

The Impact of Mental Disorders on Hospital Utilisation and In-Hospital Mortality among Elderly Patients with Diabetes in England

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Declaration of Originality

This thesis represents my own work, with support from my supervisors Prof Azeem Majeed, Prof Salman Rawaf and Dr Kiara Chang. I received statistical advice from Dr Michael Soljak. Mahsa Mazidi assisted me in the processing of data.

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Abstract

Background and Introduction: The rapidly increasing incidence and prevalence of diabetes and the progressively ageing population are unstoppable global trends. In a real-world setting, older people often suffer from multiple chronic physical or mental disorders, and it is, therefore, necessary to evaluate the impact of these disorders on hospital utilisation and mortality among older adults with diabetes.

Methods: A systematic review was conducted to understand the associations between mental/physical disabilities and medical utilisation/cost among elderly patients with diabetes. Three observational studies by using HES inpatient database were also conducted. From 2011-12 to 2013-14, patients who were 65 years old or above with diabetes were included. Multivariate regression models were performed to examine: (1) the impact of mental and physical disorders on hospital length of stay (2) the impact of physical or mental disorders on in-hospital mortality (3) the impact of mental and physical disorders on length of stay in hospital and in-hospital mortality of patients in different treatment units.

Results: Male gender, increasing age, white ethnicity, patients who lived in more deprived areas, and patients with mental or physical disorders had a higher risk for longer hospital length of stay and in-hospital mortality. Elderly patients with mental disorders had 5.88 times greater incidence Rate Ratio (IRR) for hospitalisation, and 10.96 times risk for in-hospital mortality. Patients with mood disorders had 6.54 times greater IRR for hospitalisation, and patients with dementia had 13.9 times risk for in-hospital mortality. Patients with mental disorders in ophthalmology department had 15 times higher IRR for hospitalisation.

Conclusions: Elderly diabetic patients with mental disorders have higher medical costs and in-hospital mortality than patients with diabetes only. Patients with dementia and mood disorders are the high-risk groups. To reduce medical costs and improve quality of care, early intervention and prevention for elderly diabetic patients with dementia and mood disorders are needed. Because the HES database does not include the relevant biochemical data during the patient's hospitalisation, further studies to connect to the hospital-level database to investigate the key reasons why patients with mental disorders can have a high risk for longer hospital length of stay and in-hospital mortality would be the future research.

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Abbreviations

ADI	International Association of Dementia
ADL	Activities of Daily Living
AGEs	Advanced glycosylation end products
AIRR	Adjusted Incidence-Rate Ratio
ANOVA	One-way analysis of variance
AOR	Adjusted Odds Ratio
AUD	Alcohol use disorder
BMI	Body Mass Index
BPSD	Behavioral and psychological symptoms of dementia
CBT	Cognitive behavioral Therapy
CPRD	Clinical Practice Research Datalink
DCCT	Diabetes Control and Complications Trial
DKA	Diabetic ketoacidosis
DM	Diabetes mellitus
DME	Diabetic Macular Edema
DPS	The Finnish Diabetes Prevention Study
DSM-IV	Diagnostic Manual for Mental Disorders, Fourth Edition
EASD	The European Association for The Study of Diabetes
ED	Diabetic Medicine
EDIPS	The European Diabetes Prevention Study
ESC	European Society of Cardiology
GDM	Gestational diabetes mellitus
GM	General Medicine
HbA1C	Glycated hemoglobin
HES	Hospital Episode Statistics
HESID	The HES Patient ID
HHS	Hyperglycaemic hyperosmolar state
IADL	The Instrumental Activity Daily Living
ICD-10	The 10th International Classification of Diseases

IDF	International Diabetes Federation
IFG	Impaired fasting glycaemia
IGT	Impaired glucose tolerance
IMD	The English Index of Multiple Deprivation
IMD_quintile	Index of Multiple Deprivation quintile
IRR	Incidence-Rate Ratio
MCBS	The Medicare Current Beneficiary Survey
MHA	Methodist Homes
MMSE	Mini-Mental State Examination
NCD	Non-communicable disease
NHANES III	The Third National Health and Nutrition Examination Survey
NHS	National Health Service
OGTT	The glucose tolerance test
OPH	Ophthalmology
OR	Odds Ratio
PPAR-γ	Peroxisome proliferative-activated receptor- γ
PSC	Posterior sub-capsular cataract
SCZ	Schizophrenia
SSRI	Selective serotonin-reuptake inhibitors
SU	Sulfonylureas
T1DM	Type 1 diabetes
T2D	Type 2 diabetes
T2DM	Type 2 diabetes
TCA	Tricyclic antidepressants
UKPDS	The UK Prospective Diabetes Study
UN	The United Nations
WHO	The World Health Organisation
WHO MSVDD	WHO Multinational Study of Vascular Disease in Diabetes

Chapter 1.

Introduction & Background

Benefit from better medical care and public health systems, whether it is in many developed countries or developing countries, the proportion of the elderly population has increased year by year. According to the report of the United Nations (UN), there are more than 950 million people over 60 years old. It is estimated that by 2050, the number of older adults in the world will reach 2 billion.

Coupled with the changes in diet and activity habits of modern people, the prevalence of diabetes is also increasing. According to the report of The International Diabetes Federation (IDF), about 460 million adults have had diabetes so far. It is estimated that by 2045, about 700 million people will have diabetes worldwide. More than 20% of the elderly suffer from diabetes.

As a result, the rapidly increasing incidence and prevalence of diabetes and the progressively ageing population are unstoppable global trends. Since diabetes and ageing are the most significantly concerning topics in public health, when the two health issues are superimposed, it is very hard not to be noted by health authorities around the world.

Although diabetes can occur in all ages, the incidence and prevalence of older adults are higher than other age groups. Among the elderly, one of the most common chronic diseases is diabetes. Both ageing and

diabetes discussions are crucial public health issues. Especially when the UN, World Health Organisation (WHO) and IDF statistical reports all pointed out that the problems of ageing and diabetes mainly occur in low- and middle-income countries; the in-depth analyses of the issue of diabetes among the elderly are not only urgent, but also beneficial to plan public health policies and preventive measures among those countries.

Although the United Kingdom is a high-income country, the problems of the ageing population and rising prevalence of diabetes will increase the national financial burden and the load of The National Health Service (NHS) system year by year. Therefore, an in-depth study of diabetes in the elderly is a significant public health issue that all national health authorities must face.

1.1 Diabetes mellitus (DM)

1.1.1 The Definition of Diabetes

Diabetes is one of the most critical global health issues of this century. In addition to the changes in modern people's lifestyle, coupled with changes in the environment and work pattern, as well as an ageing society, the prevalence of type 2 diabetes in the world has increased annually.

Diabetes is one of the ancient diseases that have been discovered in human history. From ancient Egypt 16th century BC, there were already written words about "polyuria", the diabetes-related symptom. In the 2nd century AD, the ancient Greek philosopher Aristotle described the phenomenon of a large amount of urine of patients with "Diabetes (Latin: polyuria)". Later, in the 5th and 6th centuries, doctors in China and Japan, as well as the Arabic world, also discovered that in those patients with polyuria, their urine tasted sweet; so, another diabetes symptom was discovered - "Mellitus (honey-sweet) sweet urine". Therefore, this name is used to describe patients with a fasting blood sugar level between 100 and 125 mg/dL, which is categorised as "pre-diabetes" (Am, 2002).

Until modern times, the medical community has known that the most crucial cause of diabetes in patients is a metabolic disease caused by insufficient insulin supply in the patient or due to decreased ability of the patient's body cells to utilise insulin.

Under normal conditions, insulin is secreted by beta cells in the pancreas. Insulin is an essential hormone in the body's regulation of blood glucose levels. Therefore, the most crucial feature of Diabetes Mellitus is that blood sugar will be higher than average.

Besides, insulin is also strongly related to the metabolism and utilisation of other essential nutrients (fat and proteins) in the body.

Therefore, in addition to affecting blood glucose concentration, diabetes can also cause dyslipidaemia and affect growth and development. For example, among young children with type 1 diabetes, if insulin is insufficiently given, in addition to the increase in blood sugar, their growth and development will also be affected.

Although the symptoms of diabetes are "polyuria" and "sweet urine", not every diabetic patient has initial symptoms of "Polyuria" and "Sugar in the urine".

People with diabetes are exposed to the highest risk of elevated blood sugar, which is a major cause of multiple organ damage. Many studies have pointed out that if the fasting blood glucose level exceeds 7.0 mmol/l (126 mg/dl), the risk of organ damage will increase substantially in the future. Therefore, the World Health Organization defines that when the fasting blood glucose level exceeds 126 mg/dL, the presence of diabetes should be considered for clinical diagnosis. Moreover, patients with a fasting blood sugar level between 100 and 125 mg/dL are categorised as having “pre-diabetes”.

The absence of sugar in the urine is not diabetes; this concept is not entirely correct. Because ordinary people need to have a blood sugar level of more than 180 mg/dl, sugar in the urine may not always be indicative of diabetes.

1.1.2 Epidemiology of Diabetes

With the development of medical technology and the control of infectious diseases, human society is now an ageing society. The increase in the ratio of the elderly population, which has led to the continual growth of the average human life; the static pattern of the

lifestyle of the world; and the prevalence of obesity have all led to making diabetes one of the most critical public health issues in the world. It was estimated that there were 108 million patients with diabetes in 1980, and the number increased to 422 million in 2014 (Zhou et al., 2016).

In both developed and developing countries, the incidence and prevalence of diabetes are rapidly increasing. The World Health Organization estimates that by 2025 there will be more than 300 million patients, the vast majority of whom have type 2 diabetes (T2DM).

Although children's leading diabetes is currently type 1 diabetes (T1DM), it is very likely that in more than a decade, children in many countries around the world, the prevalence of T2DM will outweigh T1DM soon.

In a report covering 90% of the world's population, and 70% of the countries studied for global diabetes trends and national diabetes prevalence, according to gender, from 1980 to 2014, the adult adjusted diabetes prevalence increased by more than 2 times, and that for women increased by about 1.5 times, similar to the trend in crude adult prevalence. In terms of regions, the countries of Oceania (e.g.

Polynesia, Micronesia, Melanesia) have the highest diabetes prevalence (about 15-20%), followed by the countries of the Middle East and North Africa (about 15%), while in Western Europe, the diabetes prevalence in women is less than 5%. As for Asia, due to the rapid population increase and the ageing society, compared with other regions, the total number of people who have diabetes is the highest globally. If divided by country, more than half of the diabetes patients are concentrated in the five countries of China, India, the USA, Brazil, and Indonesia (Zhou et al., 2016).

1.1.3 Different types of diabetes

In 1979, the National Diabetes Data Group of the National Institute of Health in the USA proposed the current classification and naming method for diabetes, which was then followed by the World Health Organization. In 1997, the American Diabetes Association and the World Health Organization revised and established a new classification method for diabetes due to further understanding of the aetiology and pathogenesis of diabetes.

The new classification method suggests that it is no longer divided into insulin-dependent diabetes mellitus and non-insulin-dependent

diabetes mellitus by treatment, and is classified into type 1 DM and type 2 DM according to the pathogenesis (Kumar et al., 2016). Type 2 Diabetes Mellitus (T2DM) is one of the most common chronic metabolic diseases worldwide and its prevalence continues to increase. Type 1 Diabetes Mellitus is an autoimmune disease that affects up to 10–15% of those with diabetes. Table 1 is the current classification of diabetes.

Table 1.1 Classification of diabetes

Classification of diabetes	
Type 1 diabetes	Usually caused by the destruction of beta cells, causing absolute deficiency of insulin in patients
Type 2 diabetes	Including patients with insulin resistance and relative insulin deficiency, as well as patients with insufficient insulin secretion and insulin resistance.
Gestational diabetes mellitus (GDM)	Women discovered to have diabetes when they were pregnant.
Other specific types of diabetes	Mainly due to factors such as genetic defects, infections, drugs, or chemicals

1.1.4 Risk Factors for Diabetes

Different risk factors depend on the type of diabetes. Type 1 DM, type 2 DM, and gestational DM have different risk factors.

1.1.4.1 Type 1 DM risk factors

Although the actual cause of type 1 DM is still unclear, many studies have pointed out that having a family history, environmental factors, the presence of diabetes autoantibodies, and geography may increase the risk of type 1 DM. Family history and the presence of diabetes autoantibodies may be genetically related. If a direct blood relative has type 1 DM, the risk of getting type 1 DM will increase. Studies of families with type 1 DM found that diabetes autoantibodies are more likely to be found in families.

Environmental factors and geography might be contributing factors. If there is a viral infection in the past (Filippi and von Herrath, 2005) or if people live in Finland and Sweden with efficient poliovirus vaccination programs (Soltesz et al., 2007), children have a higher risk of obtaining type 1 DM.

1.1.4.2 Type 2 DM risk factors

Family history of type 2 DM is the most commonly discussed risk factor for type 2 DM. Epidemiological studies have shown that people with diabetes in the family have about 2-6 times the risk of developing diabetes than the average person. When there is diabetes in family members, the incidence and prevalence rate is also higher than those in family members who have no relevant medical history (Harrison et al., 2003).

However, studies on diabetes and specific genetic variants have not had clear results. Although studies have found that specific genes correlate with the incidence of diabetes, these genes do not have the corresponding predictive power (Khoury et al., 2008).

Both obesity and waist circumference are important risk factors for obtaining type 2 DM. Waist circumference increases risk for type 2 DM more than Body Mass Index (BMI). Studies have shown that men with large waist sizes have a higher risk of developing type 2 DM than those with a high BMI. Women with large waist sizes have even higher risks than women with higher BMI. Although obesity and waist circumference are related to each other, the two factors are considered as independent risk factors for diabetes (Balkau et al., 2007).

In the case of inter-ethnic comparisons, according to some studies, Asians generally have a higher prevalence of insulin resistance than Caucasians if they have the same waist circumference (The Decode-Decoda Study Group et al., 2003). The degree of visceral fat accumulation among ethnic groups with the same BMI was compared, and Asians had a higher risk factor (Lear et al., 2007).

Diet and lifestyle are also critical risk factors for type 2 DM. According to statistics, compared with the past, the intake of animal fat increased from 22% to 30% during the 10 years, and the prevalence of obesity increased rapidly. The study found that women who regularly consumed high-fat foods were two times more likely to develop type 2 DM than the average female (Kitagawa et al., 1998).

Smoking is one of the significant risk factors for type 2 DM. A study pointed out that smokers have a 1.44-fold chance of getting type 2 DM (Willi et al., 2007), and the same trend was present in Asian ethnic groups (Chen et al., 2008).

1.1.4.3 Risk factors for gestational DM

Any woman can get gestational DM during pregnancy. However, studies have indicated that risks are higher in pregnant women over

35 years; women who have pre-diabetes before pregnancy; having a family member with type 2 DM; obese women with a BMI of more than 30; history of prior neonatal death; or history of having undergone caesarean section surgery (Xiong et al., 2001).

1.1.5 Diabetes Complications

1.1.5.1 Blood sugar control and DM complications

Diabetes has many acute and chronic complications. Acute diabetic complications such as diabetic ketoacidemia, hyperglycaemic hyperosmolar non-ketotic coma, or hypoglycaemia, can cause death or sequelae if not treated immediately. Chronic diabetic complications can occur in the eyes, blood vessels, nerves, kidneys, and other organs. Although it is not immediately life-threatening, the organs will gradually deteriorate due to hyperglycaemia, resulting in complete loss of organ function and eventual death. Chronic diabetic complications are also one of the most important causes of blindness or amputation in diabetic patients.

1.1.5.2 The common DM acute complications

Diabetic patients have four common acute complications: (1) Diabetic ketoacidosis (DKA); (2) Hyperglycaemic hyperosmolar state (HHS); (3) Hypoglycaemia (hypoglycaemia) (4) Lactic acidosis.

1.1.5.2.1 Diabetic ketoacidosis (DKA)

Diabetic ketoacidosis (DKA) can be divided into Mild, Moderate, and Severe according to severity. DKA occurs mainly in young type 1 diabetic patients, but it can also occur in patients with type 2 diabetes of all ages. According to statistics, the ketoacidosis hospitalisation rate among people with diabetes in the United States is about 6% per year (Stephen R. Benoit et al, 2018).

Clinically, there are three main diagnostic criteria for diabetic ketoacidosis: 1. Hyperglycaemia (blood sugar greater than 250 mg/dl), 2. Metabolic acidaemia (arterial blood bicarbonate <15mmol/L, pH <7.3) 3. Ketoacidosis (There is a ketone body reaction in the blood or the urine). Common DKA predisposing factors include infection and interruption of insulin injection.

1.1.5.2.2 Hyperglycaemic hyperosmolar state (HHS)

Hyperglycaemic hyperosmolar state (HHS) occurs mainly in patients with type 2 diabetes, but sometimes it also occurs in patients with type 1 diabetes. Older age, infection, stroke, acute myocardial infarction, use of steroids, diuretics, and other drugs are common risk factors. Common clinical symptoms of HHS include gradual deterioration of consciousness, and even lead to coma and shock, dehydration, lower blood pressure, and rapid heartbeat. The symptoms of HHS are similar to the symptoms of diabetic ketoacidosis. Differences between the two diseases lie with the susceptible population; DKA generally occurs in patients with type 1 DM, and HHS occurs in type 2 DM patients.

1.1.5.2.3 Hypoglycaemia

Hypoglycaemia is a common cause of diabetes in patients receiving oral hypoglycaemic drugs or insulin injections. Hypoglycaemia often occurs when the dose of the drug is inappropriate, or if the drug, diet, and exercise are poorly matched, or when the patient's liver and kidney function are abnormal. Most patients experience a warning of mild hypoglycaemia before severe hypoglycaemia occurs. Immediately, appropriate treatment can be taken to avoid severe hypoglycaemia. However, some patients with active insulin therapy, or long-term

diabetes or diabetic autonomic neuropathy may experience "hypoglycaemia unawareness". Such patients are prone to severe hypoglycaemia because they do not have any symptoms of mild hypoglycaemia before more severe hypoglycaemia causes generalised paralysis or coma.

1.1.5.2.4 Lactic acidosis

Although lactic acidosis is also an emergency that can occur in diabetic patients, it is rare. Lactic acidosis is only possible when the patient is in shock. However, lactic acidosis can occur in people with diabetes, whether they are diabetic or non-diabetic. The diagnosis is mainly found to have acidaemia and an increase in the concentration of lactic acid in the blood. Once severe lactic acidosis occurs, the mortality rate is quite high.

1.1.5.3 Diabetic Retinopathy

Diabetic retinopathy is one of the leading causes of blindness in adults aged 20 to 74 years, and it consumes enormous medical resources and leads to high social costs. Because of the retinopathy caused by diabetes and its related complications, the quality of life of patients will be significantly reduced, and patients will also lose their ability to

work because of blindness, and their social interaction will be severely affected, which will eventually lead to psychological problems. Early detection of diabetic retinopathy by an early retinal screening of diabetic patients and immediate provision of appropriate treatment can delay the deterioration of the condition such that vision can be retained or improved, reducing the incidence of diabetic retinopathy. Patients with either type 1 DM or type 2 DM may contract retinal microvascular diseases due to prolonged hyperglycaemia. Almost all type 1 DM patients develop retinopathy after 15 to 20 years, and 20% to 30% of them become blind. More than 60% of type 2 DM patients eventually have retinopathy. In addition to hyperglycaemia, ethnicity, genetics, high blood pressure, hyperlipidaemia, and proteinuria are risk factors for diabetic retinopathy.

The actual pathogenesis of diabetic retinopathy remains unclear. However, the possible mechanism may be due to excessive blood sugar in the long-term, leading to an increase in platelet aggregation, followed by damage to the microvascular epithelium, which may cause microvascular leakage, bleeding, and obstruction. Retinal hypoxia is also caused by microvascular occlusion, which leads to the release of angiogenic factors, which causes the retinal microvascular proliferation (Duh et al., 2017).

1.1.5.4 Diabetic nephropathy

Diabetic nephropathy is the leading cause of end-stage renal disease in developed countries. About 20–40% of diabetic patients will develop diabetic nephropathy, accounting for 40% of the total number of dialysis patients. Diabetic nephropathy usually begins with clinical signs 15 to 20 years after the onset of diabetes, and most of these patients progress to end-stage renal disease. Because patients also often have conditions such as hypertension, hyperlipidaemia, hyperuricemia, cardiovascular disease, and other diseases, the prognosis is worse than for patients with non-diabetic nephropathy.

Type 2 DM patients, because the symptoms are not apparent at the time of onset and because they are often elderly and have other vascular diseases and high blood pressure, can have early diabetic nephropathy that is not detected or treated.

However, early diagnosis and treatment can delay the occurrence and progression of the disease, so it is crucial to screen for diabetic nephropathy in diabetic patients regularly via examining the level of microalbuminuria. It is because the earliest manifestations of diabetic nephropathy are microalbuminuria. However, approximately 40% of patients with microalbuminuria develop significant albuminuria.

Microalbuminuria is not only an essential indicator of diabetic nephropathy but also an important indicator of cardiovascular disease.

1.1.5.5 Diabetic neuropathy

Diabetic neuropathy is the most common complication of chronic diabetic disease, and it is also a complication of the current unclear pathogenesis. According to epidemiological studies, about 10% of patients will have neuropathy within one year of diagnosis (Bansal et al., 2006). However, if a patient has diabetes for more than 25 years, there is a 50% chance of developing diabetic neuropathy.

Risk factors associated with diabetic neuropathy include older age, male sex, poor glucose control, and the presence of diabetic retinopathy. The type of diabetes is not a factor in getting neuropathy. The longer the duration of diabetes, the higher the chance of neuropathy.

1.1.5.6 Diabetic macrovascular disease

Macrovascular disease is the leading cause of death in diabetic patients. According to a report by the WHO Multinational Study of Vascular Disease in Diabetes (WHO MSVDD), 44% of the causes of type 1 DM

and 52% of the causes of type 2 DM are due to cardiovascular disease (Morrish et al., 2001). Major vascular diseases in diabetic patients include coronary heart disease, cerebrovascular disease, and peripheral vascular disease.

The chance of developing coronary heart disease in diabetic patients is two to four times higher than in the average person. This increase in risk is similar in different ethnic groups. Diabetic patients often have latent cardiovascular disease. If a diabetic patient has coronary heart disease, the prognosis is worse than that of non-diabetics.

People with diabetes have three times more chances of having a stroke than those without diabetes. Diabetes patients with stroke have a higher chance of developing dementia, stroke recurrence and mortality. If the diabetic patient is under 55 years old, the chance of suffering from a stroke in the future is ten times higher than that of a non-diabetic person. The carotid artery of diabetic patients has five times more chance of atherosclerosis than non-diabetics.

Diabetes patients have two to four times more risk of developing the peripheral vascular disease than the average person. According to statistics, about 15% of patients with diabetes have varying degrees of peripheral vascular disease. Diabetes patients are more likely to

develop intermittent claudication, and the risk in females is higher than in males. In male patients with diabetes, the chance of getting intermittent claudication is 3.5 times higher than that of non-diabetics, and female patients with diabetes are 8.6 times more likely to have intermittent claudication than non-diabetics. In the United States, the chance of lower extremity amputation in diabetic patients is 12.7 times higher than that of the average person.

People with diabetes are prone to macrovascular disease, and its pathogenesis may be related to insulin resistance and hyperinsulinemia, hypertension, dyslipidaemia, obesity, smoking, and genetic abnormalities. These risk factors are interrelated, directly and indirectly, and affect the severity of macrovascular disease in diabetic patients.

1.1.6 Medical Care Guidelines for Diabetes

The most important clinical manifestation of diabetes is hyperglycaemia. Therefore, if the patient can control the blood sugar to near normal range, in addition to improving the clinical symptoms of diabetes (e.g., itching, polyuria, thirst, fatigue, blurred vision), it can also delay or even prevent the occurrence of chronic complications of

diabetes (e.g., diabetic retinopathy, diabetic nephropathy, diabetic neuropathy). It can also effectively prevent the morbidity and mortality of ketoacidosis or hyperglycaemia and hyperosmolar non-ketone body coma.

Regular medical treatments for diabetes, include lifestyle interventions: nutrition treatment, exercise, weight loss, and medication use: oral hypoglycaemic agents, insulin injections. Since cardiovascular disease is the leading cause of death in diabetic patients, the control and monitoring of HbA1c, blood pressure and blood lipids are also listed as the main monitoring focus when tracking diabetic patients.

1.1.6.1 Type 1 Diabetes Management

Type 2 diabetes is due to insulin resistance combined with relative insulin deficiency, which can be treated by oral medications that improve insulin sensitivity or stimulate islet cells to secrete more insulin. However, type 1 diabetes is caused by the destruction of pancreatic islet cells by autoimmunity or for unknown reasons, so type 1 diabetes patients need to be treated with insulin for the rest of their lives. Conventional insulin therapy includes insulin injection, insulin pump, pancreas transplantation, and islet cell transplantation.

1.1.6.1.1 Insulin injection

Self-injected insulin is available in fast-acting, short-acting, intermediate-acting, and long-acting forms, and is usually recommended for combined use. In general, patients are advised to take a long-acting dosage form once a day, plus a short-acting dosage form three times a day. The actual dosage and dosage form will depend on the severity of the disease.

1.1.6.2 Insulin pump

The insulin pump is a treatment for continuous subcutaneous insulin injection that meets human physiological needs. The patient carries a small pumping device that can be connected to a thin tube that is implanted under the skin. The pump will automatically release a small amount of fast-acting insulin as a base. When the patient is eating, the pump releases additional insulin based on the type of food, the serving size, and the blood glucose level at the time.

1.1.6.1.3 Pancreas transplantation

The purpose of pancreas and islet transplantation is to inject insulin to maintain healthy blood sugar, avoid chronic complications, and

improve quality of life. If a patient with kidney failure requires a kidney transplant, conventional insulin therapy cannot be provided smoothly; or the patient does not have renal failure, but insulin therapy is difficult, resulting in frequent acute complications. Such patients are suitable for pancreas transplantation. Because of the many side effects, such transplants are mainly used in middle-aged people and are rarely used in adolescents.

1.1.6.1.4 Islet transplantation

Islet transplantation is the isolation and purification of islet cells from the pancreas and implantation into the liver of the patient via the portal vein. Because islet transplantation requires the administration of immunosuppressive agents, there are still related comorbidities. Besides, it is not easy to find the right donor.

1.1.6.2 Type 2 Diabetes Management

Although type 2 diabetes can sometimes be controlled by diet, in the end, blood sugar levels must be controlled by medication. Patients with type 1 diabetes will require insulin treatment from the time of initial diagnosis. Here is a brief introduction to the current primary international medical treatments including oral hypoglycaemic drugs and insulin therapy.

1.1.6.2.1 Oral hypoglycaemic drug

When the patient's symptoms are severe, or fasting blood glucose exceeds 250–300 mg/ml and insulin needs to be injected immediately, in general, oral hypoglycaemic drugs are the first-line treatment for type 2 diabetic patients (Mansour et al., 2017).

When a physician prescribes an oral hypoglycaemic drug prescription, it is necessary to comprehensively assess the patient's disease severity, socioeconomic status, and whether they have family members to select the most appropriate oral hypoglycaemic agent. In addition to considering the patient's current blood sugar level, it is also necessary to consider the patient's current liver function, kidney function, and heart function. Besides, the efficacy of specific drugs on patients, as well as possible side effects, and even drug prices, should be considered by physicians. If the patient does not meet the treatment goal, the physician will need to consider whether to combine other oral hypoglycaemic agents, even with insulin injections.

At present, oral hypoglycaemic drugs can be classified into the following four categories according to their drug mechanism and can be used alone or in combination with other types: a. Biguanides; b. Insulin secretagogues; c. α -glucosidase inhibitor; and d. Glitazones.

a. Biguanides

Biguanides are mainly used to reduce gluconeogenesis in the liver but not to promote insulin secretion. The most commonly used biguanide is dimethyl biguanide (metformin). About 20% of patients, after taking metformin, temporarily have side effects such as loss of appetite, abdominal discomfort, or diarrhoea. In general, taking metformin alone does not easily lead to hypoglycaemia. However, patients with heart, kidney, liver dysfunction, and concurrent infections are still not recommended to use metformin to avoid lactic acidosis.

b. Insulin secretagogues

In the classification of insulin secretagogues, two drugs can promote the secretion of insulin, but the receptors for the two drugs are different. One is sulfonylureas (SU) drugs, which are mainly used to increase insulin secretion. The other is Glinides, which is mainly used to stimulate beta-cell iodine urea receptors, which can also promote insulin secretion.

The most common adverse drug reaction with sulfonamides is hypoglycaemia. Sulfonamide is mostly metabolised by the liver and metabolites are passed through the kidneys. Therefore, if the patient

has liver dysfunction or renal function decline, the use of sulfonamides may increase or prolong the effect. Therefore, patients with reduced liver or kidney function should be especially careful if they use these drugs. The dose should be reduced, and blood glucose should be monitored intensively to reduce the chance of hypoglycaemia.

For the elderly or those who do not have a fixed mealtime, to avoid causing severe hypoglycaemia, the physician must confirm the patient's eating habits, and let the patient take the drug at a low dose, and then slowly increase the dose according to the patient's blood glucose tracking report.

In addition to the adverse drug reactions caused by sulfonamide itself, sulfonium urea also interacts with certain drugs, which needs to be taken seriously in clinical practice. Salicylate affects the binding of sulfonium urea to protein and also reduces the elimination of sulfonamide from the kidneys. Rifampicin, carbamazepine, and phenytoin promote the metabolism of sulfonamide in the liver, but cimetidine inhibits the metabolism of sulfonamide in the liver. Glucocorticoids affect the hypoglycaemic effect of sulfonamides. Sulfonamide should not be used in patients who are allergic to sulfa drugs, pregnant women, and those who have not been able to eat properly after surgery.

c. α -glucosidase inhibitor

The primary drug mechanism of α -glucosidase inhibitor is to inhibit the decomposition of starch and disaccharide and delay the absorption of glucose in the gastrointestinal tract. It can effectively reduce postprandial blood glucose and fasting blood glucose, and reduce blood insulin concentration. Because the gastrointestinal tract does not readily absorb such drugs, patients taking such drugs often have side effects such as flatulence and diarrhoea.

d. Glitazones

The drug mechanism of Glitazones is to activate peroxisome proliferative-activated receptor- γ (PPAR- γ), increase insulin sensitivity, and reduce fasting blood glucose and blood insulin levels. Common side effects include weight gain, oedema, diarrhoea, and headache. Taking these drugs may cause hepatotoxicity, and although the incidence of hepatotoxicity is extremely low, there are still sporadic reports of hepatotoxicity. Therefore, before starting to use these drugs, liver function should be checked to determine if the drug is used. After starting the medication, liver function should still be checked regularly. If the liver index rises, patients should stop taking it.

1.1.6.2.2 Insulin therapy

Although the pathophysiology of type 2 diabetes is due to the presence of insulin resistance and reduced glucose utilisation; it is not just insufficient insulin secretion. However, patients with type 2 diabetes eventually face the problem of the reduced ability of beta cells to secrete insulin. Therefore, in the course of the development of diabetes, many patients will have to eventually use insulin.

Since the invention of insulin in 1921, insulin has been used for nearly 100 years. The first use of animal insulin (mainly porcine insulin, because it is similar to the human insulin structure) was followed by genetic engineering to mass-produce high-purity human insulin, and then the emergence of insulin analogues in the 1990s. Clinical trials have found that insulin analogues are superior to human insulin in mimicking insulin secretion and reducing the risk of hypoglycaemia.

According to the speed of insulin action, agents can be divided into the following: fast-acting insulin analogues, short-acting insulin, intermediate-acting insulin, long-acting insulin (including long-acting insulin analogues) and premixed insulin (premixed insulin analogues).

