Mortality Associated with Diabetes

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Introduction

Diabetes is a major and increasingly important non-communicable disease that contributes substantially to the risk of premature death. Globally, a new epidemic of diabetes is underway, which threatens to counter the historic mortality improvements experienced in most parts of the world. India is at the centre of the diabetes epidemic; by 2025, there are expected to be 300 million people with diabetes – more than 50 million of these will be Indians.

This short paper reviews the epidemiological trends and the morbidity and mortality risks associated with diabetes, and considers some of the implications for insurance. It does not set out to be definitive on the subject, rather to highlight some of the main features and risks related to diabetes that are relevant to life and health insurance.

To appreciate mortality trends and, in particular, to be able to anticipate the prospects for future trends in mortality, an understanding of the forces at work on particular causes of death is essential. The insights gained from the epidemiological evidence for trends in major diseases and mortality risk factors, together with a knowledge of the medical developments that aim to reduce the morbidity and mortality burden, provide a basis derived from the real world with which to challenge the traditional, actuarial approach to mortality projections.

Overview of diabetes

Diabetes (or *diabetes mellitus*, to give it its full name) is a common disorder of blood glucose metabolism, which has a number of serious health consequences and increases the risk of premature death in those affected. The disorder occurs in two main forms:

Type 1 Diabetes (also known as juvenile onset diabetes) – in this form, there is deficiency of the hormone insulin, which is required to regulate blood glucose levels. Typically, it occurs in childhood or adolescence and is managed by insulin replacement. From an insurance perspective, Type 1 diabetes is less of a concern as the insurer is usually aware of its existence on application. In contrast to Type 2 diabetes, the epidemiological picture of Type 1 disease is also relatively static. For these reasons, this form of diabetes is not considered further in this paper.

Type 2 Diabetes (also known as maturity onset diabetes) – in this form, the disorder of blood glucose regulation is caused by resistance to the glucose-lowering effect of insulin. Its onset and clinical effects are generally insidious and the finding of elevated blood glucose or impaired glucose regulation is often incidental. Particularly in the early stages, blood glucose control may be achieved by dietary measures alone or by the use of (oral hypoglycaemic) drugs that increase the body's sensitivity to naturally occurring insulin. Treatment with insulin may be required in resistant cases.

Impaired Glucose Regulation (IGR) – this can be considered as a state of 'pre-diabetes' and comprises cases of *Impaired Fasting Glycaemia (IFG)* (i.e. a higher than normal blood glucose level after a period of fasting, but below that of diabetes) and *Impaired Glucose Tolerance (IGT)* (i.e. a sub-normal response to a standard oral glucose challenge test, but less impaired than that of diabetes).

Epidemiology of Type 2 Diabetes

Globally, Type 2 diabetes represents more than 90% of all diabetes. Numerous prevalence studies in virtually all parts of the globe have identified an alarming increase in the prevalence of Type 2 disease in recent decades. It is estimated that there are currently some 190 million people with diabetes and that this number will increase to in excess of 300 million within the next 20 years.

The World Health Organisation (WHO) and others predict that India will have the greatest number of people with diabetes within 20 years, increasing from around 23 million in 2000 to 57 million in 2025 [1].

In addition, the global estimate of cases of IGT and IFG is more than 350 million people, which represents a huge reservoir of future cases of diabetes. Between 25-50% of those with IGT progress to diabetes within 10 years and the rate of progression from IFG may be similar.

Perhaps even more dramatic than the recent increase in prevalence of Type 2 diabetes is that the age of onset is reducing dramatically. Once a disease largely confined to middle and late adult life, onset in young adults and even children is increasingly being seen. In Japanese children, Type 2 already accounts for 80% of childhood diabetes and it is likely to overtake Type 1 disease in the children of many ethnic groups within10 years. Among affected children, obesity, relative physical inactivity and an energy-rich, modern diet appear to be significant factors.

Asian Indians are racially predisposed to developing diabetes; there is an increased familial aggregation of Type 2 disease in Indians, suggesting a strong underlying genetic component. Compared to other ethnic groups, Indians exhibit a high degree of *central adiposity* (indicated by a high waist-to-hip ratio (WHR)[1]) even although they may have a normal body mass index (BMI)[2]. Central adiposity appears to be closely linked to the risk of diabetes in Indians.

