percentage of people with Type 1 diabetes who died during the follow up period, by systolic blood pressure group

Percentage

0.0



2006/07 groups, 2013-15 follow up (long)



2012/13 groups, 2013-15 follow up (short)

2.0 1.0

2

3 Group 1: Lowest systolic BP, 5: Highest systolic BP

	Group 1	Group 2	Group 3	Group 4	Group 5
Systolic Blood PressuremmHg	0-118	119-127	128-133	134-140	141+

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Mortality and Treatment Targets – Rates by HbA1c Group, Type 1

Both long (7 year) and short (1 year) term follow up period cohorts show the highest mortality rates in people with the lowest and highest HbA1c levels. Although RCTs have shown the mortality benefit of lowering HbA1c, severe hypoglycaemia, not measured in the NDA but possibly more common in the low HbA1c group, is a known risk factor for death.

Figure 41: Percentage of people with Type 1 diabetes who died during the follow up period, by HbA1c group



	Group 1	Group 2	Group 3	Group 4	Group 5
HbA1c mmol/mol	0-54	55-62	63-72	73-94	95+

2012/13 groups, 2013-15 follow up (short)



Mortality and Treatment Targets – Rates by Cholesterol Group, Type 1

Given the strong RCT evidence for the use of statins in people with increased cardiovascular risk, these results may initially seem perplexing. However, the greater deployment of statins in people at highest risk and the serum cholesterol depressant effect of inflammation mean that the results probably illustrate 'reverse causality' (see slide 3).

Figure 42: Percentage of people with Type 1 diabetes who died during the follow up period, by cholesterol group



	Group 1	Group 2	Group 3	Group 4	Group 5
Cholesterol mmol/L	0-3.7	3.8-4.1	4.2-4.6	4.7-5.4	5.5+

2012/13 groups, 2013-15 follow up (short)



Mortality and Treatment Targets – Rates by Blood Pressure Group, Type 2

Blood pressure is clearly associated with mortality seven years later but there is an inconsistent relationship between blood pressure and one year mortality, probably due to confounding by treatment of blood pressure and changes to blood pressure as people become severely ill.

Figure 43: Percentage of people with Type 2 diabetes who died during the follow up period, by systolic blood pressure group



2012/13 groups, 2013-15 follow up (short)



Group 1: Lowest systolic BP, 5: Highest systolic BP

	Group 1	Group 2	Group 3	Group 4	Group 5
Systolic Blood PressuremmHg	0-121	122-131	132-139	140-145	146+

Mortality and Treatment Targets – Rates by HbA1c Group, Type 2

Both long (7 year) and short (1 year) term follow up period cohorts show the highest mortality rates in people with the lowest HbA1c levels. Although RCTs have shown the mortality benefit of early sustained lower HbA1c, patients in these studies did not have levels as low as group 1 in this analysis while other studies have also suggested that later in the course of Type 2 diabetes, low HbA1c may be hazardous in some people.

Figure 44: Percentage of people with Type 2 diabetes who died during the follow up period, by HbA1c group

2006/07 groups,



2012/13 groups, 2013-15 follow up (short)

5

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Mortality and Treatment Targets – Rates by Cholesterol Level – Type 2

Given the strong RCT evidence for the use of statins in people with increased cardiovascular risk, these results may initially seem perplexing. However, the greater deployment of statins in people at highest risk of cardiovascular disease and the serum cholesterol depressant effect of inflammation mean that the results probably illustrate 'reverse causality' (see slide 3).

Figure 45: Percentage of people with Type 2 diabetes who died during the follow up period, by cholesterol group



2006/07 groups,

	Group 1	Group 2	Group 3	Group 4	Group 5
Cholester ol m mol/L	0-3.3	3.4-3.9	4.0-4.4	4.5-5.4	5.5+

2012/13 groups, 2013-15 follow up (short)



Mortality Associations with Consistently Low or Consistently High Treatment Target Levels

The following analysis compares two cohorts of people with Type 2 and other diabetes:

- Group 1 Consistently low treatment target levels between 2006-07 and 2012-13
- Group 5 Consistently high treatment target levels between 2006-07 and 2012-13.