The UK Prospective Diabetes Study (UKPDS), which analyses the

ability of beta cells to secrete insulin in diabetic patients, also found that regardless of the type of treatment that patients with type 2 diabetes receive, they still face the problem of the reduced ability of beta cells to secrete insulin. According to the study, patients with dietary control were found to have 53% of insulin secretion in the first year to 26% in the sixth year. Among patients who took oral hypoglycaemic drugs, the ability of beta cells to secrete insulin decreased from 78% to 52% in patients treated with a sulfonylurea. In patients treated with metformin for diabetes, the ability of beta cells to secrete insulin decreased from 66% to 38%.

The UKPDS study also found that as the study time prolonged, the patient's blood glucose increased year by year, and its HbA1c index also increased year by year. More than ten years later, most of the patients with type 1 diabetes who were treated with drugs had been converted to insulin therapy.

1.1.7 Economic impacts of Diabetes

According to the International Diabetes Federation (IDF) IDF diabetes report (Cho et al., 2018), the cost of diabetes-related medications and treatments for complications is enormous. In addition to the economic

burden placed on patients with diabetes and their families, it also imposes a substantial burden on the medical systems of various countries. According to statistics, 5% to 20% of health expenditures in many OECD countries are used to treat diabetes and its complications (Zhang et al., 2010).

Due to the increase in medical expenditures, as well as diabetes patients often having a lower labour force involvement than the average worker, the reduction of taxes and the expenditure of social welfare have caused a significant burden on most OECD countries' finances and are also a significant obstacle to the country's economic development. According to the IDF diabetes report, by 2040, the number of people with diabetes will increase by 35% compared with 2015, and the corresponding medical expenditure will increase by 19% of the total.

1.1.8 Diabetes in the UK

In the UK, Diabetes Mellitus is increasing in prevalence and currently affects 3.8 million individuals according to Diabetes UK statistics (Diabetes UK, 2018). Patients with T2DM are at risk of several short-term complications (such as infection) and long-term complications

(such as cardiovascular disease) (Bagust et al., 2002). These complications can lead to disability, reduced quality of life, and premature death for people with diabetes, as well as imposing a considerable economic burden on patients, their careers, society, and on the National Health Service (NHS) (Olokoba et al., 2012).

1.2 Ageing

1.2.1 Ageing is a global issue

The rapid ageing of the global population has become an issue of great concern to all countries and one of the issues that the United Nations and international organisations have attached importance to. The ageing of the population is an unstoppable global trend.

As the birth rate and the elderly mortality rate continue to decline, the elderly population proportion has increased rapidly in various countries. Many developed countries have already begun to deal with the problem of the ageing society; however, many developing countries have only recently begun to attach importance to this issue and set out to deal with various public health issues related to the ageing society.

According to statistics, the proportion of the elderly population over the age of 60 in the world has increased from 9.2% in 1990 to 11.7% in 2013. In 2017, the total population of the world was 7.6 billion, and the elderly population over 65 was 700 million, accounting for 9% of the total population. By 2050, the world population will be estimated to reach 9.8 billion, and the elderly population over 65 will exceed 1.5 billion, accounting for 16% of the world total population. (Organization, 2015).

By 2050, the total fertility rate is expected to drop to 2.2 from its current 2.5. It is estimated that with longer life expectancy, the global ageing will increase rapidly. It is estimated that the elderly population over 60 years old will exceed the young population of 0-14 years old in 2047. In 2050, the elderly population over 60 years old will exceed the total number of children under the age of 5.

The ageing population is undoubtedly one of the critical socioeconomic issues in the world. The global old-age support ratio has dropped from 12 in 1950 to 8 in 2013, and is expected to continue to reduce to 4 in 2050; in particular, the ratio will be lower in many developed countries and in some developing countries. The old-age support ratio in the population is the ratio of 15- to 64-year-old and those over 65 years. This value indicates how many people of working

age in the population support an elderly person. Therefore, the lower the ratio, the more substantial the burden on the working-age population. This means that by 2050, one adult over the age of 65 will only be supported by four young counterparts. Compared with 1950, the health and social care burden on young people has tripled, indicating that the support burden of the elderly on the elderly population has increased rapidly.

Due to the continuous rise of human life expectancy, considering the increasing prevalence of non-communicable diseases in the elderly, the increase in dementia and disability, and the slowdown in economic growth in various countries, the ageing of the population, is destined to become the human and financial burden of the medical system of each country.

As the fertility rate declines, the number of people in each household is reduced. Therefore, the growing trend for the elderly to live without family support is inevitable. According to statistics, about 30% of the elderly population in the US is living independently (Daniel B. Kaplan et al., 2019), and the independent living of the elderly is positively correlated with the ageing of the population. It is expected that this ratio will continue to rise in the future. However, when elderly people suffering from chronic diseases require long-term assistance from

others, elderly people without family members can expect that the compliance and accessibility of their related medical care will be affected. This not only directly affects the quality of health care for the elderly but also increases the cost of the medical system to care for the elderly.

Under the increasing number of elderly people living alone, the problems of economic security and health care for the elderly have arisen. It is necessary for all countries to gradually improve the economic and medical security of the elderly, especially those countries that have no demographic dividends. Due to the decline in the working-age population, how to formulate appropriate policies, strengthen investment in preventive care, improve the efficiency of the use of human resources and resources in the medical system, and respond to the challenges brought about by changes in the demographic structure are the current essential policy issues of governments.

1.2.2 The UK is an ageing society

The UK, like other developed countries, is an ageing society (Bagust et al., 2002). T2DM is most common in older people (in contrast to T1DM)

and the burden of diabetes in older people will, therefore, increase in the future through a combination of an ageing population and an increase in risk factors for diabetes such as high-calorie diets, sedentary lifestyles, and obesity. The cost of health care for patients with type 2 diabetes will rise, but the economically active age groups will reduce in size due to an ageing society. This means the relative economic burden of diabetes on people of working age will increase (Hex et al., 2012). Some studies have calculated the cost burden of diabetes mellitus to the NHS at between 5 and 10% of total spending (Kumar et al., 2006).

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1.3 Diabetes and Ageing

Diabetes and ageing have always been one of the most concerning topics in public health. When the elderly suffer from diabetes, the two health issues are superimposed and are noted by health authorities around the world.

Type 2 diabetes is also one of the most common diseases in the elderly. The prevalence of diabetes in the elderly population is increasing. Diabetic patients who are elderly often have no apparent clinical symptoms, and even if there are typical symptoms of diabetes, they are

often neglected or mistaken for signs of ageing.

For example, typical symptoms of diabetes, such as frequent urination, increased thirst, and always feeling hungry, are often absent, milder, or misunderstood in the elderly. Symptoms of polyuria are often mild in elderly diabetes because of the high glucose threshold in the kidneys of the elderly, and symptoms are often mistaken for incontinence or benign prostatic hyperplasia.

The elderly increased thirst symptoms are also mild. In addition to the elderly kidney glucose threshold is higher, the elderly's thirst is delayed. Because the appetite of the elderly is poor, even though diabetes is caused, the symptoms of eating more are not visible. Weight loss and tiredness are often overlooked,

Therefore, diabetes in the elderly is often not diagnosed or delayed. It is often diagnosed after acute complications such as diabetic hyperglycaemia and osmotic non-ketoacid coma, or there are apparent diabetic complications such as peripheral neuropathy; vision loss; kidney insufficiency; heart failure; or cerebrovascular, cardiovascular, or peripheral vascular disease.

Therefore, regular blood glucose screening is especially important for

elderly people, especially for those who are already suffering from hypertension, obesity, dyslipidaemia, cardiovascular, or cerebrovascular diseases.

Take Japan as an example, the country with the longest life expectancy in the world. It is reported that there are currently about 10 million diabetic patients. Especially in the elderly, the proportion of diabetes has increased remarkably; now around 40% of those over the age of 70 have diabetes. With a life expectancy of 80 and 90 years old or even longer, to keep high-quality life for the elderly, it is necessary to put elderly diabetes management into consideration. As for why the discussion on ageing and diabetes is remarkably critical? Here are some reasons.

1. The increase in average life expectancy leads to population ageing:

Due to the development of medicine, many acute infectious diseases have been controlled or healed. In many countries, the average life expectancy of people has gradually increased, so the proportion of elderly people in the population is increasing. According to many epidemiological studies, it is considered that age growth is the most crucial reason for the increase in the number of people with type 2

diabetes. According to The Third National Health and Nutrition Examination Survey (NHANES III) in the United States, the prevalence of diabetes in American males and females increases with age. For people over the age of 60, about 20% of men and about 18% of women have diabetes (Harris et al., 1998).

2. Human work patterns change, more people are engaged in no labour, and exercise is reduced:

Regular exercise is an essential factor in maintaining good health. Lack of exercise or lack of moderate activity is one of the critical factors contributing to diabetes. Due to the change in the work style of modern society, it has changed from the past work style mainly for physical labour to the work style based on static work dominated by the office. Because many people do not need to work hard, plus the usual exercise is low or reduced activity, it also makes older people in society more likely to suffer from diabetes than ever before.

3. Health Literacy, regular screening, and the rise in diagnostic techniques have increased the diagnostic rate of diabetes in older adults:

In the past, most patients were not diagnosed with diabetes until they

displayed its typical symptoms. However, many countries now have extensive diabetes screening mechanisms and regular health check-ups that increase the diagnostic rate of diabetes. Besides, with the advancement of diabetes diagnostic techniques, most patients can be diagnosed with diabetes in advance even if they are without any diabetes symptoms.

Also, most understand the severity of various complications of diabetes and recognise the importance of early diagnosis of diabetes. With many new screening mechanisms, many people with diabetes can be diagnosed early in the course of their illness. It also increases the overall prevalence of diabetes. Even if the elderly cannot express their symptoms clearly or do not care about their illness, but most of the family members already know the seriousness of diabetes, and the society has an excellent regular diagnosis system, the diabetes diagnosis rate of the elderly is rising. As a result, the prevalence of diabetes has increased.

4. Changes in eating habits lead to overweight or obesity

Since the 20th century, food technology and agricultural technology have developed, so that food sources are abundant. Coupled with the reduction in physical activity of the general public, the ratio of obese

people in various countries is rising rapidly. Also, because overweight or obesity is one of the crucial factors leading to diabetes, the rate of diabetes in elderly people who are obese is rapidly increasing. People who are overweight or obese, the rate of diabetes is twice that of people with an average weight. Further, regarding high waist-to-hip ratio, people with central obesity are more likely to get diabetes.

At present, the direction of treating elderly diabetes is not limited to blood sugar control, but also takes into account the quality of life, the remaining life, and the severe side effects caused by over-treatment. Besides, for the elderly, teaching the correct treatment methods or techniques for elderly diabetic patients, reducing cross-reactions of multiple drug treatments, and preventing side effects of drugs are an indispensable part of the elderly diabetes education. For the treatment of elderly diabetic patients, not only more medical resources but also better social assistance are needed.

1.4 Diabetes and good quality of care

T2DM is considered a “primary care sensitive condition” and in theory, good management of T2DM in primary care could improve health outcomes for patients and reduce emergency admissions for diabetes

(Gibbons et al., 2012). Some studies have revealed that if patients with multiple chronic diseases can have good access to primary care, this would lead to a higher quality of care, better health promotion and improved disease prevention (Flocke et al., 1998). The contribution of good access to better health care outcomes has been well established in some studies (Shi, Green, and Kazakova, 2004).

However, for those diabetic patients with mental or physical disorders, the barriers to accessing health service are greater than for other patients with chronic diseases only. Furthermore, diabetic patients who do not receive high-quality, regular treatment may be more at risk of complications, with higher mortality and shorter life expectancy.

1.5 Diabetic patients with mental or physical disorders

Disability among diabetic patients has become a serious issue in primary health care. Because of improvements in medical technology and access to health care, diabetic patients have higher life expectancy than before. On the other hand, ageing or late complications of chronic diseases already make disability and diabetes come together very

often in routine medical care. Both advancing age and presence of diabetes increase the likelihood of having a disability. According to one estimation of the prevalence of disability among diabetic patients, around 20% to 50% of diabetic patients have a disability (Songer). Diabetic patients with a physical or mental disability can face obstacles in addressing their healthcare needs. They may delay their routine treatments and this can lead to deterioration in their health outcomes.

In many studies, patients with general medical problems who also have a mental health problem have significantly higher morbidity or mortality. Although some mental health disorders can increase the risk of suicide, the major causes of death among the patients with mental health problems are due to the complications of physical diseases (Daumit et al., 2002). Among these chronic illnesses, diabetes is considered the most severe medical problem of individuals with mental disorders.

The level of physical disability among diabetic patients can be a significant barrier for them to access medical services. Because diabetes requires long-term follow-up and treatment, their poor physical health can discourage diabetic patients from using medical services.

1.6 Diabetes prevention

1.6.1 Primary Prevention

The primary prevention of diabetes should be initiated by the community based primary care system, providing the necessary risk assessments and early screening for the high-risk groups of various types of diabetes mentioned in the previous paragraphs. The purpose of primary prevention is to prevent the high-risk population from getting diabetes (Macaulay et al., 1997).

The glucose tolerance test (OGTT) can be used to diagnose definitive diabetes. In the current European guideline, according to WHO 2011 recommendations, all populations with fasting plasma glucose between 6.1-6.9 mmol and l (110-125 mg/ml) need to perform oral glucose tolerance tests to determine the diagnosis of diabetes. As for the American Diabetes Association, which adopts stricter recommendations in 2019 than the WHO, fasting plasma sugar at 5.6–6.9 mmol / L (100–125 mg / dL) is regulated to impaired fasting glycaemia (IFG). For the diagnosis of diabetes, the test data needs to be repeated twice or more before it can be used as the basis for the diagnosis. If the patient has a history of CVD, HbA1c or fasting plasma

sugar should be used for screening. When neither FPG nor HbA1c has a way to conclude, OGTT can be performed (Cosentino et al., 2019).

Large-scale diabetes prevention and control research on glucose intolerance groups has been conducted in various countries. The Diabetes Prevention Program in the United States (Knowler et al., 2002) and the Diabetes Prevention Study in Finland (Eriksson et al., 1999) found that changes in lifestyle patterns have reduced the incidence of diabetes in the United States' 2-year and 8-month control study, the effect is far better than preventive medications. These studies also show that among the high-risk groups of diabetes, if 6.9 individuals participate in lifestyle changes, one person will be prevented from developing diabetes in 3 years.

As the Finnish Diabetes Prevention Study (DPS) showed an about 60% reduction in the incidence of type 2 diabetes (T2D) in adults with impaired glucose tolerance (IGT), the European Diabetes Prevention Study (EDIPS) extended the study of DPS to Newcastle, UK. Testing the efficacy of lifestyles for preventing T2D is the same in the UK. The results show that the results in the UK are consistent with diabetes prevention trials in other countries, proving that T2D can be prevented by changing the lifestyles of adults who already face IGT (Penn et al., 2009).

In the primary prevention of diabetes, health education, and raising people's health literacy for diabetes are very important. Improve people's awareness of the dangers of diabetes, educate high-risk groups with diabetes family history, provide self-tests for early symptoms, improve bad lifestyles, and actively reduce the risk factors of diabetes.

As mentioned earlier, obesity and high waist circumference are important risk factors for diabetes. For obese people, it is recommended that they should strictly limit the consumption of high-sugar and high-fat foods, and eat vegetables and fruits rich in cellulose and vitamins to prevent excessive intake of energy. People should avoid excessive intake of energy, reduce the intake of saturated fatty acids, and effectively reduce the risk of acquiring diabetes in the future. Besides, regular physical activity to reduce weight and enhance cardiovascular function, thereby preventing diabetes and its complications. At this stage, it is necessary to improve the population's obesity, dyslipidaemia, hypertension, and insulin resistance in advance, so that the blood sugar metabolism of high-risk groups of diabetes can return to normal.

1.6.2 Secondary Prevention

The secondary prevention of diabetes lies in the early diagnosis of diabetes, and early active treatment allows patients to obtain optimal control and avoid or reduce the deterioration of diabetes. As for the tertiary prevention of diabetes, the goal is to prevent diabetes complications.

According to the UKPDS and Diabetes Control and Complications Trial (DCCT), diabetic patients, in addition to blood sugar level, strictly controlling blood lipids and blood pressure, will delay or reduce the future complications of diabetic patients. When the patient's HbA1c level can be less than 7.5%, the patient's risk for the microvascular complication is reduced substantially (UK Prospective Diabetes Study (UKPDS) Group, 1998). If the diabetic patients' HbA1c level is less than 8.0%, the chance of complications will be lower than that of patients with HbA1c>8%. The UKPDS study pointed out that if diabetic patients can control the blood pressure below 144/82 mmHg, it can effectively reduce the risk of stroke, heart failure, microvascular disease, blindness and even death.

Chapter 2. Mental disorders in the elderly & literature review

In the previous chapter, I discussed the two important public health issues regarding the ageing population and diabetes. In this chapter, I will discuss another critical public health issue, mental illness.

According to the WHO report, about 25% of people have been plagued by mental illness for at least some time in their lives.

According to WHO estimates, approximately 450 million people worldwide are suffering from mental illness. Although mental illnesses currently have drugs that can treat or control the patient's condition, only one-third of patients currently undergoing diagnosis and treatments of mental illnesses. This means that most patients in the world today have not yet been diagnosed or treated.

However, with the increasing proportion of the global elderly population, the mental health of the elderly has gradually become a significant public health issue. The WHO estimates that more than one-fifth of the elderly over the age of 60 in the world suffer from mental illness. Among the elderly, the most common mental illnesses are dementia and depression. Although the proportion of older adults suffering from mental illness is very high, due to the lack of identification of mental illness by medical staff and elderly patients, the diagnosis of mental illness in elderly patients is not as proper as physical diseases. Besides, the overall atmosphere of the society has stereotypes and misunderstandings about mental illnesses, which

also leads to the older adults who are still reluctant to seek medical assistance even if they suffer from the symptoms of related mental illnesses.

In a real-world setting, older people often suffer from multiple chronic physical or mental disorders, and it is, therefore, necessary to understand mental disorders among older adults with existing physical disorders.

Among the elderly, diabetes is one of the most common physiological diseases, while dementia and depression are the most common mental diseases. Therefore, among elderly diabetic patients, a certain percentage of patients must suffer from dementia or depression. In this chapter, I will also review the related researches between diabetes and dementia or depression.

2.1 Mental disorders in the elderly

With the rapid advancement of modern medical technology and the extension of average life expectancy, today's population faces a longer retirement period. In recent years, the proportion of the elderly population in developed countries, and even in developing countries, is the fastest-growing age group. This phenomenon of global aging is a global trend. The high ratios of elderly in the populations of the UK and Europe, by the UN definition, are referred to as an aged society. Therefore, the physical and mental health of the elderly has gradually attracted attention in various countries. However, in addition to natural deterioration of physical health of the elderly, psychological health is increasingly impacting the health care systems and national finances. As such, maintaining good mental health in the elderly is an issue that health departments of various countries and the World Health Organization are actively facing.

Aging is a complicated process involving not only apparent physiologically changes, but also psychological changes. Physiologically, the process of human aging involves the death of cells, reduced efficiency of physiological operations in tissues, organs, and systems, and the slowing of the human body's overall capacity for

physiological repair. These changes cause the body's basal metabolic rate to decrease and the body's heart, lung, and kidney functions to gradually decrease with age. The nervous system function of the human body will also gradually decline.

During the aging process of the human body, the nervous system faces neurochemical, neurophysiological, and structural changes. Microscopically, aging can lead to the loss of nerve cells, pathological changes of nerve cells, or metabolic changes of neurotransmitters. If these changes in the aging of the nervous system occur in specific brain cortical or subcortical nerve tissues, it may lead to mental diseases such as dementia, depression, or bradykinesia. If the situation continues to worsen, even abilities used in daily life will be impaired.

In addition to the physiological and psychological changes caused by aging, the relationship between the elderly and society is also slowly changing due to the increasing age of this group. The first issue for the elderly is losing their role in society due to retirement. The associated loss of economic autonomy often causes a loss of self-esteem. In addition to social isolation, the loss of family or relatives may contribute to declining mental health. The physiological, psychological, and social pressures exerted by the processes mentioned above on the elderly are risk factors for mental illness.

The elderly may also suffer from chronic diseases, which can directly or indirectly affect functioning of the brain, causing neuropsychiatric symptoms. According to statistics, more than 40% of the elderly suffer from at least one chronic disease. Common chronic diseases include hypertension, diabetes, ischemic heart disease, and atherosclerosis. These diseases have direct or indirect effects on the brain. In addition, older adults are prone to various chronic diseases and often must take multiple drugs simultaneously, resulting in reduced drug compliance. Older patients with chronic diseases may not use medications as directed and thus, these conditions are often not well controlled. Alternatively, they may overdose on medication, leading to side effects or drug toxicity, and even drug abuse.

Due to increasing diagnostic difficulties for clinicians and the complicated treatments involved, elderly having both physical and mental symptoms have prolonged hospitalisations. The prognosis of treatment is also worse than that of patients with a single disease. Therefore, it is a challenging but essential issue for all governments to provide the most appropriate medical care for the elderly.

Mental illnesses commonly experienced by the elderly include dementia, major depressive disorder, bipolar disorder, organic mental

illness, schizophrenia, anxiety disorder, substance abuse, sleep disorder, and delirium. Among them, dementia, depression, anxiety, and substance abuse are the most common.

2.2 Dementia in the elderly

2.2.1 The global population of dementia is rapidly increasing.

According to data presented by the International Association of Dementia (ADI) in 2018, it is estimated that about 10 million people with dementia will be diagnosed globally in 2018. This means that one person is diagnosed with dementia every three seconds on average. According to the report, the current global population of dementia includes approximately 50 million people. It is estimated that by 2050, the number of people with dementia will reach 150 million. Currently, the cost of medical care spent on dementia is \$1 trillion per year, and by 2030 it will double to \$2 trillion.

2.2.2 Dementia in the UK

2.2.2.1 Dementia prevalence in the UK

According to the research report, in 2015, there were more than 800,000 people with dementia in the United Kingdom, and average annual medical-related expenses neared £25 billion. It is estimated that by 2025, the total number of people with dementia in the UK will reach 1 million. By 2050, the total number of people with dementia may double to 2 million. At present, there are about 40,000 patients diagnosed with dementia in the UK under the age of 65. These patients are classified as having "early-onset dementia." The total prevalence of dementia in the UK is about 1.3%. but for adults over the age of 65, the rate is close to 7%. If compared with the past, the age-specific prevalence of dementia demonstrates an increasing trend in the age groups of 65-69 years and over 90 years.

2.2.2.2 Dementia costs in the UK

The current average medical cost per year spent on dementia in the UK is £26.3 billion. Among these costs, direct costs of National Health Service (NHS) are about £4.3 billion, while indirect social costs account for £10.3 billion. Among the latter, £5.8 billion is the additional

cost of daily living for family caregivers of dementia patients. Besides, more than two-thirds of the cost of dementia care is borne by patients' families, including £11.6 billion in expenditures, either for private medical care or in lost wages for those who leave a career to care for a loved one with dementia.

2.2.3 Symptoms and causes of dementia

Dementia is not just a matter of aging or memory loss. It is a "symptom of the brain" caused by impaired functioning. In elderly people suffering from dementia, symptoms are significantly different from memory disorders that occur in the general population due to aging.

As humans age, the body's various organs gradually age, including the brain's memory ability to access memory. All of us forget things occasionally, but normal aging does not make forgetfulness worse. Forgotten things can be recalled as long as they are familiar or when one is reminded of information by others. Moreover, memory loss caused by aging does not typically affect daily life or work.

However, the decline in memory of elders with dementia is persistent, progressive, and not sporadic. These patients do not just forget details

of an incident; they may forget that the experience even occurred. Even if these patients are reminded of an event, they are unable to recall the associated memories.

Dementia is acquired memory loss. The main symptoms include memory impairment (especially short-term memory impairment), difficulty in language expression, poor judgment, loss of spatial orientation, and cognitive impairment. In addition to the characteristics of memory loss, more than half of patients with dementia will demonstrate behavioral and psychological symptoms of dementia (BPSD), including personality changes, emotional instability (such as depression, anxiety, sluggish expression, irritability, etc.), behavioral abnormalities, delusions, hallucinations, and sleep cycle disorders. In addition to exacerbating cognitive deterioration, these symptoms also increase the burden on the primary caregiver.

Causes of dementia include degenerative brain disease, cerebrovascular disease, normal pressure hydrocephalus, endocrine imbalance, brain injury, drug abuse, central nervous system infection, and vitamin deficiency. Of these, only 12% are reversible conditions. Therefore, early screening for dementia is critical.

Although no drug can completely restore brain functions once they are lost, they may delay memory loss for mild and moderate (CDR=1) dementia patients. Behavioral and psychological symptoms of dementia should be appropriately evaluated by psychiatrists, who can prescribe relevant medications that can significantly improve emotional instability for dementia patients. Medication also reduces the physical and mental burdens on the patient's family and improves the quality of life of the primary caregiver.

2.2.4 Classification of dementia

There are roughly two categories of dementia: degenerative and vascular. However, patients with dementia may suffer from multiple related conditions, such as those with both Alzheimer's disease and vascular dementia.

2.2.4.1 Degenerative dementia

Most people with dementia fall into this category. Among these, the following three are the most common:

2.2.4.1.1 Alzheimer's disease:

This disease was discovered in 1906 by Dr. Alois Alzheimer of Germany and is the most common and well-known type of dementia. The most prominent early signs of the disease are memory loss and problems with cognitive function regarding time, places, and people. This disease is progressive and irreversible and is a type of neurodegenerative disease causing damage to the hippocampus of the brain.

2.2.4.1.2 Dementia with Lewy bodies:

This disease is the second most common degenerative dementia, occurring in people over the age of 70 years. The disease is characterized by cognitive dysfunction, which may be accompanied by body stiffness, handshaking, unstable walking, and repeated unexplained falls in the early stages of the disease. Some patients may also have obvious mental symptoms, such as visual hallucinations, emotional instability, or delusions.

2.2.4.1.3 Frontotemporal lobe degeneration:

This disease occurs most frequently in those over 50 years of age, mainly invading the frontal and temporal lobes of the brain. The disease is characterized by personality changes and loss of behavioral control in the early stages, as well as unreasonable behavior. Some

patients have language problems in the early stage, such as difficulty in expression and recall.

2.2.4.2 Vascular dementia

Vascular dementia is the second leading cause of dementia. After having a stroke or chronic cerebrovascular disease, the patient's brain blood cells become dysfunctional due to poor blood circulation, and memory is impaired.

According to statistics, about 5% of stroke survivors will have symptoms of dementia. If we continue to track stroke patients, about 25% of stroke patients will be diagnosed with dementia within five years. These patients often demonstrate early signs like slow movement, unresponsiveness, gait instability, and mental symptoms. In addition, cognitive function of patients may suddenly deteriorate through undulation, or step-like degradation.

2.2.5 Dementia disease progression

Dementia is a disease that continues to progress gradually from mild to moderate, severe, and even terminal symptoms. According to the

course of dementia, it is currently classified by the level of cognitive impairment: mild (initial), moderate (interim), or severe (late). The timeline of disease degradation is individual, with some patients progressing rapidly and others more slowly.

2.2.6 Treatment of dementia

Since there are currently no drugs or treatments that can prevent or reverse the course of dementia, it is recommended that patients with mild to moderate Alzheimer's disease be treated with acetylcholine inhibitors. For patients with moderate to severe Alzheimer's disease, NMDA receptor antagonists are given. Therefore, non-pharmaceutical interventions or treatments, correction of living habits, and development of healthy behaviors remain essential countermeasures for preventing and treating this disease. Dementia patients having associated psychiatric symptoms are encouraged to seek non-drug treatments with priority.

If a patient needs to use a drug, it is recommended they start with a low dose, begin only one new drug at a time, and review whether the drug's effectiveness over time. For dementia patients with other diseases (such as diabetes or hypertension), the treatment of these

diseases may help to slow down cognitive decline in patients; however, it is important to consider possible drug interactions.

While there is no drug for treating frontotemporal dementia, a patient's mental behavior symptoms can be treated with antidepressants or anti-anxiety drugs. Also, for patients with Lewy body dementia, only symptomatic treatment is currently available with medications used to control Parkinson's symptoms and psychiatric symptoms. Although anti-Parkinson drugs can improve dyskinesia and other movement disorders, they may increase mental symptoms. Antipsychotic drugs are used to improve mental symptoms of such patients, but they may exacerbate movement disorders in patients. Therefore, the use of medication is significant in the treatment of patients suffering from Lewy body dementia.

For patients with vascular dementia, treatment focuses on prevention of stroke to reduce the risk of further brain damage. Therefore, such patients are mainly concerned with controlling risk factors that cause strokes, such as hypertension, diabetes, hyperlipidemia, and antithrombotic prophylaxis.

2.2.7 Diabetes and dementia

2.2.7.1 Diabetes: a risk factor that causes cognitive decline

In some studies, diabetes itself is an independent risk factor for cognitive decline. Diabetes patients have a 1.5-2.5 times higher risk of dementia than those without diabetes. If MMSE is used to track the cognitive function of diabetic patients annually, the declining score for diabetic patients is 1.5 times that of non-diabetics (Bordier et al., 2014). In a meta-analysis study, diabetics had a 73% increased risk of dementia and 56% more risk of Alzheimer's disease than those without diabetes (Gudala et al., 2013).

2.2.7.2 Cognitive decline associated with poor glycemic control

Many studies have indicated that patients with higher HbA1C concentrations tend to have a poorer cognitive function (Okura et al., 2009). One study followed a group of 46-67-year-olds for 20 years, comparing the degree of cognitive decline between diabetics and non-diabetics. This study found that patients with diabetes had a faster rate

of decline in cognitive function than non-diabetics, and a 19% reduction in cognitive function. Moreover, the length of time one has had diabetes is related to a decline in cognitive functions. In an analysis of pre-diabetes patients, it was found that cognitive function for these patients declines faster than for non-diabetic patients. Also, patients with poorly controlled diabetes have a more significant decline in cognitive function than patients with well-controlled diabetes (Rawlings et al., 2014). In short, older people with poor glycemic control (higher glycated hemoglobin) are more likely to develop cognitive dysfunction. Proper control of blood glucose, according to research, was found to delay cognitive decline (Luchsinger et al., 2011).

2.2.7.3 Possibility of cognitive impairment and dementia in patients with type 2 diabetes

The most common inference is that patients develop cognitive impairment and dementia due to cerebral vascular disease, through atherosclerosis and microvascular disease, stroke, and cardiovascular comorbidities (Pathan et al., 2011). In addition, glucose toxicity increases the concentration of advanced glycosylation end products (AGEs) in patients and accelerates cognitive decline in the elderly (Yaffe et al., 2011). Because AGEs are associated with microvascular complications, they may accelerate the deposition rate of beta-amyloid

proteins (Münch et al., 1997), which in turn leads to a decline in cognitive function in patients (Carnevale et al., 2012).

2.2.7.4 Effect of insulin resistance on dementia

A growing number of studies are finding that insulin resistance is associated with neurodegeneration. Since insulin receptors are present in the medial temporal lobe and hippocampus, insulin is typically associated with cognitive or memory function (Schubert et al., 2004). Therefore, in the case of insulin resistance, the patient's body has a high concentration of insulin in the blood, resulting in a decrease in the concentration of insulin in the brain, which in turn causes downregulation of the insulin-degrading enzyme, thereby affecting the clearance of beta-amyloid in the patient (de la Monte, 2012, de la Monte, 2009).

Additionally, a decrease in insulin concentration in the brain increases the yield of Tau proteins (Grünblatt et al., 2007). Therefore, too high a concentration of insulin in the blood is also a risk factor for Alzheimer's disease (Gasparini et al., 2002).