[1] WHR = waist circumference / hip circumference
[2] BMI = Height (m) / Weight^2 (kg^2)

The DECODA study group compared the prevalence in 11 Asian cohorts from China, Japan Singapore and India [2] and found a marked variation in the pattern of diabetes across Asia. Indians had the highest prevalence, which peaked approximately 10 years younger than the other groups studied (41.0% [male] and 34.6% [female] of the study population at ages 60-69). In addition, a high IGR prevalence is established in Indians by age 30-39.

In contrast to developed (mainly Caucasian) countries, where most people with diabetes are over 65, in developed countries such as India, the burden of diabetes falls in the economically active age range of 45-65.

The National Urban Diabetes Study (NUDS), conducted in India in 2000, estimated the age-standardised prevalence of diabetes in adults aged 20+ in 6 major Indian cities to be 12.1%, with no significant gender difference (Tables 1-4). The corresponding prevalence of IGT was 14.0% [3]. The prevalence of diabetes increases with age, body-mass index, waist-to-hip ratio, family history, monthly income and reduced levels of physical activity

Age Group (years)	**Type 2 Diabetes**		**IGT**	
	MALE (%)	**FEMALE** (%)	**MALE** (%)	**FEMALE** (%)
20 – 29	2.3	2.4	10.7	12.2
30 – 39	7.3	6.8	13.8	15.3
40 – 49	16.0	16.9	17.0	14.1
50 – 59	25.2	27.3	16.1	13.3
60 – 69	31.1	27.6	16.7	16.2
> 69	26.3	25.5	19.2	19.4

Table 1: Age- and gender-specific prevalence of Type 2 diabetes and IGT in urban India (NUDS)[3]

Age Group (years)	**Age at diagnosis of Diabetes**	
	MALE (%)	**FEMALE** (%)
20 – 29	5.4	5.4
30 – 39	20.4	19.1
40 – 49	28.3	29.6
50 – 59	25.6	28.0
60 – 69	14.8	13.0
> 69	5.2	4.9

Table 2: Age at diagnosis of diabetes (new [30%] and known [70%] cases)

[3] NUDS sample size was: 5,288 (male); 5,928 (female)

Income Group (INR / month)	Diabetes (%)	IGT (%)
< =5,000	12.5	14.5
5,001 – 10,000	18.5	14.6
> 10,000	21.6	11.7
Occupation		
Unskilled	10.6	14.4
Skilled	9.6	14.2
Office Jobs	15.5	14.7
Housewife / Student	13.8	14.2
Unemployed / Retired	22.5	15.6

Table 3: Prevalence of diabetes and IGT by monthly family income and occupation (NUDS)

	Chennai	Bangalore	Hyderabad	Calcutta	Mumbai	New Delhi
Diabetes (%)	13.5	12.4	16.6	11.7	9.3	11.6
IGT (%)	16.8	14.9	29.8	10.0	10.8	8.6

Table 4: Age- and gender-specific prevalence of diabetes and IGT in 6 Indian cities (NUDS)

In Chennai, successive studies have shown an increase in the adult prevalence of diabetes [IGT] from 8.3% [8.3%] in 1989, to 11.6% [9.1%] in 1995, to 13.9% [16.7%] in 2000 [4]. These findings mirror the temporal changes seen in other studies of Indian and non-Indian ethnic groups.

The increase in diabetes has paralleled the urbanisation of modern India. One study in Southern India demonstrated a prevalence of diabetes in a semi-urban setting of 5.9%, which lies between the corresponding prevalence in urban (11.6%) and rural (2%) settings [5]. A sedentary occupation, involving only household work, was an important determinant for diabetes, independent of age, BMI and family history.

Together with a general picture of reduction in age of onset of diabetes, the prevalence of Type 2 disease is increasing in Indian adolescents [6], attributed to the epidemic of obesity. Overweight was found to be strongly associated with physical inactivity and higher socioeconomic status.