People with Type 1 diabetes were not included in this analysis due to insufficient numbers in the two cohorts.

Association of Consistently Low and High HbA1c Levels with Mortality Rates – Type 2, by Age

This clear direct association between consistently high HbA1c and higher mortality across all ages may suggest that the inverse long and short term relationships with individual values is due to confounding by sudden changes in HbA1c where rapid lowering in patients with established cardiovascular disease may be detrimental (Sattar N, Preiss D, 2017).

Figure 46: Percentage of people with Type 2 and other diabetes with consistently low/high HbA1c who died during the follow up period, by age



Sattar N, Preiss D. Reverse Causality in Cardiovascular Epidemiological Research: More Common Than Imagined? Circulation. 2017 Jun 13;135(24):2369-2372

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Association of Consistently Low and High Blood Pressure Levels with Mortality Rates – Type 2, by Age

Studies in the general population have suggested that in older people blood pressure starts to decline without treatment for at least five years before death. So although RCTs show the long term benefit of blood pressure lowering, this may be another occasion in which observational data implies the opposite due to 'reverse causality' (see slide 3).

Figure 47: Percentage of people with Type 2 diabetes who died during the follow up period, by age and consistently low/high blood pressure



Association of Consistently Low and High Cholesterol Levels with Mortality Rates – Type 2, by Age

As discussed previously, serum cholesterol levels in this observational data are probably influenced by greater statin use in patients with greater cardiovascular risk and by the cholesterol lowering influence of inflammation which accompanies vascular and other serious disease (see slide 3).

Figure 48: Percentage of people with Type 2 diabetes who died during the follow up period, by age and consistently low/high cholesterol



NDA 2015-16: Report 2b

Definitions, data sources and additional information

Definitions

Diabetes

Diabetes is a condition where the amount of glucose in the blood is too high because the pancreas doesn't produce enough insulin. Insulin is a hormone produced by the pancreas that allows glucose to be used as a body fuel and other nutrients to be used as building blocks. There are two main types of diabetes: Type 1 diabetes (no insulin); Type 2 diabetes (insufficient insulin).

Heart failure

Heart failure means that the heart is unable to pump blood around the body properly. It usually occurs because the heart has become too weak or stiff.

Renal Replacement Therapy (RRT)

RRT is therapy that replaces the normal blood-filtering function of the kidneys. RRT includes dialysis, hemofiltration and hemodiafiltration, which are various ways of filtration of blood with or without machine. It can also include kidney transplantation.

Definitions

Care Processes (NICE recommends all of these at least once a year)

Three of the eight care processes were used in the analyses for Report 2b:

Blood Pressure is a measurement of the force driving the blood through the arteries. Blood pressure readings contain two figures, e.g.130/80. The first is known as the systolic pressure which is produced when the heart contracts. The second is the diastolic pressure which is when the heart relaxes to refill with blood.

Cholesterol - this blood test measures a type of fat that can damage blood vessels.

HbA1c – this is a blood test for average blood glucose levels during the previous two to three months.

The other care processes are BMI measurement, serum creatinine, urinary albumin, foot check and smoking status.

Treatment Targets (NICE defines target levels to reduce risks of complications for people with diabetes)

Blood Pressure – high levels are a risk for heart attacks and strokes; they also drive progression of eye and kidney disease.

Cholesterol – reducing cholesterol levels lowers the risk of heart attacks and strokes.

HbA1c - the closer this is to normal (less than 42mmol/mol) the lower is the risk of all long term complications of diabetes.

Additional Information

The following documents are available from http://www.digital.nhs.uk/pubs/ndauditcm1315

- NDA Report 2a: Complications and Mortality (complications of diabetes)
- Supporting data in Excel
 - Supporting Information National tables and charts
 - CCG/GP practice level spreadsheet
- PowerPoint version of this report
- Data Quality Statement (pdf)
- Methodology (pdf)

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