2.3 Geriatric depression

The World Health Organization (WHO) ranks depression, cardiovascular disease, and malignant tumours as the three major diseases of the 21st century (Brundtland, 2000). Cardiovascular disease and malignant tumours are understood as being difficult to treat and having high mortality. Nevertheless, we must determine the reasons why depression is listed as one of the top three diseases.

The primary reason is that depression can cause severe disability in patients. In a society with an increasing proportion of elderly population, increased depression in the elderly not only reduces physical and psychological functioning of patients, but will also increase the burden on primary caregivers of the elderly (Steffens et al., 1999). Another study pointed out that the main reason depression causes physical disability is because patients reduce their physical and social activity (Penninx et al., 1999).

2.3.1 Epidemiology of depression in elderly people

According to relevant research on mental illness in elderly populations around the world, the prevalence of elderly depression is highest (average prevalence is about 20%), followed by elderly dementia. According to a review article, among Caucasian countries, the prevalence of depression in senior citizens can reach 40%. The prevalence rate of older people with related depression symptoms is nearly 50%. Expectedly, depression is more prevalent in elderly people living in institutions than those still living at home (Djernes, 2006).

The high rate and severity of depression are underestimated, so it is easy to ignore the occurrence of depression in the elderly, leading to more severe sequelae in the future. Because the elderly are a high-risk group for suicide, and older adults have a high correlation between depression and suicide, depression in older people is a public health issue that cannot be ignored (Henriksson et al., 2005).

For many older adults suffering from depression, the severity of symptoms does not meet standards for major depressive disorder, and may be classified as dysthymic disorder or subclinical depression.

These are often treated by a physician or primary care since they are considered to be a phenomenon of natural aging. As a result, previous epidemiological surveys found that prevalence of depression in the elderly was lower than that of middle-aged people.

However, recent studies have found that underestimating the prevalence of depression in older people may occur, since both researchers and adults with depression misunderstood these symptoms (e.g. fatigue, slowness of movement, and lack of appetite) as a natural progression of aging. If symptoms of depression in the elderly are carefully analyzed, it should become clear that the prevalence of depression in the elderly is similar to that of the average adult (Knäuper and Wittchen, 1994).

2.3.2 Elderly people with symptoms of depression

Depression in elderly people is divided into early-type (under 65 years old) and late-type (after age 65) according to the age at which the patient first became ill. Depression in elderly people is not manifested the same as that in general adult depression. Common symptoms are

insomnia, poor appetite, loss of interest in life, and withdrawal. However, the manifestations of senile depression include some atypical symptoms, such as depression without sadness, irritability, complaints of poor memory, physical discomfort, chronic pain, and hypochondriasis (Smarr and Keefer, 2011). Therefore, depression in elderly people is often referred to as masked depression, which is used to describe the specific depression symptoms of the elderly.

The main symptoms of late-onset depression in elderly people are apathy, loss of vitality, lack of motivation, and cognitive deterioration. Usually, such patients will be associated with chronic diseases such as hypertension, cardiovascular disease, diabetes, stroke, and other cerebrovascular risk factors. Some studies have revealed significant cerebrovascular lesions in those with late-onset depression compared to early-onset depression. In patients with the former, significant changes in white matter and grey matter hyperintensity (also known as leukoaraiosis) can be seen in magnetic resonance images of the brain (Lenze et al., 1999). The sulci and ventricles are widened and the prefrontal lobe is smaller. Some studies suggest that vascular disease is the leading cause of late-onset depression, which is different from the cause of early-onset depression that relapses in old age. Therefore, late-onset depression is termed “vascular depression.” Because the course of late-onset depression is more likely to become chronic, the

chance of recurrence is high. Clinical drug experiments have found that late-onset depression responds poorly to drug treatment (Alexopoulos et al., 1999). In addition, late-onset depression is more likely to interfere normal daily living functions for patients.

2.3.3 Pathogenic mechanism of depression in elderly people

Depression in elderly people is the same as depression in other age groups. The clear pathogenesis of the disease is unclear. Most current studies assert that depression is caused by multiple causes, such as genetic factors, physiological changes in the brain, nerve cell conduction, psychological status, and social stress. Factors can also affect each other. Some physiological evidence suggests that depression in older people is associated with serotonin, norepinephrine, and dopamine levels (Evans and Lye, 1992, Delgado, 2000).

The causes of senile depression can be analyzed from three perspectives: physical, psychological, and social. There are three main factors for physiological causes, including "cerebral blood vessels,"

"neural degeneration," and "physiological disease complications."

2.3.3.1 Physiological factors

- (1) Cerebrovascular factors: Medical imaging studies have found that the brain of elderly patients with depression often contains white matter lesions in the position of the frontal lobe cortex, and the leading cause of this is cerebrovascular disease (Barber et al., 1999). Therefore, patients with risk factors are prone to vascular depression if they also have risk factors for cerebrovascular disease, such as hypertension and diabetes.
- (2) Neurodegenerative factors: Studies have also shown that patients with depression have a higher rate of mild cognitive impairment and Alzheimer's disease, especially in patients with recurrent episodes of depression (Anisman et al., 2008). Some people with dementia also have depression, since depression can be an early symptom of dementia. Parkinson's disease is another common neurodegenerative disease, and such patients are prone to depression, as well.
- (3) Complications of physiological diseases: Patients with heart disease, diabetes, hypertension, chronic back pain, chronic

arthritis, and sensory organ impairment are prone to depression (AlKhathami et al., 2017). The patient may be suffering from depression due to long-term suffering from these chronic diseases or depressive symptoms may be caused by long-term use of certain drugs. For example, some hormones, high blood pressure drugs, and gastrointestinal drugs may cause depression in patients.

2.3.3.2 Psychological and social factors

Psychological and social factors are also important causes of depression in older people, and these factors often intersect. For example, the disabled elderly living in nursing homes may face problems including changes in their living environment (social factors). Moreover, the elderly face psychological reactions (psychological factors) to issues like the loss of life meaning or of self-control. The emergence of these two factors constitutes a cause of depression in the elderly.

Further exploration of related psychological and social factors can be distinguished as follows:

- (1) Personality factors: Older people with certain personality traits

are more likely to develop depression. These include neuroticism, compulsive personality, and people lacking a sense of security.

- (2) Behavioral factors: When a person faces a difficult situation that cannot be changed, especially if continuous efforts to address the issue fail, they may enter a state of learned helplessness, making them prone to depression. Older people face chronic diseases and/or physical disability that cannot be cured. If they cannot adjust properly, learned helplessness can occur, and that will lead to depression.
- (3) Cognitive distortion factors: Older adults who cannot change their current situation and gradually lose self-confidence may view their situation negatively. When people with cognitive distortions face stressful situations of environmental change, they think that the environment and others are not friendly to themselves, and that the situation cannot be improved, and thus depression occurs.
- (4) Insufficient social support factors: When older adults face isolation and helplessness, they are prone to depression. In particular, "insufficient emotional support" is highly related to depression.
- (5) Life stress factors: The widowed elderly are considered to have faced the most critical life stress event. Others issues, such as

illness or chronically low economic standards, are causes of depression in older people, as well.

2.3.4 Older adults with depression and diabetes

Because older people are prone to diabetes, the relationship between depression and diabetes in older adults has been the topic of some studies. A study of 220,000 senior citizens with Medicare in the United States found that after controlling for factors such as age, race, and gender, older adults with diabetes had a 1.58-fold chance of developing depression compared to those without diabetes. In terms of medical utilization, the study also found that in the elderly population with diabetes, if the patient also suffer from depression, length of hospitalisation and overall medical expenses are considerably more than for those who only have diabetes (Finkelstein et al., 2003).

Therefore, it can be expected that for elderly patients with diabetes, early diagnosis and treatment of depression can reduce the cost of medical utilization and medical care.

2.3.5 Treatment of depression in elderly people

Because depression in the elderly does not have a single cause but is developed through a combination of causes, the treatment of depression requires a multi-pronged approach. In addition to medication, it is also necessary to incorporate psychotherapy.

Drug treatment must start with a low dose, then be increased slowly, depending on the needs of the patient. Since elderly people often have other chronic diseases, they should choose drugs with fewer side effects. Therefore, use of selective serotonin-reuptake inhibitors (SSRI) as the initial treatment for elderly patients with depression is recommended. As for tricyclic antidepressants (TCA), due to the side effects of these drug, tolerance by elderly patients must be carefully measured.

Due to physiological metabolism, elderly patients often take longer to respond to drug treatment than young people, and longer observation periods are necessary to assess significant drug improvement effects. In general, when a physician adjusts a patient's medication, it takes four to six weeks, or even eight weeks, to notice any effect of the drug in the patient. Psychotherapy plays a vital role in managing the waiting period for a drug to begin working.

Studies have also confirmed that psychotherapy can strengthen the effects of anti-depressants to achieve better results (Thase et al., 1997). Also, psychotherapy can prevent recurrence of depression once it has been successfully treated. Therefore, even after the improvement of depressive symptoms in elderly patients, drug therapy and psychotherapy continue to be provided. Compared with drug therapy alone or psychotherapy alone, drug therapy combined with psychotherapy offers the best chance for preventing recurrence of depression (Nierenberg et al., 2003).

2.3.5.1 Difficulties in treating depression in elderly people

Many investigations have shown that after symptoms of depression improve, there is a high probability of relapse. According to a systematic review and meta-analysis that followed a group of older adults with depression for two years, only one-third of patients maintained a positive outlook, while one-third continued to be depressed. Moreover, one in five of these older adults died during the two years of study (Cole et al., 1999).

Therefore, depression should be considered as a chronic disease that requires long-term follow-up and engagement. Although the risk of suicide among older adults suffering from depression is high, if first-line treatment physicians follow treatment guidelines to track and treat depression in elderly patients they may effectively reduce the suicide rate of these patients (Bruce et al., 2004).

2.4 Elderly anxiety

2.4.1 Elderly people with symptoms of anxiety

Anxiety disorders in the elderly are common. Diseases such as generalized anxiety disorder, phobia, panic disorder, obsessive-compulsive disorder, and posttraumatic stress disorder are included. Among these, generalized anxiety disorder is the most common, followed by phobia.

The symptoms of anxiety disorders are multi-directional and can be divided into three aspects: cognitive, behavioral, and physiological. Common symptoms affecting cognitive performance are anxiety, fear, worry, irritability, and an inability to concentrate. Regarding these

symptoms, behavioral manifestations often occur, such as restlessness, repetitive movement, muscle tension, excessive alertness, and fearful behavior. As for physiological manifestations, symptoms such as palpitations, rapid heartbeat, chest tightness, dry mouth, dizziness, night sweats, and frequent urination are common symptoms. Although older adults suffer from less severe symptoms of anxiety than non-aged people, they still suffer severe loss of daily functions.

2.4.2 Causes of anxiety disorder & non-communicable disease (NCD)

Anxiety disorders are more commonly observed among elderly adults who are living with major chronic diseases. Older adults suffering from asthma, high blood pressure, arrhythmia, peptic ulcer, or other cardiovascular disease may feel anxiety. If the patients with chronic disease are not well-managed, anxiety will be more serious. Also, some drugs may increase the likelihood of anxiety due to side effects. Studies have shown that anxiety disorders are also associated with alcohol and sedative abuse (Grant et al., 2004b).

2.4.3 Anxiety treatment

Because many factors cause anxiety disorder, effective treatment combining medicine with psychotherapy is recommended. In addition to commonly used drugs such as benzodiazepine, antihistamines, and B-blockers, the SSRI type of antidepressant can have significant pharmacological effects. As for psychotherapy, cognitive behavioral therapy (CBT) and muscle relaxation exercises, are beneficial for the treatment of senile anxiety. Especially for older adults who are suffering from multiple chronic diseases at the same time, polypharmacy imposes an enormous burden on the patient's body and mind, so psychotherapy is the best option for such patients.

2.5 Substance abuse in the elderly

Substance abuse is also a common mental illness in the elderly, but it is not widely recognized because it is less common in older people than in other age groups. Because of chronic disease, older adults suffer from increased chronic pain, insomnia, and/or emotional distress. These factors are all risk factors for substance abuse in the elderly. However, older people who abuse substances are often occult

substance abusers without typical substance abuse presentations. Therefore, when older adults demonstrate a negative mindset (bad mood), lack of concentration, malnutrition, sudden confusion, or have an accidental fall, it is necessary to consider whether the patient suffers from substance abuse. Typical substances abused by the elderly include sedatives, sleeping pills, painkillers, and alcohol. Since these drugs may be easily obtained, family members and medical personnel must be vigilant on this issue so as not to underestimate the problem and delay treatment.

2.5.1 Alcohol abuse among the elderly

Generally speaking, the degree of one's drinking behavior can be divided into four levels: life abstainer, former drinker, current drinker, and alcohol use disorder (AUD). According to diagnostic criteria in the American Psychiatric Association's Diagnostic Manual for Mental Disorders, Fourth Edition (DSM-IV), alcohol use disorder is divided into two categories: alcohol abuse and alcohol dependence. Alcoholism is the common name for alcohol use disorder.

Although drug abuse among older adults has increased annually, the situation for alcohol abuse among older adults is less severe than that

of other age groups; however, alcohol abuse is still the most common form of substance abuse among older people (Moore et al., 2009). According to one study, 2.98% of people over the age of 50 have problems with alcohol use disorder. Those over 65 years old have a diagnosis rate of 1.2% for alcohol abuse, and 0.24% of the elderly were diagnosed with alcohol dependence (Kuerbis et al., 2014, Grant et al., 2004a).

Epidemiological studies have investigated the use of alcohol in the United States. The prevalence of alcohol consumption among the elderly (those over 65) is 55.4% in men and 37.6% in women. However, compared with prevalence rates for 25-44 years old, which were 77.7% for men and 68.3% for women, the prevalence of drinking alcohol for people over 65 years old is about 30% lower than that for young people. As for alcohol use among older adults, this study has shown that the prevalence of alcohol use disorders for those over the age of 65 is 2.8% in men and 0.5% in women. Besides, among 25-44-year-olds, the prevalence of alcohol abuse was 2.4% in men and 0.4% in women; the prevalence of alcohol dependence was 0.4% in men and 0.1% in women (Falk et al., 2006). The prevalence rate for older adults regardless of alcohol use is lower than that of younger people, and the amount of alcohol consumption is less than that of the young population.

2.6 Prevention of related mental illnesses for older adults with diabetes

Since diabetes is one of the most common chronic diseases in the elderly, when discussing their mental health, it is necessary to consider the diabetes factor. Therefore, treatment of common mental illnesses mentioned in this section, such as dementia, depression, anxiety, and substance abuse, in the elderly must take into account whether diabetes is also present. There is much evidence showing that elderly diabetes patients have microvascular circulatory abnormalities, insulin resistance, and inflammatory cytokines. These physiological factors may be associated with mental illness in these patients. Therefore, for the treatment of physical illnesses in older adults, the simultaneous assessment of patients' mental state is of great help in the success of early treatment and prevention of mental illness in older people.

Chapter 3. Research Aims, Objectives, and Justification of this Thesis and Hypothesis

3.1 Summary and justification of this work

3.1.1 Diabetes

- Due to the changes in modern people's living habits, environment and work style, as well as an ageing society, the prevalence of diabetes is rising in many countries, making it one of the most critical global health issues of this century.
- The incidence and prevalence of diabetes are rapidly increasing in both developed and developing countries. The World Health Organisation estimates that there were 108 million patients with diabetes in 1980; however, there will be more than 300 million patients in 2025. The vast majority of these will be people with Type 2 diabetes (T2DM).
- Among children, the commonest form of diabetes is Type 1 diabetes (T1DM). In children in many countries, the prevalence of T2DM will likely outweigh T1DM shortly.
- Japan has the longest life expectancy in the world. It is reported that there are currently about 10 million diabetic patients in Japan. Among the elderly population, the proportion of diabetes has

increased remarkably, up to 40% of those over the age of 70 have diabetes.

- According to The Third National Health and Nutrition Examination Survey (NHANES III) in the United States, the prevalence of diabetes, for people over the age of 60, about 20% among men and about 18% among women.
- According to the International Diabetes Federation (IDF) Diabetes Report, 5% to 20% of health expenditures in many OECD countries are used to treat diabetes and its complications.
- Diabetes has many acute and chronic complications. Acute diabetic complications can cause death or serious sequelae if not treated immediately. Chronic diabetic complications can occur in the eyes, blood vessels, nerves, kidneys. The organs will gradually deteriorate due to hyperglycemia, resulting in blindness, amputation or complete loss of organ function and eventually leading to death.
- The standard treatments for diabetes are lifestyle interventions: nutrition treatment, exercise, weight loss, and medication use: oral hypoglycemic agents, insulin injections. To control and to monitor diabetes, HbA1C, blood pressure and blood lipids are the main focus to prevent cardiovascular-related complications which are the leading cause of death in diabetic patients.

3.1.2 Ageing population

- The rapid ageing of the global population is a significant concern to all countries, the United Nations and international organisations because the ageing of the population is an unstoppable global trend.
- The proportion of the elderly population over the age of 60 in the world has increased from 9.2% in 1990 to 11.7% in 2013. The elderly population over 65 was 700 million in 2017, and will exceed 1.5 billion by 2050, accounting for 16% of the total world population.
- Because the low total fertility rate and longer life expectancy, the global old-age support ratio (ratio of 15-64 years old/65+ years olds) has dropped from 12 in 1950 to 8 in 2013, and is expected to continue to decline further to 4 in 2050; in many developed countries and in some developing countries the ratio will be even lower.
- The UK is an ageing society, and T2DM is most common in older people (in contrast to T1DM). The burden of diabetes in older

people will increase in the future through a combination of an ageing population in the UK.

3.1.3 Diabetes & Ageing

- Although the prevalence of diabetes in the elderly population is increasing, diabetic elderly patients' typical diabetic symptoms were often neglected or mistaken for signs of ageing. Therefore, elderly diabetes is usually underdiagnosed and there can be delays in starting treatment.
- Because 1) the increase in average life expectancy; 2) Human work patterns changing; 3) Health Literacy improvement, regular screening, and the rise in diagnostic techniques; 4) Changes in eating habits lead to overweight or obesity; it is critical to focus on diabetes-related issues for older people.
- Because T2DM is considered a 'primary care sensitive condition', to have proper management of T2DM and reasonable access to primary care could improve health outcomes for patients and reduce health care cost.

3.1.4 Diabetic patients with mental disorders

- The prevalence of disability among diabetic patients is high, and around 20% to 50% of diabetic patients have a disability. Therefore, diabetic patients with a physical or mental disability can face obstacles in addressing their healthcare needs, that may delay their routine treatment and lead to deterioration in their health outcomes.
- Although mental health disorders can increase the risk of suicide, the major causes of death among patients with mental health problems are due to the complications of physical diseases.
- The primary prevention of diabetes should be initiated by the community based primary care system, providing the necessary risk assessments and early screening for the high-risk groups of various types of diabetes.
- The secondary prevention of diabetes lies in the early diagnosis of diabetes, and early active treatment allows patients to obtain optimal control and avoid or reduce the deterioration of diabetes. As for the tertiary prevention of diabetes, the goal is to prevent

diabetes complications. Therefore, elderly diabetic patients with mental disorders are the target population for prevention programs.

3.1.5 Mental disorders in the elderly

- Psychological health for the elderly is a vital issue for many countries and WHO because it can have a significant impact on the health care system and national finances.
- Ageing of the nervous system may lead to mentally related diseases and daily life ability impairment.
- More than 40% of the elderly have at least one chronic disease, including hypertension, diabetes, ischemic heart disease, and atherosclerosis. These diseases have direct or indirect effects on the brain. Poor drug adherence or polypharmacy may cause damage to the CNS system.
- The management of common mental illnesses such as dementia, depression, anxiety, and substance abuse in the elderly must consider the situation in which older people may have concurrent

diabetes. Due to diabetes, elderly patients can have microvascular circulatory abnormalities, insulin resistance and inflammatory cytokines. These physiological factors may be associated with mental illness in elderly patients with diabetes.

- While treating older adults with diabetes, the simultaneous assessment of their mental state is of great help to the quality of care in older people.

3.1.6 Justification of this work

- Only very few articles studied the impact of physical or mental disability on medical utilisation for elderly patients with diabetes. There are even fewer studies related to mental disabilities. There is some related literature for hospital-level studies, but very few national-level ones were studied.
- In a real-world setting, older adults usually have more than one of chronic physical or mental disorders. However, most existing studies assessed the effect of one single disorder on medical utilisation or mortality. By considering older people often suffer from multiple chronic physical disorders, or even a combination of

physical and psychological diseases, it is necessary to conduct a study to provide the robust evidence by evaluating the impact of multiple disorders including diabetes, physical and mental on hospital length of stay and mortality among elderly adults.

- In order to understand the current existing research evidence, I will first conduct a systematic study to understand the medical utilisation of mentally or physical disability for elderly patients with diabetes. Then I will use the Hospital Episode Statistics (HES) database to analyse whether the elderly diabetic patients suffering from mental illness or other physical diseases have higher medical utilisation or mortality compared to elderly patients suffering from diabetes alone.

3.2 Aim

To evaluate the impact of mental disorders, physical disorders and other factors on hospital length of stay and in-hospital mortality among elderly patients with Type 1 and Type 2 diabetes in the UK

3.3 Objectives

1. To understand whether disability increases or decreases medical utilisation and/or cost among elderly diabetic patients (Systematic Review)
2. To examine the impact of the presence of physical or mental comorbidities on hospital length of stay and in-hospital mortality among elderly patients with Type 1 or Type 2 diabetes (HES database analyses)
3. To assess the impact of the presence of common mental comorbidities on hospital length of stay and in-hospital mortality among elderly patients with Type 1 or Type 2 diabetes (HES database analyses)
4. To compare the differences in impact of physical and mental disorders on hospital length of stay (including spell duration and post-operation duration) and in-hospital mortality among elderly T1DM or T2DM patients who were admitted in the Ophthalmology department, General Medicine department and Diabetic Medicine department (HES database analyses)

3.4 Research hypotheses

H0: The presence of physical or mental comorbidities have no effect on hospital length of stay and in-hospital mortality among elderly patients with Type 1 or Type 2 diabetes

H1: The presence of physical or mental comorbidities does contribute to differential effects on hospital length of stay and in-hospital mortality among elderly patients with Type 1 or Type 2 diabetes

The incidence and prevalence of diabetes are rapidly increasing in many countries, including the UK. At the same time, because the UK is an ageing society, and T2DM is most common in older people (in contrast to T1DM), and the financial burden of diabetes for the society will increase in the future. To manage mental health disorders for the elderly is essential for many countries, because they can have a significant impact on the health care system and national finances. It is necessary to know what the significant risk factors for prolonged hospital length of stay are as well as in-hospital mortality for the elderly. After knowing the possible risk factors, policymakers or health service providers can have a guide for providing more appropriate treatments or prevention activities for elderly adults to reduce the number of hospital stays and in-hospital mortality.

Some studies have reported that the presence of other physical and mental health disorders in patients with diabetes can affect medical utilization. Diabetic patients with schizophrenia were reported to have less medical utilisation but a higher mortality rate compared to patients with diabetes only (Copeland et al., 2009). On the other hand, diabetic patients with poor Activities of Daily Living (ADL) scores were found to have higher medical utilisation and medical costs compared to diabetic patients without any physical disabilities (Salas et al., 2000, Riewpaiboon et al., 2011). However, the actual impact of physical or mental disorders on medical utilization among elderly patients with diabetes is still unclear.

In a real-world situation, most elderly people are suffering from more than one chronic disease including physical and mental health disorders. However, most existing reports have only discussed the effect of one single disorder on the number of days of hospital stay or mortality. But considering older people often suffer from multiple chronic diseases, or even a combination of physical and psychological diseases, this study would be helpful to provide the solid evidence by evaluating the impact of multiple disorders including diabetes, physical and mental on medical utilisation and mortality among elderly adults.

By using the Hospital Episode Statistics (HES) database with linkage to the English Index of Multiple Deprivation (IMD), I will be able to assess the impacts of physical and mental disorders on hospital length of stay and in-hospital mortality in England.

It was hypothesised that age, gender, ethnicity, social-economic status, physical disorders and mental disorders could be the vital factors for prolonged hospital length of stay (Chapter 6) and in-hospital mortality (Chapter 7) among the elderly patients with T1DM & T2DM. Therefore, several statistical models were constructed to examine the null hypothesis that spell duration, episode duration, and in-hospital mortality were equivalent between population subgroups of age, gender, ethnicity, disease category (DM + physical disorders or DM + mental disorders) and areas of deprivation.

Finally, when diabetic patients are treated in different speciality units, receiving different treatments, the same factors may contribute to differing impacts in different treatment units. Therefore, several statistical models were constructed to exam the null hypothesis that diabetic elderly patients who were treated in the Ophthalmology department, General Medicine department, and Diabetic Medicine department had equivalent results on spell duration, and in-hospital

mortality between population subgroups of age, gender, ethnicity, disease category (DM + physical disorders or DM + mental disorders) and areas of deprivation.

Chapter 4. Methods

4.1 Methods for the systematic review

4.1.1 Review title

A systematic review of medical utilisation and cost among elderly diabetic patients with mental or physical disability (Chapter 5)

4.1.2 Review objective

The objective is to understand whether disability increases or decreases medical utilisation and/or cost among elderly diabetic patients.

4.1.2.1 Types of participants

1. The patient has diabetes as an underlying disease
2. The patient has a physical and/or mental disability

4.1.2.2 Types of outcomes

The economic component of this review will consider studies that include:

1. Hospital inpatient admission or stay

2. Hospital outpatient visits
3. Hospital inpatient length of stay
4. Medical cost

4.1.3 Search strategy

In this systematic review, the search strategy aims to find related published studies. Unpublished studies were not included. There will be three steps to this review. The first step is an initial limited search using MEDLINE, EMBASE, and GLOBAL HEALTH. In this step, titles and abstracts will be analyzed. The second search will include related keywords and index terms and, finally, relevant reports and articles will be selected for additional study. Studies published in English after 1945 will be considered for inclusion in this review.

4.1.3.1 Databases to be searched

1. Ovid MEDLINE(R) In-Process & Other Non-Indexed Citations and Ovid MEDLINE(R) 1946 to Present (July 22, 2015)
2. Embase Classic + Embase 1947 to 2015 July 23
3. Global Health 1973 to 2015 Week 28

Initial keywords:

Type 1 & Type 2 Diabetes, Disability, Elderly, Medical utilisation.

4.1.4 Assessment of methodological quality

Two reviewers will assess papers that are selected for retrieval using the NEWCASTLE - OTTAWA QUALITY ASSESSMENT SCALE (Appendix). This scale has three versions to fit different types of study. During our assessment, a case-control study, cohort study, and cross-sectional study will be evaluated, respectively. If there is any disagreement between reviewers, they will first discuss options and, if necessary, will ask a third reviewer for their opinion.

4.2 Methods for the quantitative studies

4.2.1 Data source

Chapter 6-8 are cross-sectional studies using the Hospital Episode Statistics (HES) database with linkage to the English Index of Multiple Deprivation (IMD). HES is an administrative dataset containing outpatient appointments, inpatient admissions, and A&E attendances in NHS-funded hospitals in England. The data is recorded during the hospitalization of each patient, and it was designed for secondary use, as well as for its primary purpose of reimbursing hospitals for NHS work. Patients' registered practice can be identified via Organisation Data Service codes in the system. Data collected for the 2011-12, 2012-13, and 2013-14 financial years were included in this study (April 1st, 2011 to March 31st, 2014).

HES database collected hospitalization data for all patients under NHS Clinical Commissioning Groups in England. Private patients who received treatment in NHS hospitals were also included. HES recorded patient hospitalization information in the system, including clinical information, patient information, administrative information and geographical information.

In the HES database, one record means one episode. It corresponds to one continuous treatment period of care under the same physician. The specific period is called episode duration. Those patients who are transferred between physicians will have several episodes in the system. In order to understand the actual treatment period even under different physicians, the HES database also contains spell duration, which means the sum of all episode durations.

HES data is an essential source of evidence for researchers to understand healthcare-related questions in England (NHS Digital, 2019). HES now processes around 125 million records annually, including inpatient, outpatient and accident and emergency patients (Health et al., 2014). In my study, I will use only the HES inpatient database. The database contains more than 300 items, including patients' demographic characteristics, such as age, gender, ethnicity and the HES Patient ID (HESID). Each patient can have up to 20 diagnoses and up to 24 operations in the medical record. The first diagnosis listed in the data would be the primary diagnosis of this admission. Geographic information including government office region, local authority, clinical commissioning group, and most importantly, Index of multiple deprivation (IMD) were also in the HES database.

HES records episode start date, episode end date, date of admission, and date of discharge in the database, both the duration of spell and the duration of episode can be provided accordingly. Episode duration means one continuous treatment under one physician and spell duration represents the total length of stay during the hospitalization of a patient (Spencer et al., 2012). The duration of spell which includes the duration of all episodes was chosen to best describe patients' hospital length of stay although some descriptive statistics for the duration of episode will be presented for comparison (Chapter 6 & 8).

HES includes discharge method in the database. Patients where the method of discharge was labelled as "Died" were considered as in-hospital deaths (Chapter 7 & 8). HES contains a code to define where the patient is treated (Chapter 8).

4.2.2 Study population

Since elderly patients were defined as those who were aged 65 years or older at the time of admission, patients who were 65 years old or above and only those elderly adults with a 1st hospital admission diagnosis as diabetes (ICD-10 codes: E10 – E14) were included in this study. Patients with unspecified gender were excluded. Each patient can have up to 20 diagnoses in the medical record. The first diagnosis

listed in the data would be the primary diagnosis of this admission.

The diagnostic coding in HES is based on the 10th International Classification of Diseases (ICD-10). Patients who received an ICD-10 diagnosis code of E10 - E14 for any type of Diabetes mellitus were included. This includes ICD-10 codes E10 for Type 1 diabetes mellitus (T1DM); E11 for Type 2 diabetes mellitus (T2DM); E12 for Malnutrition-related diabetes mellitus; E13 for Other specified diabetes mellitus; and E14 for Unspecified diabetes mellitus. (Table 4.1)

Eighty-three thousand three hundred one episodes and 57,659 spells occurred during the study period. The definition of spell duration is the in-hospital length of stay between the patient admission date and the patient discharge date. Patients' discharge method should be recorded to confirm that the spell has finished. The definition of episode duration is the days between the episode start date and the episode end date. Since one spell usually includes more than one episode, it means spell duration is longer or equal to episode duration.

4.2.3 Ethical approval

This study uses anonymised secondary data from the NHS Health and Social Care Information Centre (now NHS Digital). Approval to use the data was obtained before starting the analysis.

Table 4. 1 International Classification of Diseases 10th revision (ICD-10) diabetes diagnostic categories

ICD-10 three-character codes of diabetes mellitus (E10-E14)	
E10 Type 1 diabetes mellitus (Insulin-dependent DM)	
E11 Type 2 diabetes mellitus (Non-insulin-dependent DM)	
E12 Malnutrition-related diabetes mellitus	
E13 Other specified diabetes mellitus	
E14 Unspecified diabetes mellitus	
ICD-10 the forth-character subdivisions of Diabetes Mellitus (E10-E14), complications	
Short-term subdivisions	.0 Coma
	*Diabetic hyperosmolar, Diabetic hypoglycaemic, Diabetic hyperglycaemic
	.1 Ketoacidosis (without Coma)
Long-term subdivisions	.2 Renal complications
	*Diabetic nephropathy, Intracapillary glomerulonephrosis, Kimmelstiel–Wilson syndrome
	.3 Ophthalmic complications
	*Diabetic cataract, Diabetic retinopathy
	.4 Neurological complications
	*Diabetic amyotrophy, Diabetic mononeuropathy, Diabetic autonomic neuropathy, Diabetic polyneuropathy
	.5 Peripheral circulatory complications
	*Diabetic gangrene, Diabetic ulcer, Diabetic peripheral angiopathy
	.6 Other specified complications
	* Diabetic arthropathy, Neuropathic diabetic arthropathy
Others	.7 Multiple complications
	.8 Unspecified complications
	.9 No complications

4.2.4 Study cohort: Grouping (Disease category)

Each patient who was admitted was recorded with up to 20 diagnoses in the HES database. The first diagnosis was the main reason or diagnosis for patients' current hospitalization, and the first diagnosis of this patient should be diabetes, and the rest of the diagnoses were considered as comorbidities. Elderly patients having diabetes only without any other comorbidities were classified as the reference group in this study.