In India, it has been found that the age at diagnosis is closely related to the level of education; those educated to college level were, on average, diagnosed seven years before people with no literacy [7]. Low education is also positively associated with the likelihood of developing diabetic complications, probably related to poor health awareness and access to healthcare services.

The many epidemiological studies undertaken have established several important risk factors for IGR and diabetes, which are summarised in Figure 1.

Risk factors for Type 2 Diabetes

- Age
- Body Mass Index (BMI)
- Central obesity (high WHR)
- Sedentary lifestyle
- Family history
- Impaired Glucose Tolerance (IGT
- Impaired Fasting Glycaemia (IFG)
- Ethnicity (e.g. Indian)

Figure 1:

Indians appear to at increased risk of diabetes at lower levels of BMI than Caucasians. WHO recommends a normal range of BMI for Asian lives of 18.5 – 22 kg/m^2 for good health. BMI >23 kg/m^2 has been shown to increase the risk of diabetes in urban Indian lives [6].

The upper limit for WHR is considered to be around 0.9 (male) and 0.8 (female). In one study [8], each increase in WHR of 0.04 was found to be associated with an increase in the risk of diabetes of 20% in Indian lives (cf. 5% in Europeans), which tends to confirm the Indian sensitivity to diabetes with central obesity.

Mortality and morbidity risk of diabetes

Fore the most part, Type 2 diabetes gives rise to few clinical symptoms and may go undiagnosed for several years. Often, the diagnosis is incidental, for example the finding of a raised fasting glucose level or impaired glucose tolerance obtained in the course of insurance underwriting. General tiredness and weakness may be the only symptoms until such time as one of the many complications of diabetes occurs.

It is the complications of diabetes that cause the great burden of morbidity and mortality associated with the disease. The common and major complications are so-called *macrovascula*r and *microvascular* disease, disorders affecting large and small blood vessels respectively. These are summarised in Figure 2.

Major complications of Type 2 Diabetes

Microvascular Disease

- Diabetic retinopathy
- Diabetic nephropathy
- Peripheral neuropathy

Macrovascular Disease

- Coronary heart disease
- Cerebrovascular disease
- Peripheral vascular disease

Figure 2:

Diabetic eye disease (retinopathy) leads progressively to blindness if untreated; microvascular kidney disease (nephropathy) leads to chronic renal failure. Diabetes also predisposes to various infections.

It is, however, the cardiovascular complications of myocardial infarction (heart attack) and stroke that give rise to much of the excess major morbidity and mortality from diabetes. This is considered in more detail in the next section. Disease of the nerves (neuropathy) and the blood vessels of the limbs, the legs in particular, may lead to chronic sores, ulceration and gangrene; amputation is not an infrequent outcome.

Any analysis of the mortality or morbidity risk associated with diabetes is complicated by the other major risk factors for cardiovascular disease, which commonly co-exist in clusters. The major cardiovascular risk factors are summarised in Figure 3.

Major risk factors for cardiovascular disease

- Age
- Gender (male)
- Obesity (BMI)
- WHR / Waist circumference
- Diabetes
- Hypertension[4]
- Hyperlipidaemia[5]
- Smoking
- Physical inactivity / sedentary lifestyle
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Figure 3:

[4] High blood pressure
[5] Raised blood lipids (cholesterol fractions and/or triglycerides) – in Indian lives, a typical finding is a high level of triglycerides, together with a low level of (protective) high density lipoprotein (HDL)

Certain of these risk factors may act synergistically in combination. The so-called Metabolic Syndrome (Syndrome X) includes the constellation of high blood pressure, high insulin levels, obesity and raised blood lipids (and/or low HDL). Having some or all of these risk factors significantly increases the risk of developing diabetes and suffering a myocardial infarction or stroke. The underlying mechanism of this clustering of cardiac risk factors is thought to be resistance to the blood-sugar-lowering action of insulin

The mortality burden of diabetes

Authoritative estimates of cause of death at population level are not available for India or other South Asian countries. In India, there is medical registration of cause of death for deaths that occur in hospital and a survey of cause of death for deaths in rural areas, but the overall picture is limited by incompleteness and inaccuracies in such records.