4.2.4.1 Three Groups: disease category

For the first objectives in Chapter 6 & 7, to evaluate the impact of physical and mental disorders on hospital length of stay and in-hospital mortality among elderly patients with Type 1 or Type 2 diabetes, patients were divided into three groups per disease category.

- Group 1 was the reference group, and included elderly patients with type 1 or type 2 diabetes but without any other diseases (Labelled as “DM only”);
- Group 2 included elderly patients with type 1 or type 2 diabetes combined with physical disorders (Labelled as “DM + physical (no mental/no ICD F code)”);

- Group 3 included elderly patients with type 1 or type 2 diabetes combined with mental disorders (Labelled as “DM + physical + Mental (has ICD F code)”).

4.2.4.2 Six Groups: mental disorders subgroups

For the second objectives in both Chapter 6 & 7, to further examine which mental disorders could be highly associated with increased risk for longer length of stay or in-hospital mortality. Group 3 were further divided into four different subgroups. The classification of mental disorders was made using the ICD-10 Classification of Mental and Behavioural Disorders F00-F99 (Table 4.2). The frequency of mental disorders among elderly patients with diabetes in England from 2011-2013 was listed (Table 4.3). Diagnosis F00-F09, F10-F19, F30-F39 were specifically picked to be grouped because these three mental diagnoses are the major public mental health issues globally.

- Group 1, as the reference group, for elderly patients with type 1 or type 2 diabetes only and without any other diseases; (Labelled as “DM only”);
- Group 2, for elderly patients with type 1 or type 2 diabetes combined with physical disorders (Labelled as “DM + physical (no mental/no ICD F code)”);
- Group 3, for elderly patients with type 1 or type 2 diabetes combined

with organic, including symptomatic, mental disorders: (Labelled as “DM + Mental Disorders (F00-F09)”);

- Group 4, for elderly patients with type 1 or type 2 diabetes combined with mental and behavioural disorders due to psychoactive substance use (Labelled as “DM + Mental Disorders (F10-F19)”);
- Group 5, for elderly patients with type 1 or type 2 diabetes combined with mood affective disorders (Labelled as “DM + Mental Disorders (F30-F39)”);
- Group 6, for elderly patients with type 1 or type 2 diabetes combined with other mental disorders which are not listed above (Labelled as “DM + Mental Disorders (Others)”)

Table 4. 2 International Classification of Diseases 10th revision (ICD-10) Mental-disorders categories

ICD-10 three-character codes of Mental and behavioural disorders (F00-F99)

F00–F09	Organic, including symptomatic, mental disorders
F00–F09	Organic, including symptomatic, mental disorders
F10–F19	Mental and behavioural disorders due to psychoactive substance use
F20–F29	Schizophrenia, schizotypal and delusional disorders
F30–F39	Mood affective disorders
F40–F48	Neurotic, stress-related and somatoform disorders
F50–F59	Behavioural syndromes associated with physiological disturbances and physical factors
F60–F69	Disorders of adult personality and behaviour
F70–F79	Mental retardation
F80–F89	Disorders of psychological development
F90–F98	Behavioural and emotional disorders with onset usually occurring in childhood and adolescence
F99	Unspecified mental disorder

Table 4. 3 The frequency of mental disorders among elderly patients with diabetes in England from 2011-2013

n	ICD 10 Code	Mental Disorder Diagnosis
7756	F00-F09	Organic, including symptomatic, mental disorders
3232	F10-F19	Mental and behavioural disorders due to psychoactive substance use
599	F20-F29	Schizophrenia, schizotypal and delusional disorders
2775	F30-F39	Mood [affective] disorders
669	F40-F48	Neurotic, stress-related and somatoform disorders
20	F50-F59	Behavioural syndromes associated with physiological disturbances and physical factors
68	F60-F69	Disorders of adult personality and behaviour
38	F70-F79	Mental retardation
405	F80-F89	Disorders of psychological development
13	F90-F98	Behavioural and emotional disorders with onset usually occurring in childhood and adolescence
20	F99	Unspecified mental disorder
15595		

4.2.5 Other covariates (Age, Gender, Ethnicity, Social-economic status)

Age: I divided the study population into five age bands (65 – 69 years old, 70 – 74 years old, 75 – 79 years old, 80 – 84 years old and ≥ 85 years old). Gender: male or female (Patients with unspecified gender were excluded from the analyses). Ethnicity: HES provides 18 categories for ethnicity (British, Irish, Other White background, Indian, Pakistani/Bangladeshi, Other Asian backgrounds, Caribbean, African, Other Black background, Chinese, Others, Not stated, Not known). I classified patients into four broad ethnic groups (White, Black, Asian, and Mixed or Other). British, Irish, and Other White background were put into the white group; Indian, Pakistani/Bangladeshi, Other Asian background and Chinese were classified in the Asian group; Caribbean, African, and Other Black background were in the black group. Mixed, other ethnic groups, not known and not stated patients were put in the Mixed or Others group.

Social-economic status: I used the Index of Multiple Deprivation quintile (IMD_quintile) as the indicator of patients' social-economic status. IMD is an index describing the relative deprivation of this area compared to the other areas, and provides a deprivation measure for

each small area of England. The overall IMD score is generated based on seven individual domains. The domains are weighted as following: Income (22.5%), Employment (22.5%), Health Deprivation and Disability (13.5%), Education, Skills and Training (13.5%), Barriers to Housing and Services (9.3%), Crime (9.3%), and Living Environment (9.3%).

4.2.6 Predictors of models in my study

All the predictors will be put into all models.

1. **Age:** the 65 years old above elderly patients were divided into five broad age bands (65 – 69 years old, 70 – 74 years old, 75 – 79 years old, 80 – 84 years old and ≥ 85 years old)
2. **Gender:** male, female
3. **Ethnicity:** 4 ethnic groups (White, Black, Asian, and Mixed or Others)
4. **Grouping** (disease category): 3 main disease category groups (Group 1: DM only, Group 2: DM with physical disorders only without any mental health disorder, Group 3: DM with mental health disorders or with mental and physical disorders)
5. **IMD_ quintile:** patients were classified into five groups (group 1 is the least deprived, and group 5 is the most deprived)

All statistical analyses were conducted using Stata (version 12.1).

Chapter 5. Medical utilisation and cost among elderly diabetic patients with mental or physical disability: a systematic review

5.1 Introduction

Disability among diabetic patients is a severe public health issue in primary health care. Due to improvements in health care and longer life expectancy, complications from diabetes among elderly adults accompanied by psychological or physical disability, along with multiple aging-related health issues, will gradually become critical to routine medical care. According to an estimation of the prevalence of disability among diabetic patients, around 20% to 50% of diabetic patients have at least one disabling condition (Songer).

5.1.1 Diabetes complications and disability

Diabetes can cause many acute and chronic complications. Chronic diabetic complications, in particular, can occur in the eyes, blood vessels, nerves, and kidneys. After suffering from such chronic complications, patients often face continued consequences in the form of permanent disability. Diabetic patients with chronic complications inevitably face organ deterioration due to hyperglycemia, resulting in blindness, amputation, or complete loss of organ function. In particular, vision and limb disabilities cause daily difficulties and a reduction in the quality of life for patients. These disabilities also act as critical barriers keeping patients from having regular access to hospitals.

5.1.2 Diabetes and visual impairment

Diabetic retinopathy is the leading cause of blindness for adults with T2DM. This chronic complication of diabetes has been associated with higher medical and social costs (Romero-Aroca, 2011). Visual acuity loss due to diabetic retinopathy significantly reduces the quality of life of patients (Brown et al., 2002) whose working capabilities and social interactions are severely affected. Several studies have also found that patients with visual impairment may have a higher mortality rate among elderly adults (Freeman et al., 2005).

5.1.3 Diabetes and physical impairment

Diabetic patients have higher chances of stroke than those without diabetes. Moreover, stroke patients with diabetes have a higher chance of stroke recurrence, dementia, and mortality (Jørgensen et al., 1994). Patients with diabetes were also found to have a higher risk of developing peripheral vascular disease than the average person. It is estimated that 15% of patients with diabetes may suffer from varying degrees of peripheral vascular disease, as well as intermittent claudication. Females have a higher risk of peripheral vascular disease. Furthermore, the chance of lower extremity amputation for diabetic patients in the United States is 12.7 times higher than that of the average person.

5.1.4 Diabetes and mental disability

Tracking the cognitive function of diabetic patients annually using Mini-Mental State Examination (MMSE) reveals that the declining score for diabetic patients is 1.5 times that of non-diabetics (Bordier et al., 2014). For diabetic patients with poor glycemic control, studies have found associations between higher HbA1C concentrations and lower cognitive function (Okura et al., 2009).

Studies also show that older adults with diabetes have a higher chance of developing depression compared to elderly non-diabetics. These patients have longer hospitalizations and higher medical expenses compared to elderly diabetic patients without depression (Finkelstein et al., 2003).

5.1.5 Medical utilisation and cost for elderly patients with diabetes

Diabetic patients with a physical or mental disability face obstacles to getting their medical healthcare needs met. They may delay routine treatment, leading to worse health outcomes. Having a physical disability acts as another vital barrier to allowing diabetic patients access to medical services. Diabetes requires long treatment periods

and poor physical functioning can discourage diabetic patients from seeking out medical services.

Mentally ill patients with general medical problems face increased morbidity and mortality. Some mental disorders can cause death indirectly, such as schizophrenia or depression that may lead to suicide; however, the most significant causes of death among mentally ill patients are due to deterioration from general disease, especially diabetes (Daumit et al., 2002).

For patients with multiple chronic diseases, having easy access to primary care can lead to successful health promotion and disease prevention. (Flocke et al., 1998) The contributions of proper access to quality health care have been well established in previous studies. (Shi, Green, and Kazakova, 2004) However, for diabetic patients with a disability, the barrier to medical utilisation is high. Diabetic patients who do not receive proper and regular treatment may face multiple complications and have a shorter life expectancy.

Nevertheless, it remains unclear whether medical under utilisation among disabled diabetic patients is a result of comorbidity or the obstacles to accessing medical services.

In this systematic review, I would like to examine medical utilisation and cost among elderly diabetic patients with mental or physical disabilities.

5.2 Methods: systematic review

5.2.1 Review title

A systematic review of medical utilisation and cost among elderly diabetic patients with mental or physical disability

5.2.1.1 Reviewers

Primary reviewer

Alex, Chih-Yu CHEN, M. D, M. Sc¹

Secondary reviewer

Thamer Ahmad M. AlOhali, M. D²

Third reviewer

Erin, Chia-Wei Liang, R.D. M. Sc³

1. WHOCC, Department of Primary Care and Public Health, Imperial College London, alex.chen14@imperial.ac.uk

2. WHOCC, PCPH, Imperial College London, talohali@kfmc.med.sa

3. School of Public Health, National Taiwan University,
d00841003@ntu.edu.tw

5.2.1.2 Center conducting the review

WHOCC, Department of Primary Care and Public Health, Imperial
College London

5.2.2 Review objective

The objective is to understand whether disability increases or decreases medical utilisation and/or cost among elderly diabetic patients.

5.2.2.1 Inclusion criteria

5.2.2.1.1 Types of participants

3. The patient has diabetes as an underlying disease
4. The patient has a physical and/or mental disability

5.2.2.1.2 Types of outcomes

The economic component of this review will consider studies that include:

5. Hospital inpatient admission or stay
6. Hospital outpatient visits

7. Hospital inpatient length of stay
8. Medical cost

5.2.3 Search strategy

In this systematic review, the search strategy aims to find related published studies. Unpublished studies were not included. There will be three steps to this review. The first step is an initial limited search using MEDLINE, EMBASE, and GLOBAL HEALTH. In this step, titles and abstracts will be analyzed. The second search will include related keywords and index terms and, finally, relevant reports and articles will be selected for additional study. Studies published in English after 1945 will be considered for inclusion in this review.

5.2.3.1 Databases to be searched

4. Ovid MEDLINE(R) In-Process & Other Non-Indexed Citations and Ovid MEDLINE(R) 1946 to Present (July 22, 2015)
5. Embase Classic + Embase 1947 to 2015 July 23
6. Global Health 1973 to 2015 Week 28

Initial keywords:

Type 1 & Type 2 Diabetes, Disability, Elderly, Medical utilisation.

5.2.3.2 Search procedures

1. Diabetes Mellitus, Type 1 (or) Diabetes Mellitus, Type 2 (or) Diabetes, Gestational (or) Diabetes Complications (or) National Institute of Diabetes and Digestive and Kidney Diseases (U.S.) (or) Diabetes Mellitus
2. Insurance, Disability (or) Veterans Disability Claims (or) Disability Evaluation (or) International Classification of Functioning, Disability, and Health
3. Elderly (or) Aged
4. Medical Utilisation (or) Cost (or) Length of Stay (or) Hospitalization
5. 1 AND 2 AND 3 AND 4

5.2.4 Assessment of methodological quality

Two reviewers will assess papers that are selected for retrieval using the NEWCASTLE - OTTAWA QUALITY ASSESSMENT SCALE (Appendix). This scale has three versions to fit different types of study. During our assessment, a case-control study, cohort study, and cross-sectional study will be evaluated, respectively. If there is any disagreement between reviewers, they will first discuss options and, if necessary, will ask a third reviewer for their opinion.

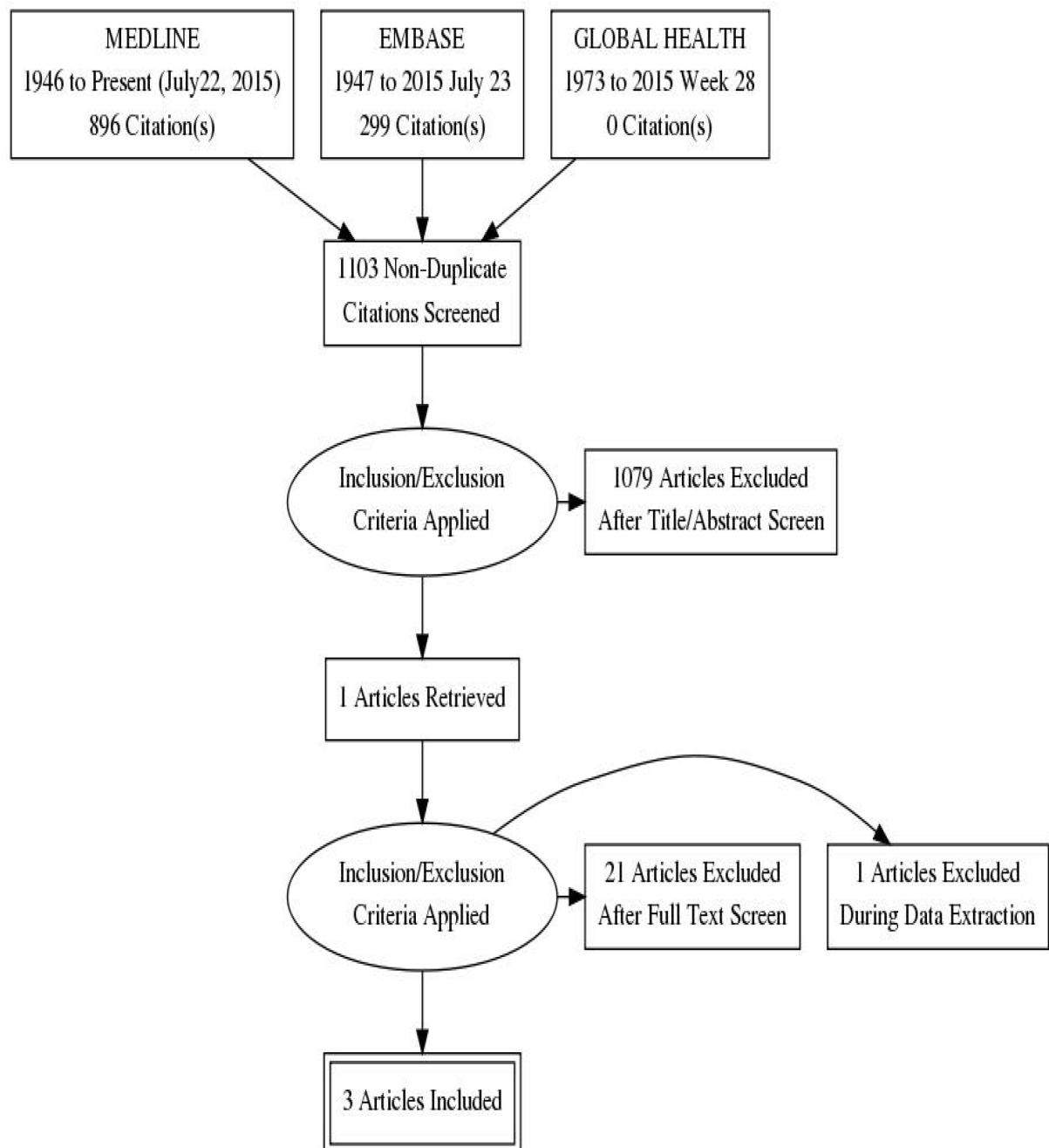
5.3 Results

Figure 5.1 shows that 1103 non-duplicate citations were screened from Medline, Embase, and Global Health, the dominant literature databanks in this field. One thousand seventy-nine articles were excluded at the very beginning due to irrelevance to research questions or purpose, according to their titles and abstracts. After retrieving one article, only 25 articles were left on the list; nevertheless, only three articles are suitable for final quality assessment.

Reasons for excluding articles are listed in Table 5.1. Ten articles were excluded for not mentioning medical utilisation or cost. Four articles were excluded due to the lack of comparison between diabetic patients and diabetic disabled patients in terms of medical utilisation. Four additional articles were excluded for no mention of disability, and one article was excluded since the majority of the researched population were under 65 years old. Lastly, one article was excluded due to lack of access to the full article.

Figure 5. 1 PRISMA CHART of Systematic Reviews

PRISMA CHART



PRISMA Flow Diagram Generator by

<http://prisma.thetacollaborative.ca/>

Table 5. 1 Reasons for excluding articles in the systematic review

Steps	Reasons for exclusion	No. of Articles
1	Not related to research questions	1079
2	Medical utilisation was not the outcome variable in the study	10
3	No medical utilisation comparison between diabetic patients and diabetic disabled patients	4
4	Disability was not mentioned in the study	4
5	The elderly were not the dominant group in the study	1
6	Cannot access the full text of the article	1

Among studies included were two cross-sectional studies and one retrospective cohort study (Table 5.2). Because the NEWCASTLE - OTTAWA QUALITY ASSESSMENT SCALE has different versions for cross-sectional studies, cohort studies and case-control studies, different scales were used accordingly to fit different study designs for the quality assessments. Each article selected received at least 8 points on the quality scale (Table 5.3).

Table 5.2 Article summaries (Question: Will disability be a factor for influencing diabetic patients' medical utilisation?)

Author	Study Design	Study Setting	Study Population	Study Aims	Outcome	Results	Study Conclusion	Interpretation & Comments	Quality Scale
Copeland, L. A., et al. (2009)	1. Retrospective cohort study 2. Administrative sources (fiscal years 2002 – 2005) 3. Provide measures of patient characteristics and care in the VA	1. VA hospitals 2. Extended care facilities 3. Outpatient clinics	1. Patients over age 50 diagnosed with schizophrenia in 2002 were age-matched 1:4 to diabetes patients. 2. All patients were followed through 2005. 3. Patient data for 241,508 VA patients with schizophrenia and/or diabetes were extracted.	To examine relationships between patterns of primary care and mortality across three groups of patients: those with schizophrenia only, diabetes only, or both conditions.	1. Four distinct trajectories of primary care use: consistent over time, increase over time, high and decreasing, low and decreasing. 2. Mortality	Those with diabetes only dominated the consistent use trajectory, and Scz-DM patients were the highest group in both the increasing and high-decreasing trajectories. Scz-DM patients have the highest mortality rate compare to Scz or DM only group.	Sch-DM show less medical utilisation than DM only patients.	Sch-DM show less medical utilisation than DM only patients.	8/10

Salas, M., et al. (2000)	1. Cross-sectional study 2. Interview with the 1993 Medicare Current Beneficiary Survey (MCBS).	1. The selection of 107 geographic primary sampling units (PSUs). 2. Consisting of counties or groups of counties chosen to represent the nation.	1. A total of 12,863 people who completed the interview with the Medicare Current Beneficiary Survey obtained in 1993 were studied. 2. The final sample constituted 10,517 non-diabetic patients and 2,003 diabetic patients.	The objective was to determine the impact of physical functioning in diabetic patients on hospitalizations, physician visits, and costs using Medicare data.	1. Hospitalizations 2. Physician visits 3. Costs	Average physician visits and hospitalizations were higher in patients; this increased proportionally with the disability score.	Self-perception is highly correlated with care costs for patients with diabetes.	Total costs were highly correlated with the ADL disability score (r = 0.75).	9/10
Riewpai boon, A., et al. (2011)	1. Cross-sectional study in 2008	1. A public district hospital in Waritchaphum district of Sakon Nakhon Province in	1. The sample size was fixed at 475 (one-third of all diabetic patients). 2. Assuming a non-availability and refusal rate of 15%, 546 patients were randomly selected	To determine the rate of disability among diabetic patients at a public district hospital in Thailand, comparing the costs of illness	Costs consisted of: (1) direct medical costs (costs of hospitalization, outpatient visits...);	When comparing costs between independent and disabled persons, considering the Barthel index score, average costs for disabled diabetic persons	The presence of complications and disability among diabetic patients has severe impacts on Thai society.	Disabled diabetic patients have higher medical costs than independent diabetic patients.	9/10

northeastern Thailand	from the electronic diabetic-patient database of the study hospital.	across different levels of severity of disability.	(2) direct non-medical costs (transportation ...); (3) productivity costs (health-related days absent from work and/or normal activities, ...)	were significantly higher than for those who were independent (US\$2700.29 versus 598.24; $P < 0.001$).
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Table 5.3 Quality assessment of selected articles

Study (first author)	Selection				Comparability	Outcome		Total out of 10
	Representativeness of sample	Sample size	Non- respondents	Ascertainment of exposure		Assessment	Statistical test	
Cross-Sectional Study								
Salas, M., et al. (2000)- Cross sectional	+	+	+	++	+	++	+	9
Riewpaiboon, A., et al. (2011)	+		+	++	++	++	+	9
Cohort Study								
	Representativeness of exposed cohort	Selection of non- exposed cohort	Ascertainment of exposure	Outcome of interest not present		Assessment	Appropriate length/ Adequacy of follow-up	
Copeland, L. A., et al. (2009) – Cohort	+	+	+	+	++	+	+	8

Copeland, L. A., et al. compared medical utilisation between diabetic patients and diabetic patients who were also schizophrenic in a four-year study. In this research, diabetic patients over 50 years of age with or without schizophrenia were included. There were three diagnostic groups: 1) patients with diabetes only (DM, n = 188,332); 2) patients with schizophrenia only (Scz, n = 40,109); and 3) patients with schizophrenia and diabetes (Scz-DM, n = 13,025). Comparing medical utilisation between these groups, patients who have schizophrenia and diabetes use slightly medical services slightly less often and have a higher mortality rate.

In the trajectories of primary care use, the diabetes-only group dominated the consistent use category. On the other hand, in the Scz-DM group, numerous patients were categorized as low-decreasing and high-decreasing. In conclusion, this study revealed that diabetic patients also having a mental disability may use medical services less often than diabetic patients without a mental disability.

Riewpaiboon, A. et al. compared medical costs and medical use by different levels of severity of disability among diabetic patients. In this one-year cross-sectional study inside a single public district hospital, physical disability is the target of the study design. Physically impaired and visually disabled patients with diabetes were included in the study.

The Barthel index score was used to evaluate the severity of disability. Medical cost is the significant outcome of this study, and is mainly based on medical utilisation among these participants. The outcome variables were direct medical costs, direct non-medical costs, and productivity costs.

In this study, diabetic patients with physical disabilities have higher medical costs than those without physical impairment. The increase in medical costs can also reflect the severity of the disability. In the cost model of this study, length of hospital stays, hospitalization, and number of hospital visits were significant outcome variables. In conclusion, diabetic patients with physical or visual disability can have higher medical utilisation costs.

Salas, M. et al. studied the influence of physical functioning on diabetic patients in terms of medical utilisation and costs. A proper sample size of participants was included in this study; 10,517 non-diabetic and 2,003 diabetic patients completed the Medicare Current Beneficiary Survey (MCBS). The Activity Daily Living (ADL) and the Instrumental Activity Daily Living (IADL) were used to evaluate physical disability among participants.

Comparing diabetic and non-diabetic patients, diabetic patients scored on average three more points on the ADL disability scale. Results also showed that diabetic patients compared to non-diabetic patients had higher total physician visits, higher total physician charges, and higher physician reimbursement. In both in-patient and out-patient data, diabetic patients had higher medical utilisation and costs compared to non-diabetic patients.

However, when looking at patients with only diabetes, I find that physician visits and the number of in-patient days correctly reflects ADL scores among diabetic patients. Patients with an ADL score of 1-2 had six more physician visits and two more in-patient days compared to patients with no IADL. Patients with an ADL score higher than 3 had 36 more physician visits and seven more days of in-patient stay compared to no IADL patients. These results showed that patients with a higher ADL score could have much higher medical utilisation.

In conclusion of our systematic review, diabetic patients can have higher medical utilisation and cost compared to non-diabetic patients. However, among diabetic patients, lower ADL scores tend to demonstrate lower medical utilisation compared to higher ADL groups. The situation is similar to diabetic patients with a mental disability who might have lower medical utilisation compared to those without

a mental disability. Due to the limited studies conducted in the past, this conclusion does not necessarily apply to all the countries or larger populations.

5.4 Discussion

There are few articles mentioning the impact of physical or mental disability on medical utilisation and cost among elderly diabetic patients. Studies related to mental disabilities were even less numerous. In this systematic review, only patients with schizophrenia were studied. There are more common mental disorders that need to be discussed for patients with diabetes.

While there are some hospital-level studies, few national-level studies have been published. Key reasons may include that it is easier to conduct research at the hospital level and obtain data on the actual disability of patients, whereas extending a study to the national level makes it more difficult to obtain relevant data on each patient. Without a registration mechanism for disability, and since the disability database and national database are linked, it is difficult to assess the relationship between the disabled patient and their medical use.

Even in the same study, conclusions can emerge in opposing directions. Taking a study by Salas et al. as an example, although diabetic patients had higher disability scores and tended to have higher medical utilisation and costs, within the diabetic patient population, those with higher ADL scores had higher medical utilisation. Diabetes is a contributing factor for higher medical utilisation and cost. However, whether the physical disability is associated with this higher medical utilisation and cost remains unclear.

Another issue is the lack of data on patients' physical or psychological disabilities in the HES database I analyzed. Therefore, subsequent chapters only use national data for patients suffering from physical or mental disorders to analyze whether these issues are related to medical use.

Through this systematic review, it is clear that further national-level studies examining mental and physical disorders are meaningful and necessary to creating a guide for policymakers and healthcare providers to initiate early preventative intervention programs for those patients with risk factors related to higher medical utilisation, cost, and mortality.

The elderly in the UK, like the elderly in other countries, are also facing the problem of lack of medical resources. Much evidence shows that the medical expenses of the elderly are much higher than other age groups. Although the ratio of senior citizens in the UK has increased year by year, the budget of the relevant medical system has not increased or even decreased.

Due to the shortage of medical budgets, the quality of medical care that the elderly can receive has declined year by year. According to statistics, over the past five years, medical care funding for older adults in the UK has decreased by £ 160 million, resulting in more than 1.5 million older people in the UK not receiving basic living and medical support. Besides, due to the shortage of local funds, the living pressure of unpaid carers increases, which directly affects the medical accessibility of the elderly.

Therefore, the importance of medical expenditure to the medical system is an essential issue for all countries. Finding factors that will increase medical expenditures and prevent them in advance is the most critical public health issue for government departments and policymakers today.

Chapter 6. The impact of physical and mental disorders on hospital length of stay among elderly patients with diabetes

6.1 Introduction

Patients with diabetes for a long period are at risk many complications and life-threatening health problems. The major complications mostly occur because of the damage to blood vessels, which can be generally classified into two categories - macro-vascular injuries and microvascular injuries. Due to the microvascular injury, diabetes can cause eye disease (diabetic retinopathy), kidney disease (diabetic nephropathy), and neuron disease (diabetic neuropathy). On the other hand, macro-vascular injury can lead to cardiovascular diseases (coronary artery disease, and stroke). Each complication above can lead to blindness, kidney failure, distal lower limb amputation, a heart attack and a cerebrovascular accident respectively (Fowler, 2008). Since multiple organ disorders can occur simultaneously in a patient with diabetes, this can cause barriers to access to medical services. In these circumstances, patients with diabetes, especially the elderly, have both a higher risk of complications and also an increased risk in the severity of complications.

In previous literature reviews (Chapter 1 & 2) and systematic reviews (Chapter 4), several studies have reported that the presence of other physical and mental health disorders in patients with diabetes can affect medical utilisation. Diabetic patients with the presence of

schizophrenia were reported to have less primary care use but have a higher mortality rate compared to patients with diabetes only (Copeland et al., 2009). Among diabetic patients with the presence of poor Activities of Daily Living (ADL) scores can have higher physician visits and several in-patient days than diabetic patients without any physical disabilities (Salas et al., 2000). Another study reported that diabetic patients with physical impairment may have a higher cost of illness (Riewpaiboon et al., 2011). However, the actual impact of physical or mental disorders on medical utilisation among elderly patients with diabetes is still unclear.

In this chapter, the primary objective is to understand the impact of physical and mental disorders on hospital length of stay among elderly patients with type 1 or type 2 diabetes. Stratified analysis by subgroups of mental disorders was the secondary objective to examine which mental disorders may be associated with increased risk for longer length of stay.

6.2 Methods

6.2.1 Data Sources

This is a cross-sectional study using the Hospital Episode Statistics (HES) database with linkage to the English Index of Multiple Deprivation (IMD). Data collected for 2011-12, 2012-13, and 2013-14 financial years were included in this study (April 2011 to March 2014).

6.2.2 Study population

Patients who were 65 years old or above, and with a 1st hospital admission diagnosis as diabetes (ICD-10 codes: E10 – E14). Each patient can have up to 20 diagnoses in the medical record. The first diagnosis listed in the data would be the primary diagnosis of this admission. 83,301 episodes and 57,659 spells occurred during the study period. One spell usually includes more than one episode, it means spell duration is longer or equal to episode duration. The definition of spell duration is the in-hospital length of stay between the patient admission date and the patient discharge date. Patients' discharge method should be recorded to confirm that the spell has finished. On the other hand, the definition of episode duration is the days between the episode start date and the episode end date.

6.2.3 Outcome variable

In the HES database, each patient can be recorded up to 20 diagnoses. The first diagnosis code recorded the main reason or diagnosis for patients' current hospitalisation. The outcome of interest was hospital length of stay. In HES, both the duration of the spell and the duration of the episode are provided. Since the duration of a spell represents the total length of stay during the hospitalisation of a patient, and this includes the duration of all episodes, the duration of the spell was chosen to best describe patients' hospital length of stay although some descriptive statistics for the duration of the episode will be presented for comparison.

6.2.4 Main covariates

6.2.4.1 Primary objective

The first variable assigns patients into one of the three disease category groups. This is aimed to evaluate the impact of physical and mental disorders on hospital length of stay among elderly patients with type 1 or type 2 diabetes.

- Group 1 was the reference group, and included elderly patients with type 1 or type 2 diabetes but without any other diseases (Labelled as “DM only”);

- Group 2 included elderly patients with type 1 or type 2 diabetes combined with physical disorders (Labelled as “DM + physical (no mental/no ICD F code)”);
- Group 3 included elderly patients with type 1 or type 2 diabetes combined with mental disorders (Labelled as “DM + physical + Mental (has ICD F code)”).

6.2.4.2 Secondary objective

The second variable assigns patients into one of the six groups. This is to further examine which mental disorders may be associated with increased risk for a longer length of stay. For the secondary analysis, Group 3 were further divided into four different subgroups to quantify the impact of the major mental disorders on elderly patients with diabetes, study subjects were separated into six groups as presented in Table 6.1.

The classification of mental disorders was made using the ICD-10 Classification of Mental and Behavioural Disorders. Diagnosis F00-F09, F10-F19, F30-F39 were specifically picked to be grouped because of high frequency in my study and because these three mental diagnoses are major public mental health issues globally.

- Group 1, as the reference group, for elderly patients with type 1 or type 2 diabetes only and without any other diseases; (Labelled as “DM only”);
- Group 2, for elderly patients with type 1 or type 2 diabetes combined with physical disorders (Labelled as “DM + physical (no mental/no ICD F code)”);
- Group 3, for elderly patients with type 1 or type 2 diabetes combined with organic, including symptomatic, mental disorders: (Labelled as “DM + Mental Disorders (F00-F09)”);
- Group 4, for elderly patients with type 1 or type 2 diabetes combined with mental and behavioural disorders due to psychoactive substance use (Labelled as “DM + Mental Disorders (F10-F19)”);
- Group 5, for elderly patients with type 1 or type 2 diabetes combined with mood affective disorders (Labelled as “DM + Mental Disorders (F30-F39)”);
- Group 6, for elderly patients with type 1 or type 2 diabetes combined with other mental disorders which are not listed above (Labelled as “DM + Mental Disorders (Others)”)

Table 6. 1 The frequency of mental disorders among elderly patients with diabetes in England from 2011-2013

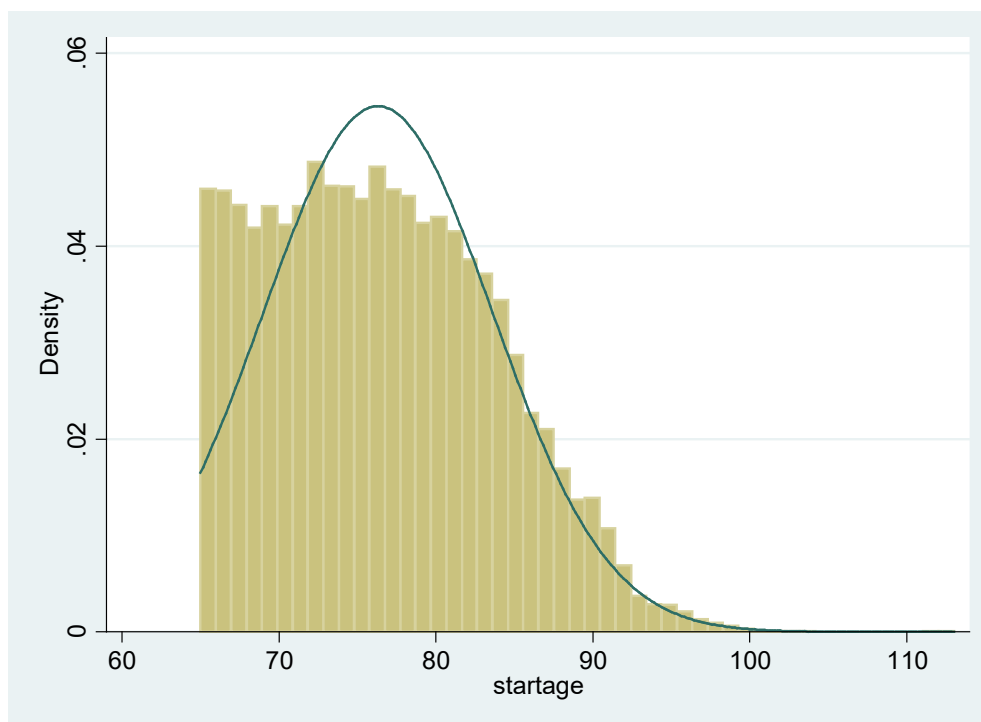
ICD 10		
n	Code	Mental Disorder Diagnosis
7756	F00-F09	Organic, including symptomatic, mental disorders
		Mental and behavioural disorders due to psychoactive substance
3232	F10-F19	use
599	F20-F29	Schizophrenia, schizotypal and delusional disorders
2775	F30-F39	Mood [affective] disorders
669	F40-F48	Neurotic, stress-related and somatoform disorders
		Behavioural syndromes associated with physiological disturbances
20	F50-F59	and physical factors
68	F60-F69	Disorders of adult personality and behaviour
38	F70-F79	Mental retardation
405	F80-F89	Disorders of psychological development
		Behavioural and emotional disorders with onset usually occurring
13	F90-F98	in childhood and adolescence
20	F99	Unspecified mental disorder

6.2.5 Other covariates

I divided the study population into five age bands (65 – 69 years old, 70 – 74 years old, 75 – 79 years old, 80 – 84 years old and ≥ 85 years old). Patients with unspecified gender were excluded.

HES provides 18 categories for ethnicity (British, Irish, Other White backgrounds, Indian, Pakistani/Bangladeshi, Other Asian backgrounds, Caribbean, African, Other Black backgrounds, Chinese, Others, Not stated, Not known). I classified patients into four broad ethnic groups - White, Black, Asian, and Mixed or Other. British, Irish, and Other White background were categorised into the white group; Caribbean, African, and Other Black background were in the black group; Indian, Pakistani/Bangladeshi, Other Asian background and Chinese were categorised into the Asian group. Mixed, other ethnic groups or patients with no ethnicity recorded were categorised into the Mixed or Others group.

Figure 6. 1 The age distribution of elderly patients with diabetes from 2011-2013 in England



Patients' social economic status were described using their English IMD based on patients' postcodes of residence. IMD is an index describing the relative deprivation of a small area (about 1,500 residents or 650 households) compared to the other areas. There are 32,844 similar-size small areas in England (The Ministry of Housing, 2019). The overall IMD score is generated based on seven individual domains. The domains are weighted as following: Income (22.5%), Employment (22.5%), Health Deprivation and Disability (13.5%), Education, Skills and Training (13.5%), Barriers to Housing and Services (9.3%), Crime (9.3%), and Living Environment (9.3%).

6.2.6 Statistical Analysis

In this study, I used data from 2011-2014, three financial years (April 2011 to March 2013). The statistical analyses were based on the whole study population. On each covariate, patients were sub grouped by patients' age (65 – 69 years old, 70 – 74 years old, 75 – 79 years old, 80 – 84 years old and ≥ 85 years old), gender (male and female), ethnicity (White, Black, Asian, and Mixed or Other) and quintiles of IMD based on patients' postcodes of residence. The actual number of participants in each subgroup was calculated as well as the percentage in the whole study population. In each subgroup, patients were even sub grouped by the main covariate to realise the distribution of that covariate in each disease category (Group 1: DM Only, Group 2: DM + physical, Group 3: DM + mental). To understand the distribution of age (five age groups), gender, ethnicity, and IMD among disease category groups, Chi-square test was performed to exam the statistical difference between disease category groups due to above covariates were all categorical variables.

To exam for differences in the means of the age among disease category groups, since age is a normally distributed continuous variable, a one-way analysis of variance (ANOVA) is used.

The number of eligible episodes or spells were given in each table. Characteristics of outcome variables were computed to understand the mean, standard deviation and the range of episode and spell duration. Characteristics of outcome variables in each disease categories were also calculated to compare the mean difference between disease categories.

Since the distribution of patients' spell duration was left-skewed with variance greatly exceeded the mean, negative binomial regression was used to compare hospital length of stay (spell duration) between elderly patients with different physical or mental comorbidities. The main covariate is a disease category, and the other covariates were the patient's age, gender, ethnicity, and IMD. Unadjusted and adjusted models were performed respectively. In the unadjusted regression model, only one covariate (one of the following covariates: disease category, patient's age, gender, ethnicity, and IMD) was put into the model without other covariates. In the adjusted regression model, all the covariates (disease category, patient's age, gender, ethnicity, and IMD) were put into the model. To make the results of each model more easily understood, coefficients were converted to Incidence-Rate Ratio (IRRs). 95% confidence intervals obtained from models are presented in the tables.

Since age, gender, ethnicity, and IMD are important covariates and should be adjusted in the model. I calculated the predicted counts at each patient disease category, and I held all other variables in the model at their means.

Statistical analysis was conducted using Stata (version 12.1).

6.3 Results

Table 6.2 showed the entire study period from 2011-12 to 2013-14 financial years (April 2011 to March 2013) in England, 83,301 in-patient visits had diabetes mellitus as the primary hospital admission diagnosis, where at the date of admission, the patient's age was above 65 years and over.

6.3.1 Characteristics of the study population

6.3.1.1 Gender and Patients

The characteristics of T1DM and T2DM patients are shown in Table 6.2. In this study, among the patients, the proportion of men was higher

than women. However, if we divided the patients into three disease category groups, the gender distribution in these three subgroups had a different picture. For those patients that have DM as the major and only diagnosis, the gender proportion is equal in this group; for those patients have DM as the major diagnosis and include other physical disorders without any mental disorder, the male proportion is dominant in this group; on the other hand, for those patients have DM as the major and combine at least one mental disorder, the female proportion is higher than the male proportion (See Table 6.2).

There was a statistically significant relationship between gender and disease category ($P < 0.001$). The proportion of male in Group 2 is statistically higher compared to male; on the other hand, the proportion of female in Group 3 is statistically greater compared to male.

Table 6. 2 Characteristics of elderly patients with diabetes who had been admitted to a hospital in England, April 2010 to March 2013 (N=83,301)

				Group 2:	Group 3:				
	n	%	Group 1: DM Only	DM+physic al (no mental)	DM+mental or DM+mental + physical	Group 1: DM Only (%)	Group 2: DM+physical (no mental) (%)	Group 3: DM+mental or DM+mental + physical (%)	p Value
Gender									
Male ^a	46,221	55.49%	888	38,587	6,746	50.7%	57.1%	48.5%	<0.001
Female	37,080	44.51%	862	29,044	7,174	49.3%	42.9%	51.5%	
Age group									
65-69 ^a	18,114	21.75%	522	15,123	2,469	29.8%	22.4%	17.7%	<0.001
70-74	18,576	22.30%	449	15,664	2,463	25.7%	23.2%	17.7%	
75-79	18,500	22.21%	363	15,232	2,905	20.7%	22.5%	20.9%	
80-84	15,897	19.08%	241	12,656	3,000	13.8%	18.7%	21.6%	
>85	12,214	14.66%	175	8,956	3,083	10.0%	13.2%	22.1%	
Ethnicity									
British ^a	67,267	80.75%	1,335	54,654	11,278	76.3%	80.8%	81.0%	<0.001
Irish	825	0.99%	8	660	157	0.5%	1.0%	1.1%	
Other White background	2,312	2.78%	65	1,827	420	3.7%	2.7%	3.0%	
Indian	1,694	2.03%	27	1,458	209	1.5%	2.2%	1.5%	
Pakistani / Bangladeshi	1,641	1.97%	55	1,408	178	3.1%	2.1%	1.3%	
Other Asian background	559	0.67%	12	447	100	0.7%	0.7%	0.7%	
Caribbean	2,957	3.55%	60	2,241	656	3.4%	3.3%	4.7%	
African	648	0.78%	19	558	71	1.1%	0.8%	0.5%	
Other Black background	415	0.50%	11	325	79	0.6%	0.5%	0.6%	
Chinese	198	0.24%	2	171	25	0.1%	0.3%	0.2%	
Others ^b	1,131	1.36%	34	912	185	1.9%	1.3%	1.3%	
Not stated	2,874	3.45%	96	2,321	457	5.5%	3.4%	3.3%	

Not known	780	0.94%	26	649	105	1.5%	1.0%	0.8%	
IMD quintile									
1 - Least deprived ^a	16,547	19.86%	274	13,650	2,623	15.7%	20.2%	18.8%	
2	16,535	19.85%	278	13,896	2,361	15.9%	20.5%	17.0%	
3	16,540	19.86%	446	13,335	2,759	25.5%	19.7%	19.8%	
4	16,529	19.84%	362	13,288	2,879	20.7%	19.6%	20.7%	<0.001
5 - Most deprived	16,530	19.84%	363	12,980	3,187	20.7%	19.2%	22.9%	
Missing*	620	0.74%	27	482	111	1.5%	0.7%	0.8%	
Total	83,301		1,750	67,631	13,920				

Notes: DM=Diabetes Mellitus; physical=physical disorders other than diabetes; mental=mental disorders; IMD=index of multiple deprivation; ^a Reference group. ^b Others - mixed background (White and Black Caribbean, White and Black African, White and Asian, Any other mixed background) and other ethnic groups. *Missing – patients had all other data but did not have residential records in the data.

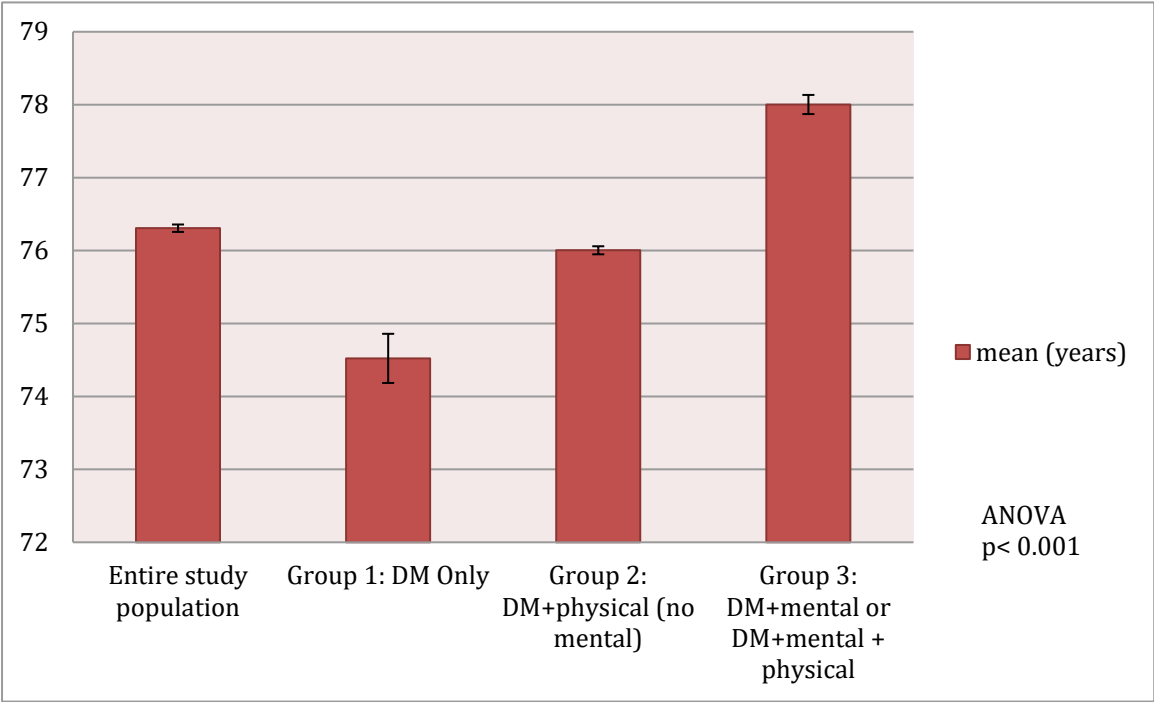
6.3.1.2 Age and Patients

The mean age of my study population was 76.3 years old, the standard deviation was 7.31, and the maximum age is 113 years old (Fig 6.1). Among the patients included in my study, around 66% were under 80 years old and less than 15% of the patients were more than 85 years old. The mean age was 76.3 years (95%CI: 76.26 to 76.36). However, if we divided the patients into three disease category groups, the age distribution in these three subgroups had a different picture.

For those patients having DM as the major and only diagnosis, more than 50% of the patients were between 65-69 years old and only 10% of the patients were over 85 years old. The mean age of this group was 74.52 years old (95%CI: 74.18 to 74.86). For those patients having DM as the major diagnosis and other physical disorders without any mental disorder, the age distribution was similar to the total group, and the mean age of this group was 76.00 years (95%CI: 75.95 to 76.06), around 1.5 years older than the group which has only DM as the only diagnosis.

On the other hand, for those patients having DM as the major diagnosis, combined with at least one mental disorder, more than 20% of the patients were older than 85 years old and the proportion of the 85-year-old-above group is higher than any other group. The mean age of this group is 78.00 years old (95%CI: 77.87 to 78.13), about 1.7 years older than the overall mean for all patients. (See Table 6.2). There was a statistically significant relationship between age and disease category ($P<0.001$), as well as the mean age among three disease category groups, ($P<0.001$) (Figure 6.2).

Figure 6. 2 The mean of Age among groups

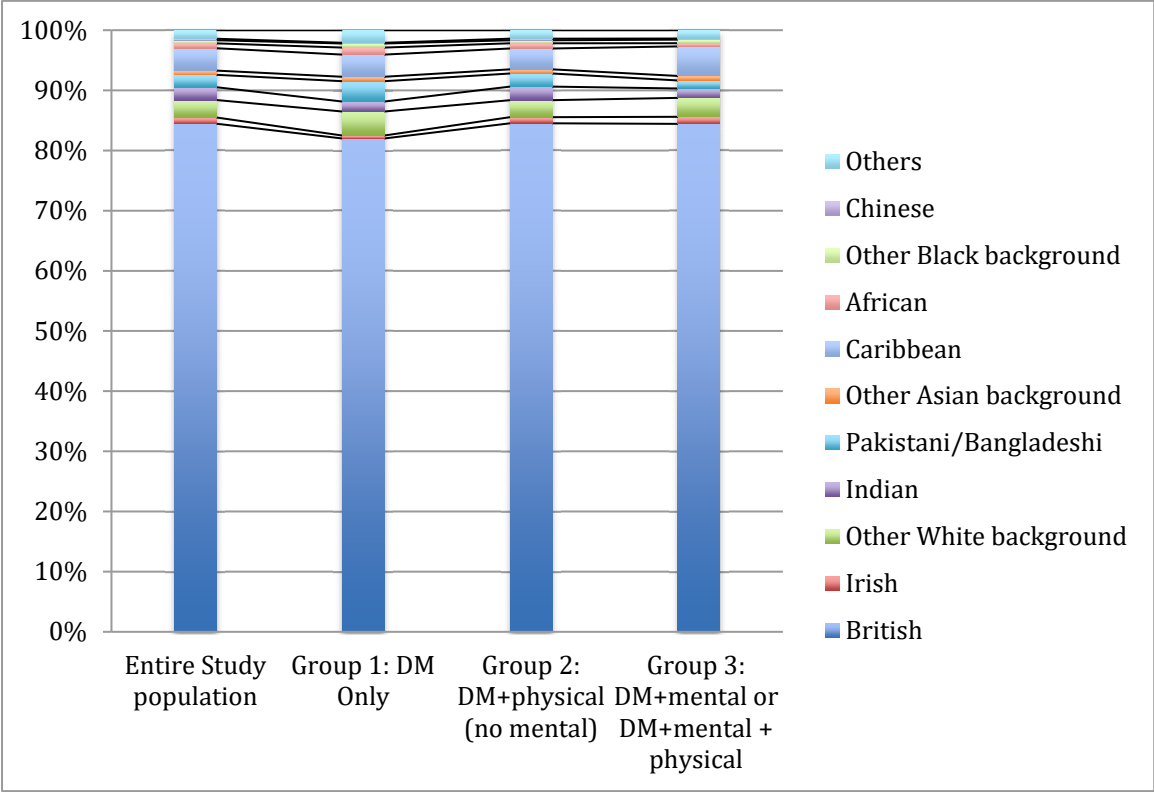


6.3.1.3 Ethnicity and Patients

Among the entire study population, British (80.75%) is the major ethnicity and Caribbean (3.55%) has the second-highest proportion. After dividing the patients into three disease category groups, the ethnicity distribution in these three subgroups is similar. For those patients having DM as the major and only diagnosis, other White background (3.7%) has the second-highest proportion; on the other hand, for those patients having DM as the major diagnosis and include other physical disorders without any mental disorder, or for those patients having DM as the major diagnosis and combined with at least one mental disorder, in both subgroups, Caribbean (3.55%) has the

second-highest proportion. (See Table 6.2 and Figure 6.3). There was a statistically significant relationship between ethnicity and disease category ($P<0.001$).

Figure 6. 3 Ethnicity proportion among groups

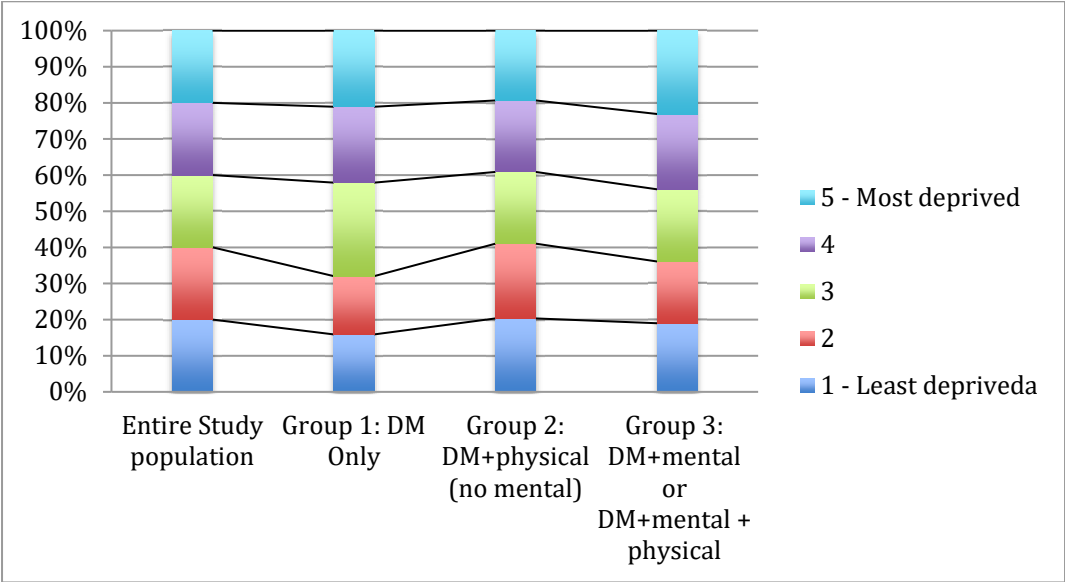


6.3.1.4 IMD quintile and Patients

Among all the patients included, patients were evenly divided in deprivation quintile. However, among the three subgroups, the IMD quintile had a different distribution. For those patients having DM as the major and only diagnosis, the medium quintile (25.5%) has the highest percentage; for those patients having DM as the major

diagnosis and including other physical disorders without any mental disorder, the majority were less deprived; on the other hand, for those patients having DM as the major and combined with at least one mental disorder, the most deprived quintile (22.9%) has the highest percentage. (See Table 6.2 and Figure 6.4). There was a statistically significant relationship between IMD quintile and disease category ($P<0.001$).

Figure 6. 4 IMD quintile Proportion among groups



6.3.2 Characteristics of outcomes (Hospital length of Stay: Spell Duration & Episode Duration)

Hospital length of stay is the major outcome of my study. One spell consisted of several episodes, so spells can represent the entire

hospital length of stay better than episodes. Table 6.3 shows the mean of episode duration for the entire study population (5.3 days, 95%CI: 5.22 to 5.38) is 2.5 days shorter than the mean of spell duration for the entire study population (7.8 days, 95%CI: 7.67 to 7.94). The mean episode duration of Group 1 (1.86 days, 95%CI: 1.38 to 2.34) is 3.44 days less than the mean episode duration of whole study population, but the mean episode duration of Group 3 (7.07 days, 95%CI: 6.83 to 7.32) is 1.77 days more than the mean episode duration of whole study population (Figure 6.6). On average, the elderly in Group 3 stays 3.8 times longer than Group 1.

On the other hand, the mean spell duration of Group 1 (2.08 days, 95%CI: 1.52 to 2.65) is 5.72 days less than the mean spell duration of whole study population, but the mean spell duration of Group 3 (12.41 days, 95%CI: 11.90 to 12.92) is 4.61 days longer than the mean spell duration of whole study population. In average spell, the elderly in Group 3 stays 4.61 times longer than Group 1. The mean duration of episodes differs significantly among three disease category groups ($P<0.001$), as well as the mean duration of spells among three disease category groups ($P<0.001$) (Table 6.3, Figure 6.5, Figure 6.6).

Table 6. 3 Outcome characteristics of eligible hospital admissions among diabetic elderly in England (2010-2013)

	n	min	MAX	mean	95% CI of mean	standard deviation	p Value
Episode Duration (N=83301)							
Entire study population	83301	0	804	5.30	(5.21, 5.38)	11.80	<0.0001
Group 1: DM Only	1750	0	269	1.86	(1.38, 2.34)	10.02	
Group 2: DM+physical (no mental)	67631	0	373	5.02	(4.93, 5.10)	11.19	
Group 3: DM+mental or DM+mental + physical	13920	0	804	7.07	(6.82, 7.31)	14.44	
Spell Duration (n=57659)							
Entire study population	57659	0	1227	7.80	(7.66, 7.94)	16.74	<0.0001
Group 1: DM Only	1538	0	269	2.08	(1.52, 2.64)	11.03	
Group 2: DM+physical (no mental)	48006	0	379	7.21	(7.06, 7.34)	15.44	
Group 3: DM+mental or DM+mental + physical	8115	0	1227	12.41	(11.9, 12.9)	22.98	

Notes: N=number eligible; n=number in each group; DM=Diabetes Mellitus; physical=physical disorders other than diabetes; mental=mental disorders; IMD=index of multiple deprivation; ^a Reference group. ^b Others - mixed background (White and Black Caribbean, White and Black African, White and Asian, Any other mixed background) and other ethnic groups.

Figure 6. 5 The mean of episode duration among groups

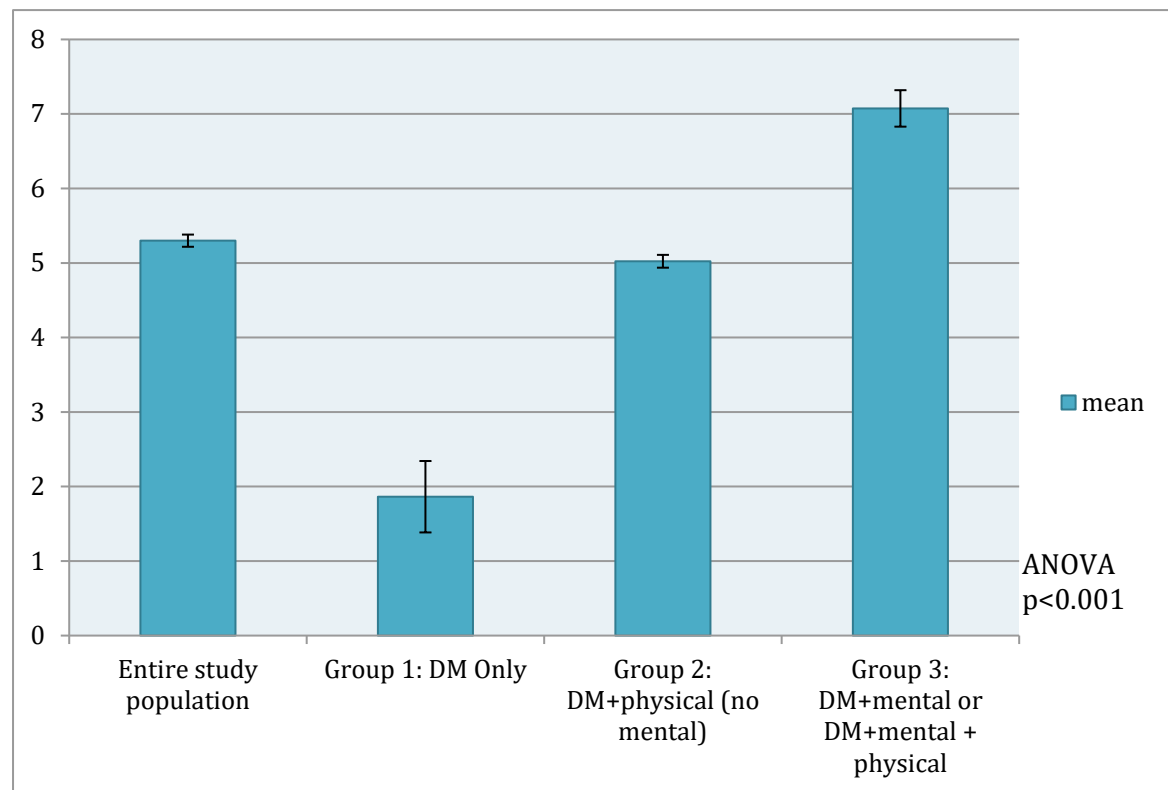
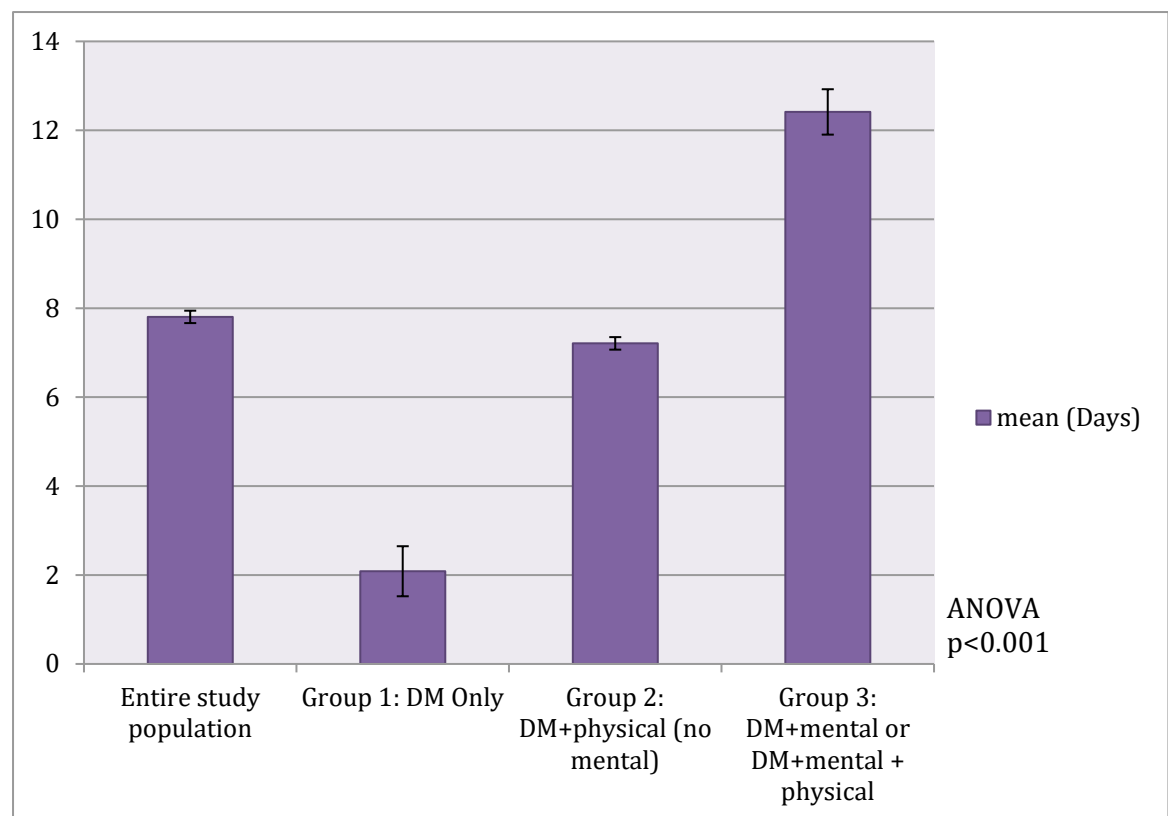


Figure 6. 6 The mean of spell duration among groups



6.3.3 Regression modelling (by Disease Category)

6.3.3.1 Physical disorders, Mental disorders, or None

6.3.3.1.1 Factors related to diabetic elderly people's spell duration

A spell can contain more than one episode, so spell duration is longer than episode duration. There are 57659 spells included in this model. Table 6.4 shows the results of unadjusted negative binomial regression analysis on spell duration. Age, ethnicity, and disease category were significantly associated with spell duration in this model. Older patients had greater IRRs for spell duration. The oldest group, 85 years old and above, has a 2.1 times greater IRR for spell duration than the 65-69 years old group (IRR: 2.1, 95%CI: 1.99 to 2.22). The IRR among 80-84 years old group 75-79 years old group, and 70-74 years old group were 1.75, 1.45, and 1.21 respectively.