Nonetheless, diabetes is an important non-communicable cause of death. WHO estimates of major, non-communicable causes of death in 2000 for India are shown in Table 5.

Cause of death	% of ALL deaths
Cardiovascular disease	31.7
Diabetes mellitus	**1.1**
Cancer	7.4
Chronic obstructive lung disease & asthma	2.5

Table 5: Deaths in India from non-communicable diseases in 2000 (as % of all deaths), WHO

Undoubtedly, this headline number for diabetes deaths understates the mortality burden of the disease, because of the major contribution of diabetes to cardiovascular risk. Incomplete death certification is also likely to understate the existence of diabetes.

One study method to overcome death reporting problems is that of 'verbal autopsy', in which trained researchers perform a standard interview with surviving relatives, the results of which are interpreted by experienced physicians. In one such study of 48,000 deaths in Chennai [9], the causes of death attributed were as shown in Table 6.

Age Group	25-34	35-44	45-54	55-64	65-69	70-74	75+
MALE cause of death (% of all deaths)							
Cardiovascular	15.1	26.2	36.3	40.9	38.1	34.2	26.9
Cerebrovascular	1.0	2.2	3.4	5.0	6.0	6.8	6.2
Diabetes	**0.5**	**1.1**	**1.5**	**3.6**	**4.0**	**5.4**	**4.7**
Renal (kidney)	2.6	2.6	3.1	3.0	2.8	1.8	2.9
Neoplasm[6]	4.5	6.6	9.4	10.8	9.6	7.8	4.3
Other medical	32.6	36.3	33.7	30.2	36.5	41.8	53.3
Non-medical	56.4	75.0	87.3	93.6	96.9	97.7	98.2
FEMALE cause of death (% of all deaths)							
Cardiovascular	14.0	28.3	35.4	38.1	37.6	31.4	24.6
Cerebrovascular	1.8	1.6	3.6	5.4	6.2	7.0	6.2
Diabetes	**0.7**	**1.5**	**4.8**	**5.6**	**5.1**	**7.1**	**3.9**
Renal (kidney)	3.6	3.4	3.8	3.8	3.1	2.3	1.5
Neoplasm	6.6	16.6	21.1	14.7	10.3	8.1	3.2
Other medical	27.8	29.2	24.2	28.8	35.8	42.3	59.2
Non-medical	54.5	80.6	92.9	96.3	98.0	98.1	98.6

Table 6: Selected causes of death by gender and age, based on verbal autopsy reports in Chennai

It is interesting to note that, even in other parts of the world where cause of death reporting is more complete, there is underreporting of the role of diabetes. In a longitudinal study of nearly 5,000 known diabetics in the UK [10], in which over 1,200 deaths were recorded, diabetes was certified as the underlying cause of death in only 11% of cases and appeared anywhere on the death certificate in only 48% of cases

A number of studies have been done to estimate the relative mortality risk of people with Type 2 diabetes. A long-term cohort study in the U.S. [11] looked at mortality of diabetics versus that of non-diabetics over a follow-up period of 22 years. Although the results are presented in summarised form the pattern of relative mortality risk is quite evident (Table 7). It should be noted that the diabetes mortality at younger ages is, in part, due to Type 1 disease.

	Diabetic adults (DM)		**Non-diabetic adults (non-DM)**		
Gender / Age *at baseline*	**Deaths**	**Mortality Rate** (per mille)	**Deaths**	**Mortality Rate** (per mille)	**Ratio of Mortality Rates** (DM : non-DM)
Male / 25-44	10	22.0	154	4.5	**4.9**
Male / 45-64	60	49.1	706	24.8	**2.0**
Male / 65-74	157	105.8	1,371	75.4	**1.4**
Female / 25-44	13	9.3	218	2.9	**3.2**
Female / 45-64	65	33.8	443	12.6	**2.7**
Female / 65-74	181	79.2	1,200	48.8	**1.6**

Table 7: Mortality rates of diabetic and non-diabetic lives during follow-up between 1971 and 1993, by gender and age at baseline

[6] i.e. principally malignant cancer

In this same study, the relative mortality rates by cause, standardised by age, were as shown in Table 8.