Among different ethnicities, both Asian (IRR: 0.62, 95%CI: 0.57 to 0.66) and Mixed or Others (IRR: 0.82, 95%CI: 0.77 to 0.88) had lower IRRs

for spell duration than White. As with the episode duration model results, not surprisingly, diabetic patients with physical disorders had a higher risk for longer spell duration (IRR: 3.46, 95%CI: 3.12 to 3.83) compared with patients with diabetes only. Diabetic elderly patients with a mental disorder had even greater IRRs for spell duration than elderly with diabetes only, 5.96 times higher (IRR: 5.96, 95%CI: 5.34 to 6.64). The IMD group did not have a significant association with spell duration.

Table 6. 4 Unadjusted negative binomial regression analysis on spell duration among diabetic elderly in England (2010-2013), n=57659

Spell Duration (Un-Adjusted)					
	n	% population	IRR	95% CI	p Value
Gender	57659				
Male ^a	32,229	55.9	1.00		
Female	25,430	44.1	0.99	(0.95, 1.02)	0.52
Age group	57659				
65-69 ^a	13,751	23.9	1.00		
70-74	13,444	23.3	1.21	(1.15, 1.27)	<0.001
75-79	12,663	22.0	1.45	(1.38, 1.51)	<0.001
80-84	10,340	17.9	1.75	(1.66, 1.83)	<0.001
>85	7,461	12.9	2.10	(1.99, 2.22)	<0.001
Ethnicity	57659				
White ^a	48,425	84.0	1.00		
Black	2,696	4.7	0.99	(0.91, 1.06)	0.73
Asian	3,027	5.3	0.62	(0.57, 0.66)	<0.001
Mixed or Others ^b	3,511	6.1	0.82	(0.76, 0.87)	<0.001
Group	57659				
Group 1: DM Only ^a	1,538	2.7	1.00		
Group 2: DM+physical (no mental)	48,006	83.3	3.46	(3.12, 3.83)	<0.001
Group 3: DM+mental or DM+mental + physical	8,115	14.1	5.96	(5.33, 6.64)	<0.001
IMD quintile	57253				
1 - Least deprived ^a	11,528	20.1	1.00		
2	11,705	20.4	0.93	(0.88, 0.97)	<0.001
3	11,408	19.9	1.01	(0.96, 1.06)	0.60
4	11,361	19.8	0.98	(0.93, 1.03)	0.43
5 - Most deprived	11,251	19.7	1.02	(0.97, 1.07)	0.36
Total	57659				

Notes: n=number eligible; IRR=incidence-rate ratio; 95%CI= 95% confidence interval; DM=Diabetes Mellitus; physical=physical disorders other than diabetes; mental=mental disorders; IMD=index of multiple deprivation; a Reference group. b Others - mixed background (White and Black Caribbean, White and Black African, White and Asian, Any other mixed background) and other ethnic groups.

Gender, age, ethnicity, and disease category were significantly associated with spell duration in the adjusted negative binomial regression model (Table 6.5). Female sex was a protecting factor, with 0.9 times the spell duration of males (AIRR: 0.9, 95%CI: 0.87 to 0.92). Older patients, as in the unadjusted model, had higher risks for longer spell duration. The oldest group, 85 years old and above group, has 2.12 times greater IRRs for spell duration than the 65-69 years old group (AIRR: 2.12, 95%CI: 2.00 to 2.24). The IRR among 80-84 years old group, 75-79 years old group and 70-74 years old group were 1.75, 1.46, and 1.22 respectively.

Both Asian (AIRR: 0.66, 95%CI: 0.61 to 0.71) and Mixed or Others (AIRR: 95%CI: 0.81, 0.76 to 0.87) had lower IRRs for spell duration than White. Diabetic elderly with a mental disorder had a greater risk for longer spell duration than elderly with diabetes only, 5.88 times higher IRR (AIRR: 5.88, 95%CI: 5.27 to 6.56).

Likewise, diabetic patients with physical disorders had a greater IRR for spell duration (AIRR: 3.50, 95%CI: 3.16 to 3.88) compared to patients with diabetes only. The IMD group did not have a significant association with spell duration except for the most deprived group, which shows having a significantly greater IRR for spell duration than the least deprived group.

Table 6. 5 Adjusted multivariate negative binomial regression analysis on spell duration among diabetic elderly in England (2010-2013), n=57253

Spell Duration (Adjusted)					
	n	% population	AIRR	95% CI	p Value
Gender					
Male ^a	32,002	55.9	1.00		
Female	25,251	44.1	0.90	(0.86, 0.92)	<0.001
Age group					
65-69 ^a	13,636	23.82	1.00		
70-74	13,350	23.32	1.22	(1.16, 1.27)	<0.001
75-79	12,589	21.99	1.46	(1.39, 1.53)	<0.001
80-84	10,278	17.95	1.75	(1.66, 1.83)	<0.001
>85	7,400	12.93	2.12	(2.00, 2.23)	<0.001
Ethnicity					
White ^a	48,145	84.09	1.00		
Black	2,658	4.64	0.95	(0.87, 1.02)	0.18
Asian	2,993	5.23	0.66	(0.61, 0.70)	<0.001
Mixed or Others ^b	3,457	6.04	0.81	(0.75, 0.86)	<0.001
Group					
Group 1: DM Only ^a	1,515	2.65	1.00		
Group 2: DM+physical (no mental)	47,681	83.28	3.50	(3.15, 3.87)	<0.001
Group 3: DM+mental or DM+mental + physical	8,057	14.07	5.88	(5.27, 6.56)	<0.001
IMD quintile					
1 - Least deprived ^a	11,528	20.14	1.00		
2	11,705	20.44	0.93	(0.88, 0.98)	0.01
3	11,408	19.93	1.05	(0.99, 1.10)	0.06
4	11,361	19.84	1.02	(0.97, 1.07)	0.41
5 - Most deprived	11,251	19.65	1.12	(1.06, 1.17)	<0.001
Total	57,253				

Notes: n=number eligible; AIRR=adjusted incidence-rate ratio; 95%CI= 95% confidence interval; DM=Diabetes Mellitus; physical=physical disorders other than diabetes; mental=mental disorders; IMD=index of multiple deprivation; a Reference group. b Others - mixed background (White and Black Caribbean, White and Black African, White and Asian, Any other mixed background) and other ethnic groups.

6.3.3.2 The impact of major mental disorders

Table 6.5 shows that the diabetic elderly with at least one mental disorder have a greater IRR for spell duration than the elderly with diabetes as the only diagnosis, 5.88 times higher risk (IRR: 5.88, 95%CI: 5.27 to 6.56). It reveals that the impact of mental disorders on hospital length of stay in general, on elderly patients with diabetes, is larger than elderly patients with diabetes combined with physical disorders (IRR: 3.50, 95%CI: 3.16 to 3.88). To understand further about which categories of mental disorders are playing a stronger role in increasing spell duration, subgroup analyses were performed (Table 6.6 and Table 6.7).

Table 6.6 presents the results of unadjusted negative binomial regression analysis on spell duration. As in Table 6.4, age, ethnicity, and disease category were all significantly associated with spell duration in each model, apart from gender and IMD. Elderly patients had shown a clear age-response effect, such that the older patients had the longest spell duration. White people were still the highest risk group.

Table 6. 6 Unadjusted negative binomial regression analysis on spell duration among diabetic elderly in England (2010-2013), n=57659

Spell Duration (Un-Adjusted)					
	n	% population	IRR	95% CI	P Value
Gender	57659				
Male ^a	32,229	55.9	1.00		
Female	25,430	44.1	0.99	(0.95, 1.02)	0.52
Age group	57659				
65-69 ^a	13,751	23.9	1.00		
70-74	13,444	23.3	1.21	(1.15, 1.27)	<0.001
75-79	12,663	22.0	1.45	(1.38, 1.51)	<0.001
80-84	10,340	17.9	1.75	(1.66, 1.83)	<0.001
>85	7,461	12.9	2.10	(1.99, 2.22)	<0.001
Ethnicity	57659				
White ^a	48,425	84.0	1.00		
Black	2,696	4.7	0.99	(0.91, 1.06)	0.73
Asian	3,027	5.3	0.62	(0.57, 0.66)	<0.001
Mixed or Others ^b	3,511	6.1	0.82	(0.76, 0.87)	<0.001
Group	57659				
Group 1: DM only (without any Mental or Physical disorder) ^a	1,538	2.7	1.00		
Group 2: DM+Physical Disorders (no mental disorder)	48,006	83.3	3.46	(3.12, 3.83)	<0.001
Group 3: DM+Mental Disorders (F00-F09)	3,998	6.9	6.42	(5.70, 7.21)	<0.001
Group 4: DM+Mental Disorders (F10-F19)	1,799	3.1	4.90	(4.28, 5.60)	<0.001
Group 5: DM+Mental Disorders (F30-F39)	1,512	2.6	6.29	(5.47, 7.23)	<0.001
Group 6: DM+Mental Disorders (Others) ^c	806	1.4	5.39	(4.56, 6.36)	<0.001
IMD quintile	57253				
1 - Least deprived ^a	11,528	20.1	1.00		
2	11,705	20.4	0.93	(0.88, 0.97)	<0.001

3	11,408	19.9	1.01	(0.96, 1.06)	0.60
4	11,361	19.8	0.98	(0.93, 1.03)	0.43
5 - Most deprived	11,251	19.7	1.02	(0.97, 1.07)	0.36
Total	57,253				

Notes: n=number eligible; IRR=incidence-rate ratio; 95%CI= 95% confidence interval; DM=Diabetes Mellitus; physical=physical disorders other than diabetes; mental=mental disorders; IMD=index of multiple deprivation; a Reference group. b Others - mixed background (White and Black Caribbean, White and Black African, White and Asian, Any other mixed background) and other ethnic groups. c Others - F20-F29 & F40-F99

In Table 6.7, both Group 3 (DM + Mental Disorders, F00-F09) and Group 5 (DM + Mental Disorders, F30-F39) show a stronger and significant impacts on spell duration respectively (Group 3 IRR: 6.42, 95%CI: 5.70 to 7.21; Group 5 IRR: 6.29, 95%CI: 5.47 to 7.23), than mental disorders in general (Group 3 in Table 6.4, IRR: 5.96). It reveals that elderly patients with diabetes with organic mental disorders (F00-F09) or mood disorders (F30-F39), can have even greater IRRs for hospital length of stay than diabetic elderly patients with other mental disorders.

Gender, age, ethnicity, and disease category were significantly associated with spell duration in the adjusted negative binomial regression model (Table 6.7). Females had 11% lower IRR for spell duration than male (AIRR: 0.89, 95%CI: 0.86 to 0.92). Elderly patients, the same trend as the unadjusted model, had greater IRRs for spell

duration. The oldest group, 85 years old and above group, has a 2.12 times higher risk for longer spell duration than 65-69 years old group (AIRR: 2.12, 95%CI: 2.00 to 2.24). The IRRs for spell duration among 80-84 years old group, 75-79 years old group, and 70-74 years old group comparing with 65-69 years old group, were 75%, 46%, and 22% greater respectively. Asian (AIRR: 0.66, 95%CI: 0.61 to 0.70) had a significantly lower IRR for spell duration than White.

Group 5 (DM + Mental Disorders, F30-F39) in Table 6.7 shows stronger and significant impact on spell duration (Group 5 AIRR: 6.54, 95%CI: 5.69 to 7.51), than mental disorders in general (Group 3 in Table 6.5, AIRR: 5.88, 95%CI: 5.27 to 6.56). Both Group 3 (DM + Mental Disorders, F00-F09) and Group 4 (DM + Mental Disorders, F10-F19) have significant impacts on spell duration (Group 3 AIRR: 5.77, 95%CI: 5.13 to 6.48; Group 4 AIRR: 5.53, 95%CI: 4.82 to 6.32), are close to mental disorders in general (Group 3 in Table 6.5). Patients from the most deprived areas, not surprisingly, had a 12% greater IRR for spell duration than patients from the most affluent areas (AIRR: 1.12, 95%CI: 1.06 to 1.17, $p < 0.001$).

Table 6. 7 Adjusted multivariate negative binomial regression analysis on spell duration among diabetic elderly in England (2010-2013), n=57253

Spell Duration (Adjusted)					
	n	% population	AIRR	95% CI	P Value
Gender					
Male ^a	32,002	55.9	1.00		
Female	25,251	44.1	0.89	(0.86, 0.92)	<0.001
Age group					
65-69 ^a	13,636	23.82	1.00		
70-74	13,350	23.32	1.22	(1.16, 1.27)	<0.001
75-79	12,589	21.99	1.46	(1.39, 1.53)	<0.001
80-84	10,278	17.95	1.75	(1.66, 1.83)	<0.001
>85	7,400	12.93	2.12	(2.00, 2.23)	<0.001
Ethnicity					
White ^a	48,145	84.09	1.00		
Black	2,658	4.64	0.95	(0.87, 1.02)	0.18
Asian	2,993	5.23	0.66	(0.61, 0.70)	<0.001
Mixed or Others ^b	3,457	6.04	0.81	(0.75, 0.86)	<0.001
Group					
Group 1: DM only (without any Mental or Physical disorder) ^a	1,515	2.65	1.00		
Group 2: DM+Physical Disorders (no mental disorder)	47,681	83.28	3.50	(3.15, 3.87)	<0.001
Group 3: DM+Mental Disorders (F00-F09)	3,972	6.94	5.77	(5.13, 6.48)	<0.001
Group 4: DM+Mental Disorders (F10-F19)	1,781	3.11	5.53	(4.82, 6.32)	<0.001
Group 5: DM+Mental Disorders (F30-F39)	1,502	2.62	6.54	(5.69, 7.51)	<0.001
Group 6: DM+Mental Disorders (Others) ^c	802	1.4	6.00	(5.08, 7.08)	<0.001
IMD quintile					

1 - Least deprived ^a	11,528	20.14	1.00		
2	11,705	20.44	0.93	(0.88, 0.98)	0.01
3	11,408	19.93	1.05	(0.99, 1.10)	0.06
4	11,361	19.84	1.02	(0.97, 1.07)	0.39
5 - Most deprived	11,251	19.65	1.12	(1.06, 1.17)	<0.001
Total	57,253				

Notes: n=number eligible; AIRR=adjusted incidence-rate ratio; 95%CI= 95% confidence interval; DM=Diabetes Mellitus; physical=physical disorders other than diabetes; mental=mental disorders; IMD=index of multiple deprivation; a Reference group. b Others - mixed background (White and Black Caribbean, White and Black African, White and Asian, Any other mixed background) and other ethnic groups. c Others - F20-F29 & F40-F99

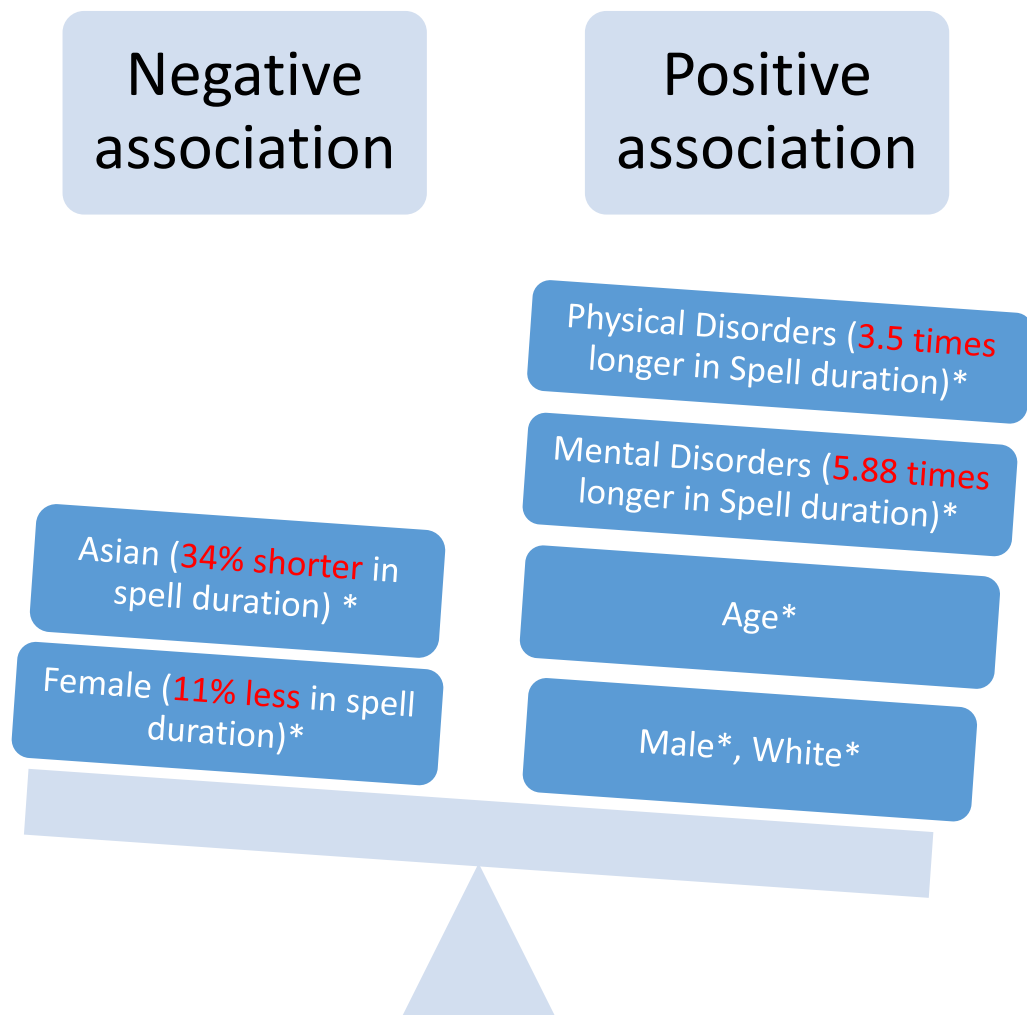
6.4 Discussion

The results suggest that male gender, increasing age, white ethnicity, and patients with mental disorders, on average, have higher hospital length of stay. Both unadjusted and adjusted models have similar findings. Female patients with diabetes had a slightly lower IRR for the length of stay than male patients with diabetes. 85 years old above patients with diabetes, on average, have 2.12 times greater IRR than 65 years old patients with diabetes. Comparing the impacts of these factors, diabetic patients with mental disorders had the longest hospital length of stay.

Patients with diabetes and mental disorders (F00-F09: Organic, symptomatic, mental disorders; F10-F19: Mental and behavioural disorders due to psychoactive substance use; F30-F39: Mood [affective] disorders), have greater IRRs for hospital length of stay than patients with diabetes and other physical disorders, statistically significant in both adjusted and unadjusted models.

In particular, diabetic elderly patients having organic mental disorders or affective disorders have the longest hospital length of stay. Diabetic patients with other physical disorders have 3.5 times greater risk to be hospitalised than diabetic patients without comorbidity ($p < 0.001$); on the other hand, diabetic patients with mental disorders (organic mental disorders; mental disorders due to substance use; and affective disorders), have 5.77 times, 5.53 times, and 6.54 times greater IRRs for hospital length of stay than diabetic patients without comorbidity respectively ($p < 0.001$).

Figure 6. 7 Summary diagram of positive or negative association on hospital length of stay among patients with diabetes (* p< 0.001)



Understandably, elderly patients with diabetes and other physical comorbidities can have greater IRRs for hospital length of stay, since the combination of different diseases implies more complex disease (Olthof et al., 2014). On the other hand, mental disorders and diabetes can be considered as independent diseases without apparent direct physiological or pathological interaction between each other (Balhara, 2011). However, in this study, in elderly patients with diabetes and other mental comorbidities, the presence of mental disorders are obvious to be a contributing factor in patients' length of stay. The impact of mental disorders is even bigger than the impact of physical disorders in terms of elderly diabetic patients' hospital length of stay.

6.4.1 Possible Explanations & Relation to Existing Literature

Excluding age, gender, comorbidity, and socioeconomic status, longer hospital length of stay in previous studies is related to occupation, payment method, source of referral, doctor's speciality, initial glycated haemoglobin level, hospital-acquired infection and hospital treatment efficacy (Liu et al., 2001, Haghparast-Bidgoli et al., 2013, Huang et al., 2016). Occupation can be excluded as a risk for longer hospital length of stay because the patients in this study are all above 65 years old and

most will be retired. Payment method can also be excluded as a cause because the National Health Service (NHS) in the United Kingdom provides free of charge medical services. Hospital treatment efficacy and doctor's speciality are not considered in this study. There is no direct pathological interaction between mental disorders and hospital-acquired infection. High initial glycated haemoglobin levels, indicating poor blood sugar control, maybe a possible explanation for diabetic patients with mental disorders having a greater risk for a longer hospital stay. Disease severity is a contributing factor for staying longer in the hospital.

Poor blood sugar control is related to poor diet control, bad medication compliance, and low levels of physical activity. In my study, patients with diabetes with mental disorders (ICD 10: F00-F09 or F30-39) have a higher relative risk for longer hospital length of stay. Table 6.8 shows that among elderly patients with diabetes and ICD 10 (F00-F09), 89.9% of the patients had dementia. It implies a clear direction of a possible explanation: that it is challenging for patients with dementia to have proper nutrition because of the decline in patients' cognitive function. Patients with dementia may forget to get proper food which is suitable for patients with diabetes. Besides, patient medication adherence among patients with dementia was low and this can also be a contributing factor to poor blood sugar control for

diabetic patients with dementia (Arlt et al., 2008). Patients having dementia tend to be less physically active than patients with normal cognitive function (Laurin et al., 2001).

Table 6. 8 The diagnoses frequency within F00-F09 among diabetic elderly in England (2010-2013)

ICD Code	Diagnosis	Frequency	Percentage
F00	Dementia in Alzheimer's disease	697	9.0%
F01	Vascular dementia	2007	25.9%
	Dementia in other diseases		
F02	classified elsewhere	120	1.5%
F03	Unspecified dementia	4151	53.5%
	Organic amnesic syndrome, not induced by alcohol and other		
F04	psychoactive substances	1	0.0%
	Delirium, not induced by alcohol and other psychoactive		
F05	substances	518	6.7%
	Other mental disorders due to brain damage and dysfunction		
F06	and to physical disease	257	3.3%
	Personality and behavioural disorders due to brain disease,		
F07	damage, and dysfunction	5	0.1%
	Unspecified organic or		
F09	symptomatic mental disorder	0	0.0%
Total		7756	

Table 6.9 shows that among elderly patients with diabetes and with ICD 10 (F30-F39), 88.2% of the patients had depressive episodes. Due to unhealthy diet, poor medication adherence, and low physical activity, patients with major depression were found to have higher blood sugar levels because it is harder for them to maintain healthy behaviours (Lin et al., 2004). A meta-analysis also confirms the strong association between complications of diabetes and depression (de Groot et al., 2001).

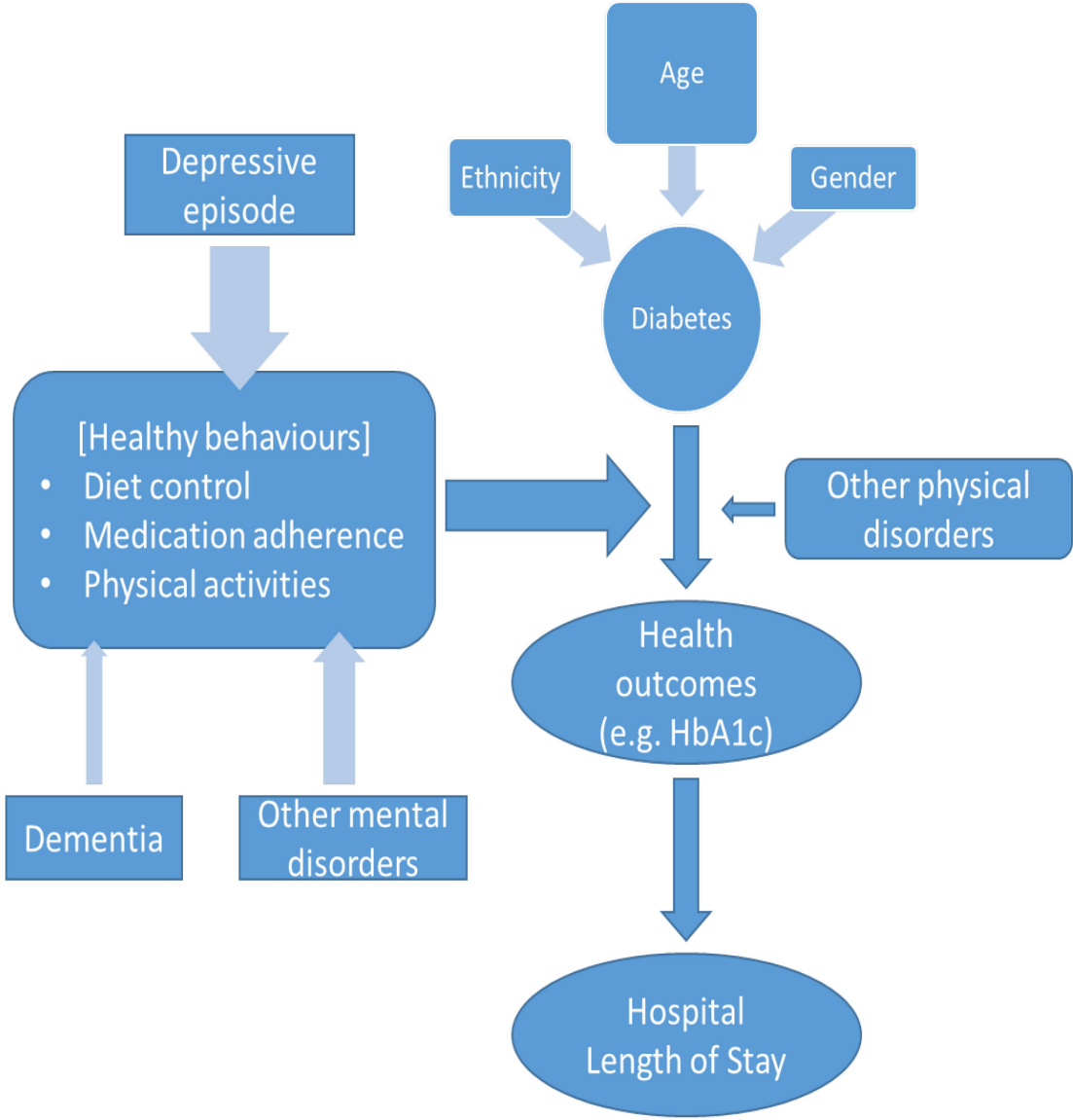
According to Table 6.7, the impact of the depressive episode on patient's diabetes self-management behaviours is stronger than the impact of dementia. These phenomena might be due to patients with depression tend to have more comorbidities or other non-communicable diseases.

Table 6. 9 The diagnoses frequency within F30-F39 among diabetic elderly in England (2010-2013)

ICD Code	Diagnosis	Frequency	Percentage
F30	Manic episode	10	0.4%
F31	Bipolar affective disorder	259	9.3%
F32	Depressive episode	2447	88.2%
F33	Recurrent depressive disorder	41	1.5%
	Persistent mood [affective]		
F34	disorders	6	0.2%
F38	Other mood [affective] disorders	6	0.2%
	Unspecified mood [affective]		
F39	disorder	6	0.2%
Total		2775	

Although mental disorders cannot have direct pathological interactions with diabetes, due to unhealthy health behaviours and bad medications adherence among patients with diabetes, poor blood sugar control is more likely. Because of poor blood sugar control and high initial glycated haemoglobin levels, complications of diabetes are higher in patients with mental disorders than patients without mental disorders. In these circumstances, patients are likely to stay longer in the hospital.

Figure 6. 8 The possible mechanism of the association between mental/ physical disorders and hospital length of stay



6.4.2 Strengths & Limitations

There are only a few studies reported the impact of the presence of physical or mental disorders on hospital length of stay among patients with diabetes. This chapter provides the quantified evidence that diabetic elderly patients with the presence of physical disorders can have a greater risk for longer hospital length of stay, furthermore, diabetic elderly patients with the presence of mental disorders can even stay longer in the hospital than diabetic elderly patients with physical disorders.

The actual blood sugar levels of patients cannot be obtained from HES data. Hence, the severity of diabetes and the levels of diabetes control cannot be examined in this study. This dataset also cannot present the severity of patients' physical or mental disorders. The English IMD was used as the indicator of patients' socioeconomic status, but IMD was provided at the residential area level, not at the patient level. Hence, IMD might not be truly present the exact socioeconomic status of patients.

According to the Methodist Homes (MHA) report, most older adults live in their own homes. Nevertheless, there is still a certain percentage of older people living in specialist retirement housing or

care homes (4% of people over 65; 15% of people over 85). Moreover, among the elderly living in care homes, up to 40% of the elderly suffer from dementia. It means that in the IMD data, a small number of older adults come from geographical clusters.

All the possible confounding factors that I can obtain from HES data were all put into statistical models to be controlled. However, there might be some other confounding factors that should be controlled but were not recorded in HES dataset.

6.5 SUMMARY

Few studies have examined the impact on hospital length of stay of physical or mental disorders among patients with diabetes. This chapter provides evidence that among diabetic elderly patients that the presence of physical disorders leads to having a greater risk for longer hospital length of stay. Patients with mental disorders can even higher risk to stay longer than patients with physical disorders.

Among patients with mental disorders, the presence of dementia (F00-F03) and depressive episodes (F32) have the strongest associations with greater risk for longer hospital length of stay. Age (the older the higher IRR), gender (male), and ethnicity (white people) are also important factors for elderly patients with diabetes to have a higher risk to stay longer in the hospital. However, socioeconomic inequality did not show a statistically significant association with hospital length of stay in this study.

Chapter 7. The impact of physical and mental comorbidities on in- hospital mortality among elderly patients with diabetes

7.1 Introduction

7.1.1 Mortality: a key health indicator for diabetes care

The 65 years old and above population in Europe (EU-28) on January 1st 2016 was estimated as 19.2 % of the whole EU population. Because of an ageing society, the prevalence of type 2 diabetes now in Europe is increasing. But it is not just type 2 diabetes that is a significant issue; the prevalence of type 1 diabetes is also increasing around the world (You and Henneberg, 2016). Since the prevalence of type 1 diabetes in Europe is the highest among the continents, along with the prevalence of type 2 diabetes in Europe increasing due to the ageing population, type 1 and type 2 diabetes are both significant health care issues in Europe, and better disease monitoring and management are necessary.

In order to provide a better policy making, good health indicators to help policy makers to evaluate, estimate, and monitor the health care system are important. Among the health indicators, mortality indicators are the most commonly used tools to measure the general health status of a population. Mortality indicators are also very good measurements with which to compare health care quality among countries (Larson and Mercer, 2004).

7.1.2 Diabetes plays an important role in mortality among the elderly in the UK

Diabetes and complications due to diabetes are one of the leading causes of

premature death around the world. According to UK government reports, patients with type 2 diabetes will die 6 years earlier than patients without diabetes. Furthermore, cancer, heart disease, stroke, lung disease, and liver disease are the five major cause of premature death in England. Both heart disease and stroke are both classified as cardiovascular disease and are closely related to diabetes. Men with metabolic syndrome can have higher mortality in both cardiovascular disease (2.6-3.0 times higher) and all-cause mortality (1.9-2.1 times higher) (Lakka et al., 2002).

It is very difficult to estimate the exact number of deaths around the world due to a lack of diabetes mortality data. However, according to the World Health Organization (WHO) 2016 global report on diabetes and some other studies, the possible number of death due to diabetes is around 1.5 million to 5 million worldwide (Organization, 2016b). The WHO report also mentioned that the leading global top three risk factors for premature death are high blood pressure (13%), tobacco use (9%) and high blood glucose (6%) respectively, irrespective of socioeconomics group (Organization, 2009).

In Europe, It was estimated that around 450,000 elderly patients died due to diabetes in 2015. The 2016 WHO Diabetes country profiles showed that among elderly people (age 70+) in the UK, the number of diabetes deaths is 2170 (males) and 2750 (females), as well as the number of deaths attributable to high blood glucose, is 8240 (males) and 9350 (females). The proportional mortality of all age's total deaths in the UK, Cardiovascular diseases is number one (31%), diabetes is also the contributing factor for cardiovascular diseases (Organization, 2016a).

The major complications of diabetes mostly arise from damage to blood vessels. This damage can cause several non-communicable diseases; such as cardiovascular disease (e.g. coronary artery disease) and kidney disease (e.g. diabetic nephropathy). These complications can eventually lead to a heart attack and kidney failure, and increase mortality in people with diabetes.

In previous literature reviews and systematic reviews, just a few studies have reported the impact of the presence of other physical or mental disorders on mortality in patients with diabetes, and only very limited studies used national-level data. In this chapter, I used national-level data and quantified the impact of physical or mental disorders on mortality among elderly patients with type 1 or type 2 diabetes to understand the actual impact of the presence of other physical and mental health disorders on mortality of elderly patients with diabetes. Further mental disorders subgroup analyses were completed to identify the major mental disorders that increase mortality among elderly patients with diabetes.

7.2 Methods

7.2.1 Data Sources

As in Chapter 6, this is a cross-sectional study using the Hospital Episode Statistics (HES) database; including the English Index of Multiple Deprivation (IMD). My study periods were during the financial years of 2011-12, 2012-13, and 2013-14 (April 2011 to March 2014). Only patients who were at least 65 years old with 1st hospital admission diagnosis as diabetes (ICD-10 codes: E10 – E14) were included. In total, 83,301 patients were included in this study.

7.2.2 The outcome variable (In-hospital mortality)

The main outcome variable of the study is in-hospital mortality. In the HES database, patients where the method of discharge was labelled as “Died” were considered as in-hospital deaths.

7.2.3 Main covariates (Disease category)

In the HES database, each episode or spell can record up to 20 diagnoses. The first diagnosis is the main reason or diagnosis for patients' current hospitalisation and the first diagnosis of this patient should be diabetes. The rest of the diagnoses were considered as comorbidities. Patients having diabetes only without suffering from other comorbidities were classified as the reference group in this study.

7.2.3.1 Primary objective: Physical comorbidities, Mental comorbidities, or None comorbidities (3 groups)

The first variable assigns patients into one of the three groups. This is to examine the impact of the presence of physical or mental comorbidities on mortality in elderly patients with diabetes to differentiate the actual impact of mental or physical disorders on these patients. The second variable assigns patients into one of the six groups. This is to further examine the impact of the presence of frequent mental comorbidities among patients with diabetes

- Group 1 was the reference group, and included elderly patients with type 1 or type 2 diabetes but without any other diseases (Labelled as “DM only”)
- Group 2 included elderly patients with type 1 or type 2 diabetes combined with physical disorders (Labelled as “DM + physical (no mental/no ICD F code)”)
- Group 3 included elderly patients with type 1 or type 2 diabetes combined with mental disorders (Labelled as “DM + Physical + Mental (has ICD F code)”).

7.2.3.2 Secondary objective: The impact of major mental comorbidities (6 groups)

The second variable assigns patients into one of the six groups for the secondary analysis. Group 3 in the first analysis were further divided into four different subgroups. The classification of mental disorders was made using the ICD-10 Classification of Mental and Behavioural Disorders. Diagnosis F00-F09, F10-F19, F30-F39 were specifically picked to be grouped because of high frequency in my study and because these three mental diagnoses are major public mental health issues globally.

- Group 1, as the reference group, for elderly patients with type 1 or type 2 diabetes only and without any other diseases; (Labelled as “DM only”);
- Group 2, for elderly patients with type 1 or type 2 diabetes combine with physical disorders (Labelled as “DM + physical (no mental/no ICD F code)”);

- Group 3, for elderly patients with type 1 or type 2 diabetes combine with organic, including symptomatic, mental disorders: (Labelled as “DM + Mental Disorders (F00-F09)”);
- Group 4, for elderly patients with type 1 or type 2 diabetes combine with mental and behavioural disorders due to psychoactive substance use (Labelled as “DM + Mental Disorders (F10-F19)”);
- Group 5, for elderly patients with type 1 or type 2 diabetes combine with mood affective disorders (Labelled as “DM + Mental Disorders (F30-F39)”);
- Group 6, for elderly patients with type 1 or type 2 diabetes combine with other mental disorders which are not listed above (Labelled as “DM + Mental Disorders (Others)”)

Table 7. 1 The frequency of mental disorders among elderly patients with diabetes in England from 2011-2013 (n=15595)

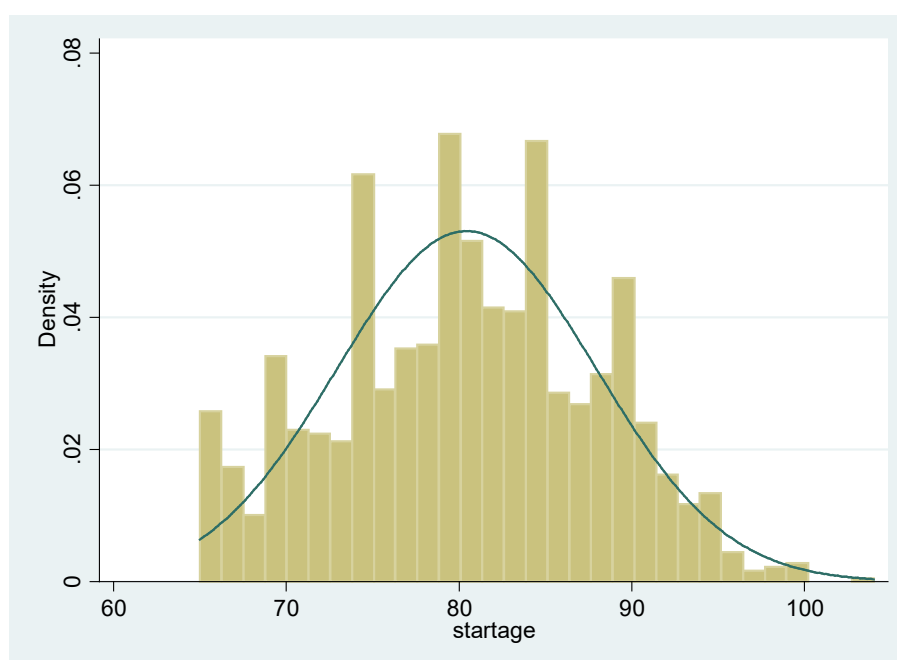
n	ICD 10 Code	Mental Disorder Diagnosis
775		
6	F00-F09	Organic, including symptomatic, mental disorders
323		
2	F10-F19	Mental and behavioural disorders due to psychoactive substance use
599	F20-F29	Schizophrenia, schizotypal and delusional disorders
277		
5	F30-F39	Mood [affective] disorders
669	F40-F48	Neurotic, stress-related and somatoform disorders
		Behavioural syndromes associated with physiological disturbances
20	F50-F59	and physical factors
68	F60-F69	Disorders of adult personality and behaviour
38	F70-F79	Mental retardation
405	F80-F89	Disorders of psychological development
		Behavioural and emotional disorders with onset usually occurring in
13	F90-F98	childhood and adolescence
20	F99	Unspecified mental disorder

7.2.4 Other covariates

7.2.4.1 Age, Gender and Ethnicity

I divided the study population into five age bands (65 – 69 years old, 70 – 74 years old, 75 – 79 years old, 80 – 84 years old and ≥ 85 years old). Patients with unspecified gender were excluded. HES provides 18 categories for ethnicity (British, Irish, Other White backgrounds, Indian, Pakistani/Bangladeshi, Other Asian backgrounds, Caribbean, African, Other Black backgrounds, Chinese, Others, Not stated, Not known). I classified patients into four broad ethnic groups (White, Black, Asian, and Mixed or Other). British, Irish, and Other White background were put into the white group; Indian, Pakistani/Bangladeshi, Other Asian background and Chinese were classified in the Asian group; Caribbean, African, and Other Black background were in the black group. Mixed, other ethnic groups, not known and not stated patients were put in the Mixed or Others group.

Figure 7. 1 The age distribution of elderly patients with diabetes who died in the hospital between 2011-2013 in England (n=1418)



7.2.4.2 Socioeconomic inequalities in mortality

The impact of socioeconomic status on patients' health has been widely addressed in previous studies. Many studies conducted in European countries also confirm that socioeconomic inequalities were a significant factor for mortality of patients (Mackenbach et al., 2003, Mackenbach et al., 1997, Huisman et al., 2004). To measure the socioeconomic status of the patients, the same as Chapter 6, the English IMD was used as the indicator to describe the relative deprivation of this area compared to the others. The overall IMD score is generated based on seven individual domains. The domains are weighted as following: Income (22.5%), Employment (22.5%), Health Deprivation and Disability (13.5%), Education, Skills and Training (13.5%), Barriers to Housing and Services (9.3%), Crime (9.3%), and Living Environment (9.3%). IMD was widely used in many studies to discover the association between socioeconomic deprivations and health (Woods et al., 2005, Coleman et al., 2004, Shack et al., 2008).

7.2.5 Statistical analysis

I used data from 2011-2014, three financial years (April 2011 to March 2013). Missing data (620 patients without IMD data) were excluded in adjusted models. The number of eligible elderly patients were given in each table. Patients were sub-grouped by age (65 – 69 years old, 70 – 74 years old, 75 – 79 years old, 80 – 84 years old and ≥ 85 years old), gender (male and female), ethnicity (White, Black, Asian, and Mixed or Other) and quintiles of IMD based on patients' postcodes of residence. The actual number of elderly patients in each subgroup was calculated as well as the percentage in the whole study population. In each subgroup, patients were also sub-grouped

by the main covariate to realise the mortality distribution in the death group or non-death group.

To understand the unadjusted mortality differences between population subgroups by age (five age groups), gender (male and female), ethnicity (White, Black, Asian, and Mixed or Other), and IMD (quintiles), I used two-tailed z-tests to examine for proportions as mortality was a binary variable. On the other hand, to compare the means on age between mortality and non-mortality elderly patients with diabetes in England (both groups are normally distributed), I used two independent samples t-test to exam both groups.

The outcome variable of all logistic regression models was mortality. The main covariate of this study was the disease category (3 groups or 6 groups), and the other covariates were the patient's age, gender, ethnicity, and IMD. Unadjusted and adjusted models were performed respectively. In the unadjusted logistic regression models, only one covariate (one of the following covariates: disease category, patient's age, gender, ethnicity, and IMD) was put into the models without including other covariates. In the adjusted regression models, all the covariates (disease category, patient's age, gender, ethnicity, and IMD) were all put into the models at the same time. To make the results of each model can be easily understood, coefficients were converted to odds ratios (OR); 95% confidence intervals obtained from models are presented in the tables.

Because the outcome variable, mortality, was binary, I built several multilevel logistic regression models to examine (primary objective) the associations between in-hospital mortality and the presence of physical or mental comorbidities and other potential predictors; (secondary objective)

stratified analyses by subgroups of mental disorders were conducted to understand the associations between in-hospital mortality and the presence major mental comorbidities (Mental Disorders (F00-F09); Mental Disorders (F10-F19); Mental Disorders (F30-F39)).

To calculate the impact of the presence of physical and mental comorbidities, disease category was put into each logistic model. Since age, gender, ethnicity, and IMD were all necessary variables, the covariates above were all put into models. In each model, disease category was tested to exam the difference between each patient group and the reference group was statistically significant. In unadjusted models, since the outcome variable is binary, simple logistic regression was used. In adjusted models, due to having a dichotomous dependent variable and more than two categorical independent variables, factorial logistic regression was used in my study. Tests for examining the effect of interactions between independent variables in adjusted models were performed to understand the statistical significance of the actual overall effect of interactions.

Statistical analysis was conducted using Stata (version 12.1).

7.3 Results

Table 7.2 provides the descriptive statistics of patients. The entire study period is from 2011-12 to 2013-14 financial years (April 2011 to March 2013) in England. A sum of 83,301 patients had diabetes mellitus as the primary hospital admission diagnosis, where at the date of admission, the patient's age was above 65 years and over. There are 46,221 male patients and 37,080 female patients who met the selection criteria. In the age group 65-69, 70-

74, and 75-79, all have more than 18,000 patients. Only 12,214 patients were 85 years old or over. A total of 1,418 patients who died in hospital. The mean age of patients with diabetes and died in the hospitals is 80.44 years old, the standard deviation was 7.51, and the maximum age is 104 years old (Fig 7.1).

7.3.1 Characteristics of the study population

7.3.1.1 Gender, Ethnicity, IMD, and Mortality

The characteristics of patients in the death group and non-death group are shown in Table 7.2. The proportion of men was higher than women in the total study population, as well as in both death group and non-death group, but there was not statistically different from the gender proportion between death group and non-death group ($p=0.672$).

White is the major ethnicity of this study (84.5%) and is followed by Asian (4.91%) and Black (4.83%). The proportion of White mortality is 1.8%, higher than both Asian (1.0%) and Black (1.0%). There is also a statistically significant difference in ethnicity proportion between death group and non-death group ($p=0.036$).

Patients were well divided into deprivation quintile in this study. In both death and non-death groups, the IMD quintile has a similar distribution. There is no statistically significant IMD quintile proportion difference between death group and non-death group.

Table 7. 2 Characteristics of elderly patients with diabetes who had been admitted to a hospital in England, April 2010 to March 2013 (N=83,301)

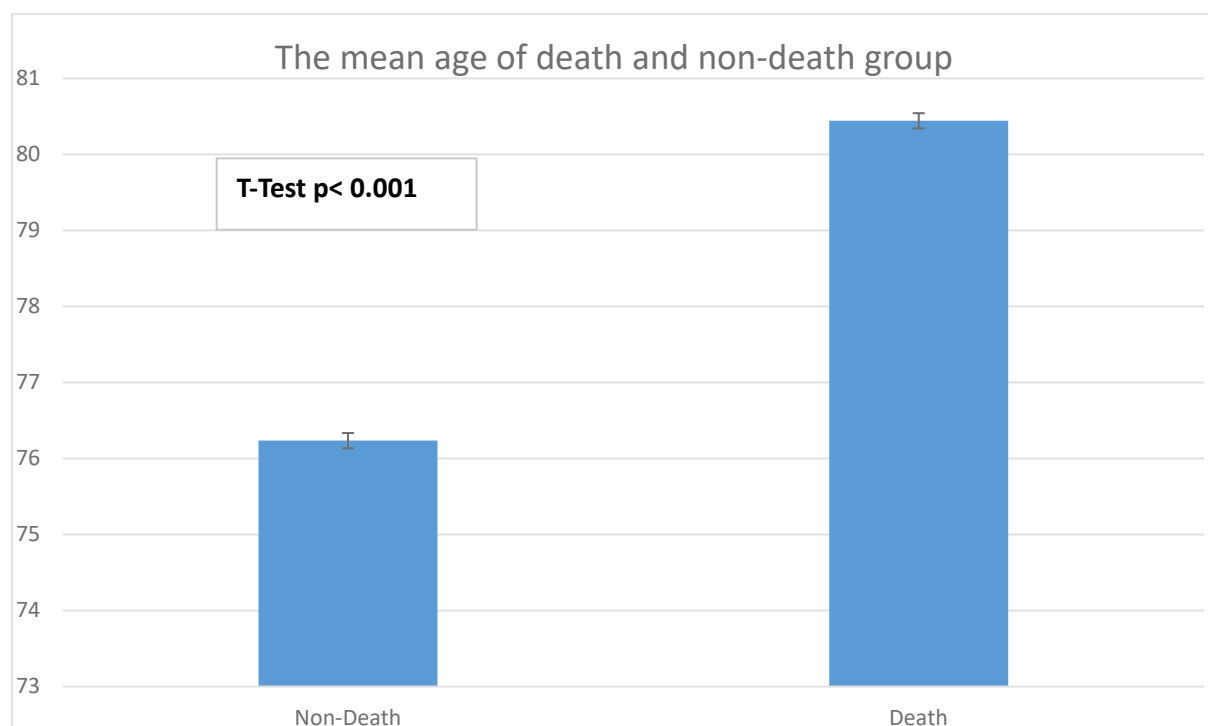
	n	%	Non-Death	Death	Non-Death (%)	Death (%)	Z test P Value
Gender							
Male ^a	46,221	55.49%	45,450	771	98.3%	1.7%	0.672
Female	37,080	44.51%	36,433	647	98.3%	1.7%	
Age group							
65-69 ^a	18,114	21.75%	17,988	126	99.3%	0.7%	<0.001
70-74	18,576	22.30%	18,380	196	98.9%	1.1%	
75-79	18,500	22.21%	18,198	302	98.4%	1.6%	
80-84	15,897	19.08%	15,540	357	97.8%	2.2%	
>85	12,214	14.66%	11,777	437	96.4%	3.6%	
Ethnicity							
White ^a	70,404	84.52%	69,151	1253	98.2%	1.8%	0.036
Black	4,020	4.83%	3,980	40	99.0%	1.0%	
Asian	4,092	4.91%	4,051	41	99.0%	1.0%	
Mixed or Others ^b	4,785	5.74%	4,701	84	98.2%	1.8%	
IMD quintile							
1 - Least deprived ^a	16,547	19.86%	16,258	289	98.3%	1.7%	0.278
2	16,535	19.85%	16,254	281	98.3%	1.7%	
3	16,540	19.86%	16,248	292	98.2%	1.8%	
4	16,529	19.84%	16,257	272	98.4%	1.6%	
5 - Most deprived	16,530	19.84%	16,257	273	98.3%	1.7%	
Total	83,301		81,883	1,418			

Notes: N=number eligible; n=number in each group; Death=Patient who was discharged from the hospital because of death; IMD=index of multiple deprivation; ^a Reference group. ^b Others - mixed background (White and Black Caribbean, White and Black African, White and Asian, Any other mixed background) and other ethnic group.

7.3.1.2 Age and Mortality

Nearly 15% of patients were more than 85 years old, and around 44% of patients are under 75 years old. Table 7.2 shows that from the 65-69 years old group to the 85 years old group, the proportion of deaths in each group is steadily increasing (0.7%, 1.1%, 1.6%, 2.2% and 3.6 %). There is a statistical difference in age proportion between death and non-death group ($p < 0.001$). The mean age of death group is 80.44 years old, 4.21 years older than the non-death group (76.23 years old). Fig 7.2 shows the statistically significant mean age difference between death and non-death group in ($p < 0.001$).

Figure 7. 2 The mean age difference between mortality and non-mortality elderly patients with diabetes in England (2010-2013), N=83,301



7.3.2 Regression modelling (By Disease category)

7.3.2.1 Physical comorbidities, Mental comorbidities, or None comorbidities (3 groups)

7.3.2.1.1 Factors related to in-hospital mortality in elderly patients with diabetes

Table 7.3 shows the results of unadjusted logistic regression analysis on in-hospital mortality of elderly patients with diabetes. Age, ethnicity, and grouping were all significantly associated with in-hospital mortality in this model. Only gender and IMD group did not show a statistical association with in-hospital mortality. The oldest patients had the highest in-hospital mortality, as expected. The oldest group, 85 years old and above group, has 5.3 times higher mortality than 65-69 years old group (OR: 5.3, 95% CI: 4.34 to 6.47). The OR for the in-hospital mortality among 80-84 years old group, 75-79 years old group, and 70-74 years old group were 3.28, 2.37, and 1.52 respectively. Among different ethnicities, both Asians (OR: 0.56, 0.41 to 0.76) and Black (OR: 0.55, 0.40 to 0.76) had significantly lower in-hospital mortality than Whites.

7.3.2.1.2 Disease category and in-hospital mortality

Most surprisingly, the presence of mental comorbidities in elderly patients with diabetes resulted in significantly higher in-hospital mortality which was 14.01 times higher than elderly patients with diabetes only (OR: 14.01, 95%CI: 5.23 to 37.56). On the other hand, diabetic patients with physical disorders had 6.42 times higher in-hospital mortality (OR: 6.42, 95%CI: 2.4 to 17.17) compared to patients with diabetes only. The presence of mental comorbidities showed a much stronger impact than physical comorbidities on in-hospital mortality.

Table 7. 3 Unadjusted logistic regression analysis on in-hospital mortality among elderly patients with diabetes in England (2010-2013), N=83301

In hospital mortality (Un-Adjusted)					
	n	% population	OR	95% CI	P Value
Gender	83301				
Male ^a	46,221	55.49	1.00		
Female	37,080	44.51	1.05	(0.94, 1.16)	0.39
Age group	83301				
65-69 ^a	18,114	21.75	1.00		
70-74	18,576	22.30	1.52	(1.21, 1.90)	<0.001
75-79	18,500	22.21	2.37	(1.92, 2.91)	<0.001
80-84	15,897	19.08	3.28	(2.67, 4.02)	<0.001
>85	12,214	14.66	5.30	(4.33, 6.46)	<0.001
Ethnicity	83301				
White ^a	70,404	84.52	1.00		
Black	4,020	4.83	0.55	(0.40, 0.76)	<0.001
Asian	4,092	4.91	0.56	(0.40, 0.76)	<0.001
Mixed or Others ^b	4,785	5.74	0.99	(0.78, 1.23)	0.90
Disease category	83301				
Group 1: DM Only ^a	1,750	2.10	1.00		
Group 2: DM+physical (no mental)	67,631	81.19	6.42	(2.40, 17.1)	<0.001
Group 3: DM+mental or DM+mental+physical	13,920	16.71	14.01	(5.22, 37.5)	<0.001
IMD quintile	82681				
1 - Least deprived ^a	16,547	20.01	1.00		
2	16,535	20.00	0.97	(0.82, 1.14)	0.74
3	16,540	20.00	1.01	(0.85, 1.19)	0.90
4	16,529	19.99	0.94	(0.79, 1.11)	0.48
5 - Most deprived	16,530	19.99	0.94	(0.79, 1.11)	0.50
Total	83,301				

Notes: n=number eligible; OR=odds ratio; 95%CI= 95% confidence interval; DM=Diabetes Mellitus; physical=physical disorders other than diabetes; mental=mental disorders; IMD=index of multiple deprivation; a Reference group. b Others - mixed background (White and Black Caribbean, White and Black African, White and Asian, Any other mixed background) and other ethnic group.

Gender, age, ethnicity, and disease category show significantly associated with in-hospital mortality in the adjusted factorial logistic regression model (Table 7.4). Female sex was a protecting factor in this study, with 14% less in-hospital mortality than among males (AOR: 0.86, 95%CI: 0.77 to 0.96). As in the unadjusted regression model, unsurprisingly, the older the patients, the higher the in-hospital mortality. The oldest group, 85 years old and above, has 4.93 times higher mortality than 65-69 years old group (AOR: 4.93, 95%CI: 4.02 to 6.03). The adjusted OR among 80-84 years old group, 75-79 years old group and 70-74 years old group were 3.19, 2.34, and 1.55 respectively. Both Asian (AOR: 0.65, 95%CI: 0.48 to 0.89) and Black (AOR: 0.52, 0.37 to 0.71) had lower in-hospital mortality compared to White. IMD group did not have a significant association with in-hospital mortality.

The adjusted model showed a significant association that the presence of mental comorbidities in diabetic elderly patients had high adjusted odds ratio in this model (AOR: 10.96, 95%CI: 4.09 to 29.4), 10.96 times higher in-hospital mortality rate compared to elderly patients with diabetes only. Likewise, diabetic patients with physical comorbidities also had high in-hospital mortality (AOR: 5.65, 95%CI: 2.11 to 15.11) compared to elderly patients with diabetes only. Mental comorbidities played a much stronger role in increasing in-hospital mortality compared to physical comorbidities.

Table 7. 4 Adjusted multivariate logistic regression analysis on in-hospital mortality among diabetic elderly in England (2010-2013), n=82681

In hospital mortality (Adjusted)					
	n	% population	AOR	95% CI	P Value
Gender					
Male ^a	45,886	55.50	1.00		
Female	36,795	44.50	0.86	(0.76, 0.95)	0.01
Age group					
65-69 ^a	17,953	21.71	1.00		
70-74	18,434	22.30	1.55	(1.23, 1.93)	<0.001
75-79	18,396	22.25	2.34	(1.89, 2.88)	<0.001
80-84	15,782	19.09	3.19	(2.59, 3.91)	<0.001
>85	12,116	14.65	4.93	(4.02, 6.03)	<0.001
Ethnicity					
White ^a	69,982	84.64	1.00		
Black	3,964	4.79	0.52	(0.37, 0.71)	<0.001
Asian	4,041	4.89	0.65	(0.47, 0.89)	0.01
Mixed or Others ^b	4,694	5.68	1.05	(0.83, 1.31)	0.68
Disease category					
Group 1: DM Only ^a	1,723	2.08	1.00		
Group 2: DM+physical (no mental)	67,149	81.21	5.65	(2.11, 15.1)	<0.001
Group 3: DM+mental or DM+mental + physical	13,809	16.70	10.9 6	(4.08, 29.3)	<0.001
IMD quintile					
1 - Least deprived ^a	16,547	20.01	1.00		
2	16,535	20.00	1.00	(0.84, 1.18)	0.97
3	16,540	20.00	1.10	(0.92, 1.29)	0.28
4	16,529	19.99	1.05	(0.88, 1.24)	0.55
5 - Most deprived	16,530	19.99	1.12	(0.94, 1.32)	0.19
Total	82,681				

Notes: n=number eligible; AOR=adjusted odds ratio; 95%CI= 95% confidence interval; DM=Diabetes Mellitus; physical=physical disorders other than diabetes; mental=mental disorders; IMD=index of multiple deprivation; a Reference group. b Others - mixed background (White and Black Caribbean, White and Black African, White and Asian, Any other mixed background) and other ethnic group.

7.3.2.2 The impact of major mental comorbidities (6 groups)

From Table 7.4, it is evident that both the presence of physical or mental comorbidities are significantly associated with in-hospital mortality. Patients with mental comorbidities have around 11 times higher in-hospital mortality compared to patients with diabetes only, and patients with physical comorbidities have 5.65 times higher in-hospital mortality. This information shows clearly that mental comorbidities have a stronger impact on in-hospital mortality among elderly patients with diabetes. To understand which mental comorbidity plays a stronger role, subgroup analyses were performed (Table 7.5 & Table 7.6).

The Unadjusted logistic regression model results are presented in Table 7.5. The results clearly show that age, ethnicity, and disease category are all correlated with in-hospital mortality. Age, as expected, has an obvious age-response effect; with the elderly having the highest in-hospital mortality. The oldest group, 85 years old above, has 5.3 times higher in-hospital mortality compared to the youngest group, which is between 65-69 years old (OR: 5.3, 95%CI: 4.33 to 6.46).

Table 7.5 shows that among different ethnic groups, White was in a higher risk category for in-hospital mortality compared to Black 45% less (OR: 0.55, 95%CI: 0.4 to 0.76) and Asian 44% less (OR: 0.56, 95%CI: 0.40 to 0.76). IMD groups, socioeconomic deprivation did not show a statistical difference between groups in this model.

Among different factors in my models, physical and mental comorbidities had significant impacts on in-hospital mortality (Table 7.5). The presence of other physical comorbidities on elderly patients with diabetes resulted in 6.42 times higher in-hospital mortality than those diabetic elderly patients without other physical or mental comorbidities (OR: 6.42, 95%CI: 2.4 to 17.1).

Furthermore, the presence of mental comorbidities on elderly patients with diabetes had a much stronger impact on in-hospital mortality. The presence of mental comorbidities (F00-F09) in elderly patients with diabetes resulted in 20.85 times higher in-hospital mortality compared to the reference group, diabetic elderly patients without other comorbidities (OR: 20.85, 95%CI: 7.76 to 55.9). Surprisingly, the impact of mental comorbidities (F00-F09) on in-hospital mortality was four times stronger than the impact of the oldest age group and three times stronger than for physical comorbidities. Other mental comorbidities, Group 4 (F10-F19) and Group 5 (F30-F39) both showed significant statistical associations with in-hospital mortality (Group 4 OR: 5.8; Group 5 OR: 9.71).

Table 7. 5 Unadjusted logistic regression analysis on in-hospital mortality among diabetic elderly in England (2010-2013), N=83301

In hospital mortality (Un-Adjusted)					
	n	% population	OR	95% CI	P Value
Gender	83301				
Male ^a	46,221	55	1.00		
Female	37,080	45	1.05	(0.94, 1.16)	0.39
Age group	83301				
65-69 ^a	18,114	22	1.00		
70-74	18,576	22	1.52	(1.21, 1.90)	<0.001
75-79	18,500	22	2.37	(1.92, 2.91)	<0.001
80-84	15,897	19	3.28	(2.67, 4.02)	<0.001
>85	12,214	15	5.30	(4.33, 6.46)	<0.001
Ethnicity	83301				
White ^a	70,404	85	1.00		
Black	4,020	5	0.55	(0.40, 0.76)	<0.001
Asian	4,092	5	0.56	(0.40, 0.76)	<0.001
Mixed or Others ^b	4,785	6	0.99	(0.78, 1.23)	0.90
Disease category	83301				
Group 1: DM only (without any Mental or Physical disorder) ^a	1,750	2	1.00		
Group 2: DM+Physical Disorders (no mental disorder)	67,631	81	6.42	(2.40, 17.1)	<0.001
Group 3: DM+Mental Disorders (F00-F09)	7,064	8	20.85	(7.76, 55.9)	<0.001
Group 4: DM+Mental Disorders (F10-F19)	2,974	4	5.80	(2.06, 16.2)	<0.001
Group 5: DM+Mental Disorders (F30-F39)	2,574	3	9.71	(3.51, 26.8)	<0.001
Group 6: DM+Mental Disorders (Others) ^c	1,308	2	5.41	(1.80, 16.2)	<0.001
IMD quintile	82681				
1 - Least deprived ^a	16,547	20	1.00		
2	16,535	20	0.97	(0.82, 1.14)	0.74
3	16,540	20	1.01	(0.85, 1.19)	0.90
4	16,529	20	0.94	(0.79, 1.11)	0.48
5 - Most deprived	16,530	20	0.94	(0.79, 1.11)	0.50
Total	83,301				

Notes: n=number eligible; OR=odds ratio; 95%CI= 95% confidence interval; DM=Diabetes Mellitus; physical=physical disorders other than diabetes; mental=mental disorders; IMD=index of multiple deprivation; a Reference group. b Others - mixed background (White and Black Caribbean, White and Black African, White and Asian, Any other mixed background) and other ethnic group. c Others - F20-F29 & F40-F99

Table 7.6 shows the results of an adjusted factorial logistic regression model from my study. Females had a 15% lower in-hospital mortality, i.e. female sex was a protecting factor. Age was an important risk factor on in-hospital mortality, the age-response effect can be seen in Table 7.6. The oldest group, 85 years old above, not surprisingly had 4.35 times higher in-hospital mortality compared to the youngest group those between 65-69 years old (AOR: 4.35, 95%CI: 3.54 to 5.35).