Cause of death	Ratio of Mortality Rates (DM : non-DM)	
	MALE	**FEMALE**
All Causes	2.0	2.2
All infectious diseases	2.3	1.8
Cancer	1.1	1.2
All heart diseases	2.6	3.0
Ischaemic heart disease	3.3	3.1
Cerebrovascular disease	2.0	2.9
Other circulatory disease	1.8	2.0
Renal disease	4.1	4.6

Table 8: Mortality rate ratios of diabetic and non-diabetic lives for selected causes of death

Similar data from a longitudinal study made in the UK are presented in Tables 9 and 10 [8].

Gender	**Age at death**	**Type 2 Diabetic adults**	
		Deaths	**Mortality Ratio** (cf. local popn.)
Male	40-59	73	3.1
	60-79	411	1.4
	80+	143	1.1
	All ages		1.4
Female	40-59	24	2.6
	60-79	279	2.0
	80+	218	1.3
	All ages		1.6

Table 9: Mortality ratio of people with Type 2 diabetes compared to the local population without known diabetes, by age and gender

Gender	Cause of death	Type 2 Diabetic adults	
		Deaths	Mortality Ratio (cf. local popn.)
Male	Cardiovascular diseases	370	2.0
	Ischaemic heart disease	273	2.2
	Cerebrovascular disease	67	1.8
	Neoplasm	133	1.0
	Renal diseases	11	4.6
Female	Cardiovascular diseases	317	2.3
	Ischaemic heart disease	200	2.7
	Cerebrovascular disease	80	1.9
	Neoplasm	75	1.0
	Renal diseases	7	2.9

Table 10: Mortality ratio of people with Type 2 diabetes compared to the local population without known diabetes, for selected causes of death

The consequence of the additional mortality risk is a substantial reduction in life expectancy. The US study data in Table 7 were calculated to correspond to a reduction in median life expectancy of ~8 years at ages 55-64 (at baseline study) and ~4 years at ages 65-74. Similarly, the UK study data in Table 9 were calculated to correspond to a reduction in life expectancy of ~7-8 years (on diagnosis, at ages 40-50), reducing to ~2 years for males and ~3 years for females on diagnosis at age 75.

However, the relative mortality risk of diabetes is also influenced by other factors, including socioeconomic status and ethnicity. The socioeconomic gradient for general mortality is a well-established phenomenon in many populations. A WHO multinational study of vascular disease in diabetes [12] also observed a relationship between social class and the relative mortality risk among diabetes sufferers (Table 11).

Cause of Death	Social Class[7]			
	I and II	III non-manual	III manual	IV and V
All causes				
Age adjusted mortality ratio	1.0	1.2	1.1	2.1
Fully adjusted* mortality ratio	1.0	1.0	1.0	1.7
Cardiovascular disease				
Age adjusted mortality ratio	1.0	1.3	1.9	3.0
Fully adjusted* mortality ratio	1.0	1.0	1.5	2.1
Ischaemic heart disease				
Age adjusted mortality ratio	1.0	0.9	1.4	2.3
Fully adjusted* mortality ratio	1.0	0.7	1.2	1.6

Table 11: Mortality ratio by social class of people with diabetes, for selected causes of death, WHO multinational study (* adjusted for age, blood pressure and smoking habits)

[7] Social class: I – professional / II – managerial / III – skilled / IV – semi-skilled, manual / V - unskilled, manual

These data are consistent with the observations in India that those from lower socioeconomic strata suffer a heavier burden of clinical complications of diabetes [7].

Ethnicity predisposes to a greater or lesser degree to the risk of acquiring diabetes. It also influences the pattern of mortality in established diabetics. In a comparison of the mortality of ethnic European and African Caribbean residents in the UK with Type 2 diabetes [13], it was observed that those of black African descent maintained a lower rate of vascular complications of their diabetes and all-cause mortality, compared to European lives (Table 12).

Cause of Death	**Mortality Ratio** (African : European)
All causes	
Age and gender adjusted mortality ratio	0.42
Fully adjusted* mortality ratio	0.59
Circulatory disease	
Age and gender adjusted mortality ratio	0.35
Fully adjusted* mortality ratio	0.54
Ischaemic heart disease	
Age and gender adjusted mortality ratio	0.40
Fully adjusted* mortality ratio	0.64

Table 12: Mortality ratio of African Caribbeans with diabetes, compared with Europeans
(* adjusted for age, gender, BMI, proteinuria and smoking habits)

It has been suggested that the observed lack of association between diabetes and cardiovascular disease in African Caribbeans, compared to Europeans, is related to a low degree of central obesity and a favourable blood lipid profile [13]. Indians exhibit a high degree of central obesity and often have an unfavourable blood lipid profile for cardiovascular risk; it may well be the case that diabetic Indians experience an excess cardiovascular mortality risk compared to Caucasians. In which case, the mortality hazard ratios presented in Tables 7-10 for US and UK lives could understate the relative mortality risk for Indian lives with diabetes. It also suggests (but does not prove) that, given the high prevalence of diabetes in Indians, diabetes is likely to be a significant factor in the large proportion of deaths attributed to cardiovascular disease (Tables 5 and 6).

Insurance implications

Diabetes is hugely relevant for life and health insurance. This is particularly so in India, given the high and rapidly increasing prevalence of the disease and its adverse effects on the risk of premature death, major morbidities[8] and healthcare costs[9].

Life insurance underwriting seeks to identify previously undiagnosed diabetes and pre-diabetic impairment of glucose regulation. A random (or preferably fasting) blood glucose test is a routine component of the fluid testing done for higher sums assured. However, there are several reasons to question the effectiveness of current underwriting practice in this regard.

A single, fasting blood sample may not detect diabetes or impaired glucose tolerance; a more sensitive method of detection is to undertake an oral glucose tolerance test, but this is a more involved and expensive procedure, which is infrequently performed for insurance purposes.

The age of onset of diabetes peaks in the age range 40 – 60 in India (Table 2), which is greater than the typical, peak age range for new insurance business. This suggests that many cases of diabetes will still affect the in-force book of insured lives, regardless of underwriting practice.

That such an important mortality risk factor is prevalent in a large proportion of the potential insured population brings into question what we mean by 'standard lives mortality'. In the face of a rapidly increasing prevalence and a reduction in the age of onset, consideration needs to be given to the implications for standard mortality, particularly of the majority of business which is accepted below insurers' non-medical limits.

In India, the observation that the urban, socioeconomically-advantaged sections of society are leading in the diabetes epidemic, and that urbanisation of the rural areas comes with a price of much more diabetes, insurers can expect to be at the forefront of the adverse health and mortality effects, since they source much of their business from the most at-risk groups.

The risks for insurers are exacerbated by the trend towards simplified underwriting, in which a short health questionnaire or declaration of good health is provided in lieu of a full proposal. The fact that diabetes may remain largely asymptomatic until such time as one or more complications set in means that this form of risk assessment is likely to overlook a substantial proportion of existing diabetes.

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[8] The major morbidities include several of the 'critical illnesses' commonly insured under long-term contracts – for example, myocardial infarction, coronary artery surgery, stroke, chronic renal failure, blindness.

[9] In the UK, it is estimated that diabetes costs the National Health Service around GBP 5 billion per year, or approximately 10% of its entire budget.

So, the trends in diabetes incidence and insurance risk assessment both need to be considered in the outlook for future mortality of insured lives and expected claim rates for health insurances. There is no straightforward way to integrate the epidemiological trends, demographic characteristics and insurance selection effects into a predictive model of diabetes-related mortality. However, the risks that are identified here do underline the importance of good and detailed claim experience monitoring including, in particular, information related to cause of death, to be able to identify leading indications of new, adverse mortality and morbidity trends.

Conclusion

Diabetes is a major risk factor for premature life and health insurance claims, the importance of which is not fully appreciated (particularly by actuaries!). For the foreseeable future, the burden of diabetes is set to increase at a phrenetic pace and, together with the parallel epidemic of obesity that is afflicting modern, developed societies, this represents a real threat to continued, future mortality improvements. As actuaries, we should be aware and watchful of the health risk factors that jeopardise our mortality and morbidity pricing assumptions.

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