Adjusted OR of in-hospital mortality among different ethnic groups are described in Table 7.6, Black had 50% lower in-hospital mortality (AOR: 0.50, 95%CI: 0.36 to 0.69) and Asian had 36% lower in-hospital mortality (AOR: 0.64, 95%CI: 0.46 to 0.87). However, among IMD groups, socioeconomic deprivation did not show a statistical difference between groups in adjusted models.

As in the unadjusted models, the most significant results of adjusted models were for Disease category. The presence of physical and mental comorbidities had major impacts on in-hospital mortality in my models. Patients with other physical comorbidities with diabetes had 5.69 times higher in-hospital mortality than those diabetic elderly patients without other physical or mental comorbidities (OR: 5.69, 95%CI: 2.12 to 15.2). Although physical comorbidities showed a strong impact on in-hospital mortality, mental comorbidities had a much higher influence on in-hospital mortality.

The presence of mental comorbidities (F00-F09) on elderly patients with diabetes led to 13.9 times higher in-hospital mortality compared to diabetic elderly patients without other comorbidities (OR: 13.9, 95%CI: 5.16 to 37.3).

Other mental comorbidities, both Group 4 (F10-F19) and Group 5 (F30-F39) had shown significant statistical associations with in-hospital mortality (Group 4 AOR: 6.35; Group 5 AOR: 8.45. Both Group 4&5 had a higher odds ratio than Group 2 (physical comorbidities).

Table 7. 6 Adjusted multivariate logistic regression analysis on in-hospital mortality among diabetic elderly in England (2010-2013), n=82681

In hospital mortality (Adjusted)					
	n	% population	AOR	95% CI	P Value
Gender					
Male ^a	45,886	55.5	1.00		
Female	36,795	44.5	0.85	(0.75, 0.94)	<0.001
Age group					
65-69 ^a	17,953	21.71	1.00		
70-74	18,434	22.3	1.51	(1.20, 1.88)	<0.001
75-79	18,396	22.25	2.19	(1.77, 2.70)	<0.001
80-84	15,782	19.09	2.91	(2.36, 3.57)	<0.001
>85	12,116	14.65	4.35	(3.54, 5.35)	<0.001
Ethnicity					
White ^a	69,982	84.64	1.00		
Black	3,964	4.79	0.50	(0.36, 0.69)	<0.001
Asian	4,041	4.89	0.64	(0.46, 0.87)	0.01
Mixed or Others ^b	4,694	5.68	1.05	(0.83, 1.31)	0.70
Disease category					
Group 1: DM only (without any Mental or Physical disorder) ^a	1,723	2.08	1.00		
Group 2: DM+Physical Disorders (no mental disorder)	67,149	81.21	5.69	(2.12, 15.2)	<0.001
Group 3: DM+Mental Disorders (F00-F09)	7,016	8.49	13.90	(5.16, 37.3)	<0.001
Group 4: DM+Mental Disorders (F10-F19)	2,943	3.56	6.35	(2.26, 17.8)	<0.001
Group 5: DM+Mental Disorders (F30-F39)	2,552	3.09	8.45	(3.05, 23.4)	<0.001
Group 6: DM+Mental Disorders (Others) ^c	1,298	1.57	5.68	(1.89, 17.0)	<0.001
IMD quintile					
1 - Least deprived ^a	16,547	20.01	1.00		
2	16,535	20	1.00	(0.84, 1.18)	0.97
3	16,540	20	1.10	(0.93, 1.30)	0.24
4	16,529	19.99	1.06	(0.89, 1.25)	0.50
5 - Most deprived	16,530	19.99	1.14	(0.95, 1.34)	0.14
Total	82,681				

Notes: n=number eligible; AOR=adjusted odds ratio; 95%CI= 95% confidence interval; DM=Diabetes Mellitus; physical=physical disorders other than diabetes; mental=mental disorders; IMD=index of multiple deprivation; a Reference group. b Others - mixed background (White and Black Caribbean, White and Black African, White and Asian, Any other mixed background) and other ethnic group. c Others - F20-F29 & F40-F99

7.4 Discussion

Because the prevalence of type 1 diabetes in Europe is the highest compared to other continents (You and Henneberg, 2016), and the prevalence of type 2 diabetes in Europe is increasing due to rising rates of obesity and the ageing of the population, type 1 and type 2 diabetes are both significant health care issues in Europe. It is necessary for policymakers to monitor both diseases and to find an efficient way to manage them. Mortality, one of the most commonly used global health indicators, is a suitable measurement to monitor the general health status of a population as well as to compare health care quality among countries (Larson and Mercer, 2004).

UK government studies have reported that type 2 diabetic patients have 6 years shorter life expectancy compared to patients without diabetes. Among the major causes of premature death in England, heart disease and stroke, classified as cardiovascular diseases, are both closely related to diabetes. Similar findings of the association between metabolic syndrome and cardiovascular disease mortality were also reported in several other studies (Lakka et al., 2002). Diabetes complications mostly come from the damage to blood vessels and cause complications such as coronary artery disease and diabetic nephropathy, and can eventually lead to lethal complications like heart attack, and kidney failure.

Because there are just a few articles reporting the impact of the presence of other physical or mental comorbidities on mortality among patients having diabetes by using national-level data, this chapter provides evidence to quantify the actual impact of the presence of other physical and mental

comorbidities on mortality among elderly diabetic patients in England.

The results suggest that patients with male gender, increasing age, white ethnicity and the presence of other physical and mental comorbidities, on average, have higher in-hospital mortality. Unadjusted and adjusted models both provide similar findings.

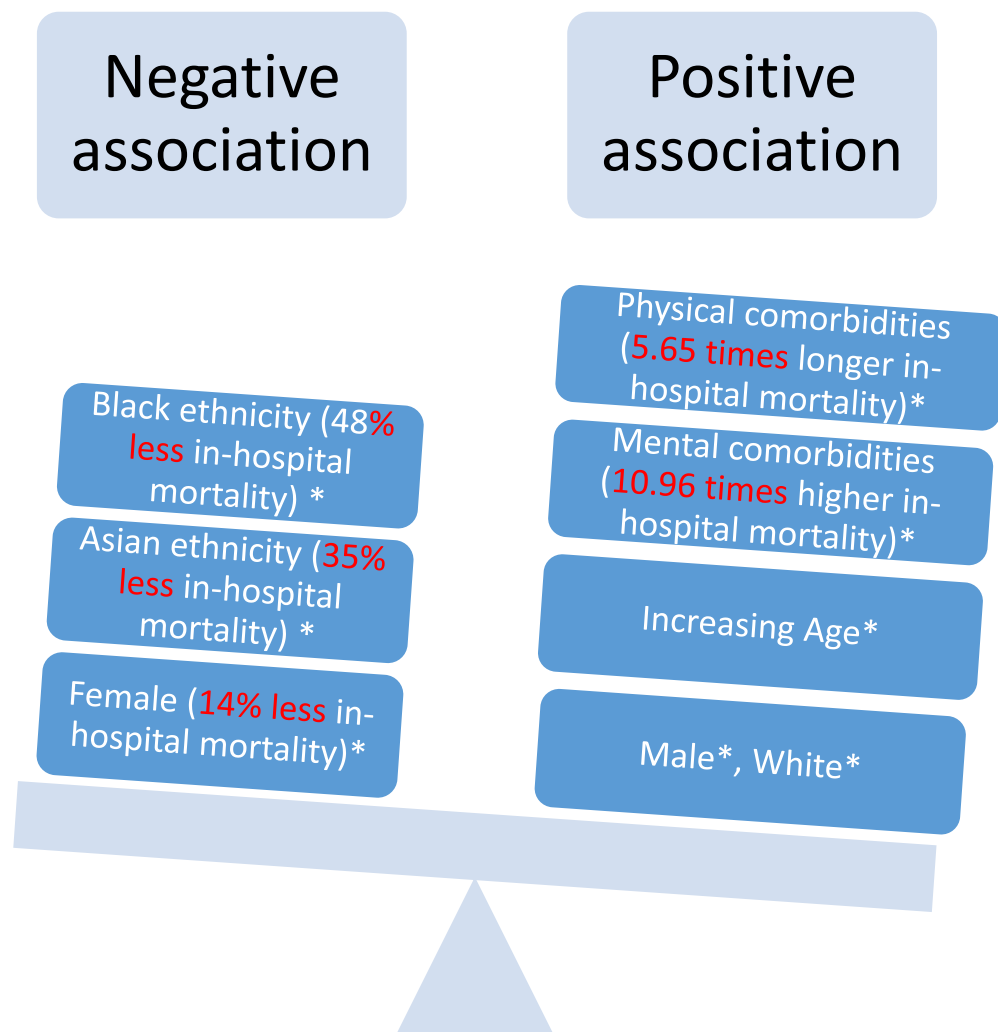
Females had a 15% lower in-hospital mortality than males. A clear age-response effect on in-hospital mortality was present in both unadjusted and adjusted models. Patients with diabetes aged 85 years old or older had 4.35 times higher in-hospital mortality compared to the 65-69 year age group.

Comparing the impacts of all the factors put in the adjusted models, elderly patients having the presence of mental comorbidities had the highest in-hospital mortality (AOR: 10.96, 95%CI: 4.09 to 29.4). Among the mental comorbidities, patients with diabetes and mental disorders (F00-F09: Organic, symptomatic, mental disorders; F10-F19: Mental and behavioural disorders due to psychoactive substance use; F30-F39: Mood [affective] disorders), have much higher in-hospital mortality than diabetic elderly patients having physical comorbidities, statistically significant in both adjusted and unadjusted models. In particular, diabetic elderly patients having organic mental disorders have the highest in-hospital mortality (AOR: 13.9, 95%CI: 5.16 to 37.3).

Diabetic elderly patients having other physical comorbidities had 5.69 times higher in-hospital mortality than diabetic patients without comorbidities ($p < 0.001$); on the other hand, diabetic patients with mental comorbidities (organic mental disorders; mental disorders due to substance use; and

affective disorders), had 13.9 times, 6.35 times, and 8.45 times higher in-hospital mortality than diabetic patients without comorbidities respectively ($p < 0.001$).

Figure 7. 3 Summary diagram of positive or negative association on in-hospital mortality among patients with diabetes (* $p < 0.001$)



Several studies have reported that physical comorbidities can increase mortality in patients with existing chronic diseases (Ording et al., 2016, Gregersen et al., 2017). Understandably, the physical comorbidities can

interact with diabetes, and increase the complexity of disease management, to increase mortality in elderly patients (Olthof et al., 2014). Mental comorbidities and diabetes can be considered as independent diseases without apparent direct physiological or pathological interaction between each other (Balhara, 2011). However, in my study, the presence of mental comorbidities was a much stronger contributing factor to elderly patients' in-hospital mortality than the presence of physical comorbidities (Mental comorbidities AOR: 10.96; physical comorbidities AOR: 5.65).

7.4.1 Possible Explanations & Relation to Existing Literature

Excluding age, gender, comorbidity, and socioeconomic status, longer hospital length of stay in previous studies is related to disease severity, place of hospitalisation, physical functional capacity or performance, specialist consultation (Silva et al., 2009, Marrie and Wu, 2005, Agabiti et al., 2004, Sacks and Pendle, 1998, Huang et al., 2015).

Disease severity is a contributing factor for increasing in-hospital mortality. Poor diabetes control can cause more diabetic comorbidities. In this study, physical comorbidities and mental comorbidities are both significant contributing factors for in-hospital mortality.

Due to hospital size, the number of medical practitioners in each hospital, the number of specialists, and hospital teaching status all vary between hospitals. However, hospital-level factors are discussed in this study.

The impact of elderly patients' physical functions has been widely studied. Patients' physical functional capacity can be considered as a significant predictor for in-hospital mortality (Davis et al.). Patients with cognition or activity of daily living (ADL) impairment had higher mortality (Salive et al.). Diabetic patients with poor blood sugar control are at higher risk of cognition or physical function impairment. This literature supports my findings that those diabetic elderly patients with the presence of physical or mental comorbidities have higher in-hospital mortality.

Patients under management by different specialists can have statistically significant differences in in-hospital mortality. Patients with complications can be transferred to different departments. Those departments receiving patients with more severe complications will inevitably have higher mortality than departments accepting patients with less-lethal complications. However, this factor, specialist consultation was not discussed in this chapter, but the impact of specialist consultation will be reported in the next chapter.

Table 7.6 shows that diabetic patients with mental disorders (ICD 10: F00-F09) had the highest odds ratio for in-hospital mortality. In my study, Table 7.7 shows that among elderly patients with diabetes and ICD 10 (F00-F09), 89.9% of patients had dementia. The major complications of diabetes are mostly due to the damage to blood vessels and can lead to conditions such as coronary artery disease or diabetic nephropathy, and finally can lead to a heart attack or kidney failure. Many studies reported that the presence of cardiovascular diseases and renal diseases were associated with higher mortality among patients with diabetes (Tseng, 2004, McEwen et al., 2007).

Diabetes complications are closely related to blood sugar control. A healthy diet, compliance with medications, and physical activity are three significant factors needed for blood sugar control. However, if patients with diabetes do not have healthy behaviours such as a healthy diet, good medication compliance, and adequate physical activity, it can be difficult to control their blood sugar level and increase the risk of diabetic complications. Among diabetic elderly patients with dementia, it is challenging to have a proper diet because of the decline in patients' cognitive function. Patients with cognitive impairment may not be able to remember to eat food which is suitable for patients with diabetes. Furthermore, some studies reported that patients with dementia had low medication adherence, and the presence of dementia was associated with poor blood sugar control for diabetic patients (Arlt et al., 2008).

Because of dementia, patients can have cognition or memory impairment (the key factor) and both are associated with poor medication adherence. Memory impairment and forgetfulness were reported in some studies as important factors for low medical adherence (Pettinger et al., 1999, Nikolaus et al., 1996). Medication misuse can be another important issue in patients with dementia. Some studies also reported that patients with dementia can have difficulties with drug naming or recalling the dosage (Blenkiron, 1996, Nikolaus et al., 1996).

Physical activity has been associated with blood sugar control in many studies (Reisi et al., 2017, Jiamjarasrangsi et al., 2014). However, patients having dementia tend to be less physically active than patients with normal cognitive function (Laurin et al., 2001).

This evidence implies a possible explanation: because of memory or cognition impairments, patients with dementia have poor diet control, bad medication adherence, and less physical activity. These three reasons lead to poor blood sugar control among patients with dementia and are related to the higher possibility of obtaining diabetic complications and finally increase the mortality of patients with diabetes.

Table 7. 7 The diagnoses frequency within F00-F09 among diabetic elderly in England (2010-2013)

ICD			
Code	Diagnosis	Frequency	Percentage
F00	Dementia in Alzheimer's disease	697	9.0%
F01	Vascular dementia	2007	25.9%
	Dementia in other diseases		
F02	classified elsewhere	120	1.5%
F03	Unspecified dementia	4151	53.5%
	Organic amnesic syndrome, not induced by alcohol and other		
F04	psychoactive substances	1	0.0%
	Delirium, not induced by alcohol		
F05	and other psychoactive substances	518	6.7%
	Other mental disorders due to brain damage and dysfunction and		
F06	to physical disease	257	3.3%
	Personality and behavioural disorders due to brain disease,		
F07	damage and dysfunction	5	0.1%
	Unspecified organic or		
F09	symptomatic mental disorder	0	0.0%
Total		7756	

Diabetic patients with mental disorders (ICD 10: F30-F39) were also found to have higher in-hospital mortality (Table 7.6). Table 7.8 shows that among

elderly diabetic patients with ICD 10 (F30-F39), 88.2% of patients had depressive episodes. Patients with depressive episodes are more likely to have unhealthy diets, poor medication adherence, and low physical activity, which will lead to higher blood sugar levels among these patients. Line et al. reported that patients having major depression were found to have higher blood sugar levels because it is harder for them to maintain healthy behaviours (Lin et al., 2004). A meta-analysis also confirms the strong association between complications of diabetes and depression (de Groot et al., 2001).

According to Table 7.6, the impact of the depressive episode on in-hospital mortality is stronger than the impact of physical disorders. It might imply that patients with depressive episodes have more severe diabetic complications or worse blood sugar control than patients who only have other physical disorders.

Table 7. 8 The diagnoses frequency within F30-F39 among diabetic elderly in England (2010-2013)

ICD			
Code	Diagnosis	Frequency	Percentage
F30	Manic episode	10	0.4%
F31	Bipolar affective disorder	259	9.3%
F32	Depressive episode	2447	88.2%
F33	Recurrent depressive disorder	41	1.5%
	Persistent mood [affective]		
F34	disorders	6	0.2%
F38	Other mood [affective] disorders	6	0.2%
	Unspecified mood [affective]		
F39	disorder	6	0.2%
Total		2775	

7.5 SUMMARY

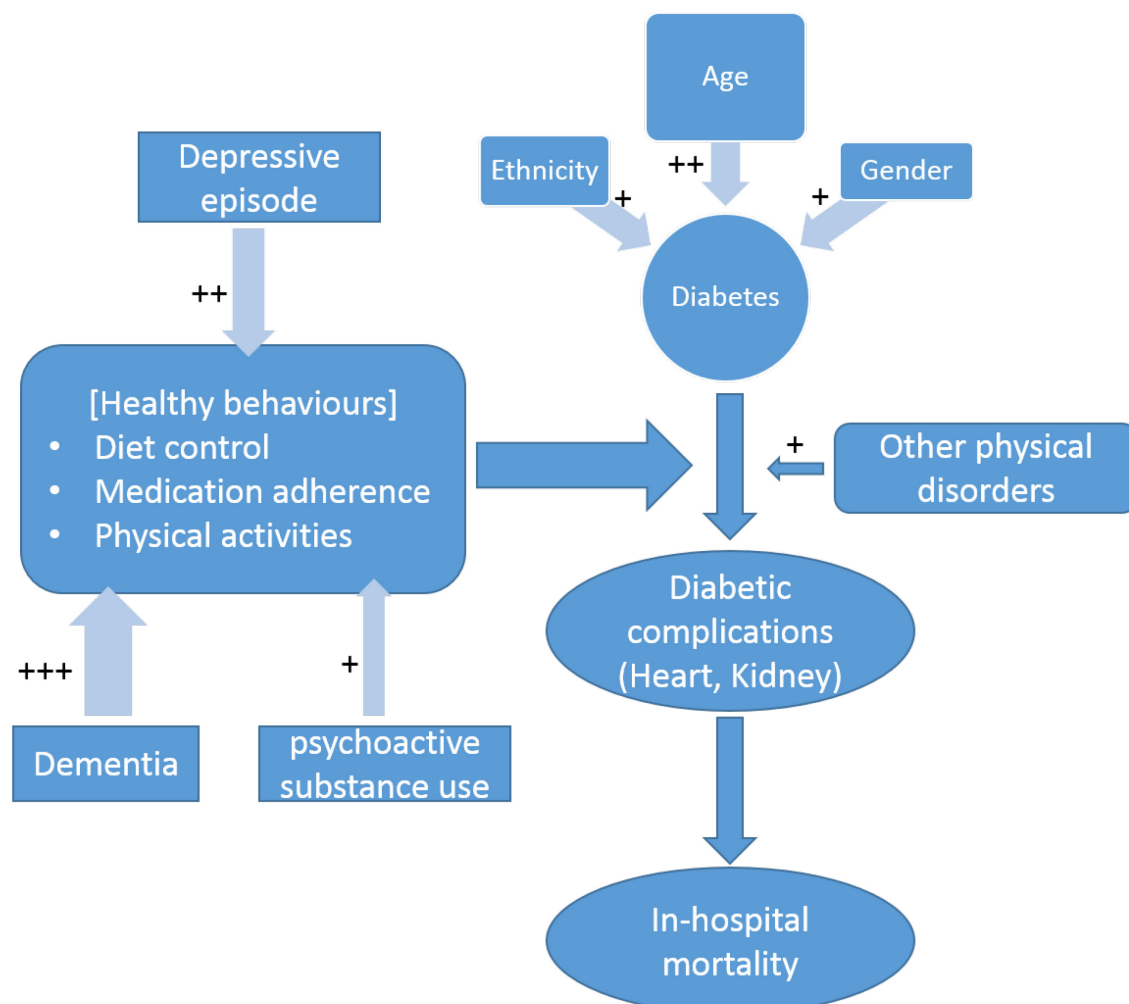
The ageing population is a significant health issue in the UK and Europe. Mortality is a good health indicator to monitor the general health status of the elderly population. The presence of physical or mental comorbidities has important impacts on in-hospital mortality among diabetic patients. However, there are only a few studies that have examined the impact of physical or mental comorbidities on in-hospital mortality among elderly patients with diabetes.

Fig 7.4 describes the possible mechanism of the association between physical or mental comorbidities and in-hospital mortality. Although there are no direct pathological interactions between mental disorders and diabetes, diabetic patients with mental disorders still have the highest in-hospital mortality in this study compared with other factors evaluated. The possible explanations would be an unhealthy diet, poor medication adherence, and less physical activity among diabetic patients with mental comorbidities. Because of poor blood sugar control and high glycated-haemoglobin levels, complications of diabetes are higher in the presence of mental comorbidities than in patients without mental comorbidities. Under these circumstances, patients are likely to have higher in-hospital mortality.

This chapter provides convincing evidence that the presence of physical disorders among elderly patients with diabetes can lead to higher in-hospital mortality. The statistical impact of mental comorbidities on in-hospital mortality is much higher than patients with physical comorbidities or. The presence of dementia (F00-F03) and depressive episodes (F32) among

patients with diabetes have significant associations with in-hospital mortality. Increasing age, gender (male), and ethnicity (white people) also lead to higher in-hospital mortality among elderly patients with diabetes. However, socioeconomic inequality did not show a statistically significant association with in-hospital mortality in this study.

Figure 7. 4 The possible mechanism of the association between mental/physical disorders and in-hospital mortality (+++ means very strong positive impact, ++ means fair positive impact, + means relative weak positive impact)



7.5.1 Limitations

The blood sugar levels of patients with diabetes cannot be obtained from HES data. Hence, the severity of diabetes and the levels of diabetes control cannot be examined in this study. This dataset also cannot assess the severity of patients' physical or mental disorders. The English IMD was used as the indicator of patients' socioeconomic status, but IMD was provided at the residential area level, not at the patient level. IMD might not be truly present the exact socioeconomic status of patients.

According to the MHA report, most older adults live in their own homes. Nevertheless, there are about 4% of people over 65 and 15% of people over 85 living in specialist retirement housing or care homes. Moreover, among the elderly living in care homes, up to 40% of the elderly suffer from dementia. It means that in the IMD data, a small number of older adults come from geographical clusters. It can be the reason why the impact of socioeconomic status difference on in-hospital mortality of older people.

All the possible confounding factors that I can obtain from HES data were all put into statistical models to be controlled. However, there might be some other confounding factors that should be controlled but were not recorded in HES dataset.

Chapter 8. Length of stay in hospital and in-hospital mortality of elderly patients with diabetes in different treatment units

8.1 Introduction

In Chapter 6, I have reported the impact of different factors that can affect hospital length of stay among elderly patients with diabetes. In Chapter 7, I have evaluated the impact of several factors that can increase the risk of in-hospital mortality. However, when patients are treated in different speciality units, receiving different treatments, the same factor may contribute to differing impacts in different treatment units. In this section, we will be devoted to the discussion of whether there are essential factors affecting hospital length of stay or in-hospital mortality when treated with different treatment units.

In different treatment units, due to different admissions criteria, hospitals will receive patients with different characteristics. In this chapter, I will conduct various analyses specifically for the treatment departments in England that admitted the most diabetic elderly (ophthalmology department, general medicine department, diabetic medicine department). Understandably, diabetic elderly receive treatments mainly in two departments of diabetes medicine and general medicine. However, the ophthalmology department is also the first three departments to treat diabetic elderly patients. Therefore, here is a brief description of the statistics on hospitalisation in the ophthalmology departments in England.

According to the Eye health data summary in the 2014 report, approximately 57% of patients in England undergoing surgery are mainly due to cataract surgery. The number of people in this section is about 341,000 in all of England. The second highest cause of hospitalisation in an ophthalmology

ward is that the patient received the relevant surgery due to retina diseases. This part of the population accounted for about 20% of the total number of hospitalisation due to ophthalmology problems, totalling 123,267 episodes (Slade, 2014).

As for the principal primary hospital admission diagnosis, disorders of lens and disorders of the eye accounted for more than 95% of the eye patients in England who were hospitalised. The first place is due to the disorders of the lens (including cataracts), accounting for 59% of the total ophthalmology hospitalisation, followed by other disorders of the eye, and accounting for 36.7% of the hospitalisations.

8.1.1 Diabetes & Lens disorders

Why are patients with diabetes likely to get eye diseases? According to past studies, it is easier for diabetic patients to obtain cataract more than 2-5 times better than those without diabetes. In addition, patients with diabetes will get cataract at a younger age than those without diabetes (Institute, 2015). Another study supported that diabetes is a risk factor on the lens. Patients with posterior sub-capsular cataract (PSC) showed statistically significant associated with diabetes (odds ratio, OR: 1.8) (Rowe et al., 2000).

8.1.2 Diabetes & Retina (Diabetic Macular Edema, DME)

Among patients with either type 1 DM or type 2 DM, long-term increases in blood glucose can cause retinal-microvascular diseases in the eye, called

diabetic retinopathy. Almost all patients with type 1 DM are at high risk of developing retinopathy 15 to 20 years after diagnosis, and 20% to 30% of them are at high risk of developing blindness. More than 60% of patients with type 2 DM have retinopathy, which is the leading cause of blindness among the 20 to 65-year-old population (Fong et al., 2004).

The actual pathogenesis of diabetic retinopathy is still not fully understood, but basically, it is due to the increase in long-term blood glucose, resulting in increased platelet aggregation, and damage to retinal capillaries, which in turn causes local enlargement of capillaries, leakage, bleeding, and even obstruction. Furthermore, blockage of micro vessels causes hypoxia in the retina and leads to the formation of new blood vessels in the retina. In this process, angiogenic factors play an essential role. In the neovascularisation, it is accompanied by fibrosis, which causes changes seen in proliferative diabetic retinopathy (Duh et al., 2017). It is, therefore, understandable that many diabetic patients are hospitalised in the ophthalmology department due to retinal diseases.

Therefore, the purpose of this study is to analyse the three departments in the United Kingdom that treat the most diabetic elderly. In addition to the General Medicine and Diabetes Medicine departments that often treat diabetic patients, the ophthalmology department, which treats diabetic eye disease, was also included. Because diabetic older adults will be admitted to different departments due to specific diseases or must receive different treatments, this study can analyse whether factors such as mental or physical disorders will affect the number of hospital stays and hospital mortality of diabetic older adults receiving different treatments.

8.2 Methods

8.2.1 Data Sources and Study population

This is a repeated cross-sectional study using Hospital Episode Statistics (HES) database including the English Index of Multiple Deprivation (IMD). My study period were 2011-12, 2012-13, and 2013-14 financial years. Elderly patients who were at least 65 years old with 1st hospital admission diagnosis as diabetes (ICD-10 codes: E10 – E14) were included in this study. Patients were categorised into three groups depending on whether they were admitted into 1) Ophthalmology, 2) General Medicine, and 3) Diabetic Medicine wards for management. Patients who were 65 years or older, and had received a primary diagnosis of diabetes (ICD-10 codes: E10 – E14) and were treated in the above three units were analysed. Patients who were not admitted into one of these three treatment units were excluded from the analyses.

8.2.2 Outcome variables (hospital length of stay & In-hospital mortality)

The main two outcome variables of the study were hospital length of stay and in-hospital mortality. In HES, the duration of spell and post-operation duration were both chosen to be used to present hospital length of stay in this study. The definition of spell duration is the in-hospital length of stay between the admission date and the discharge date. Patients' discharge method should be recorded to confirm that the spell has finished. However,

post-operation duration only existed in patients who have received surgery. Among the three departments that were included, the ophthalmology department is the only department having post-operation duration record; this is because, among the three departments, ophthalmology department involves operational procedures and is, therefore, the only source of data for the postoperative length of stay.

In the HES database, patients' discharge method should be recorded. Patients with diabetes who were discharged by their consultants and the method of discharge labelled as "Died" were considered as in-hospital deaths.

8.2.3 Main covariates (Disease category)

In the HES database, each patient who was admitted was recorded with up to 20 diagnoses. The first diagnosis was the main reason or diagnosis for patients' current hospitalisation and the first diagnosis of this patient should be diabetes and the rest of the diagnoses were considered as comorbidities. Elderly patients having diabetes only without suffering from other comorbidities were classified as the reference group in this study.

8.2.3.1 Primary objective: Physical comorbidities, Mental comorbidities, or None comorbidities (3 groups)

The first variable assigns patients into one of the three groups. This is to examine the impact of the presence of physical or mental comorbidities on mortality in elderly patients with diabetes to differentiate the actual impact of mental or physical disorders on patients with diabetes. The second

variable assigns patients into one of the six groups. This is to further examine the impact of the presence of frequent mental comorbidities among patients with diabetes

- Group 1 was the reference group, and included elderly patients with type 1 or type 2 diabetes but without any other diseases (Labelled as “DM only”)
- Group 2 included elderly patients with type 1 or type 2 diabetes combined with physical disorders (Labelled as “DM + Physical (no mental/no ICD F code)”)
- Group 3 included elderly patients with type 1 or type 2 diabetes combined with mental disorders (Labelled as “DM + Physical + Mental (has ICD F code)”).

8.2.4 Other covariates

8.2.4.1 Age, Gender and Ethnicity

The study population was divided into five age groups (65 – 69 years old, 70 – 74 years old, 75 – 79 years old, 80 – 84 years old and ≥ 85 years old). If the patient has no record of gender, it will not be included in this analysis. There were 18 categories for ethnicity in HES and I classified patients into four broad ethnic groups (White, Black, Asian, and Mixed or Others). British, Irish, and Other White background were put into the white group; Indian, Pakistani/Bangladeshi, Other Asian background and Chinese were classified in the Asian group; Caribbean, African, and Other Black background were in the black group. Mixed, other ethnic groups, not known and not stated patients were put in the Mixed or Others group.

The age distribution of the elderly patients in three treatment units was presented in Figure 8.1, Figure 8.2 and Figure 8.3. The age distribution of diabetic elders has a left-skewed unimodal distribution in all three sectors. The age distribution of patients treated in diabetes medicine is higher than that of patients with diabetes treated in ophthalmology or General Medicine. The age distribution of patients with diabetes in ophthalmology and General Medicine is similar, but the elderly with diabetes treated in ophthalmology are slightly younger than those with diabetes treated in General Medicine.

Figure 8. 1 The age distribution of elderly patients with diabetes who were treated in the Ophthalmology department from 2011-2013 in England (n=16,249)

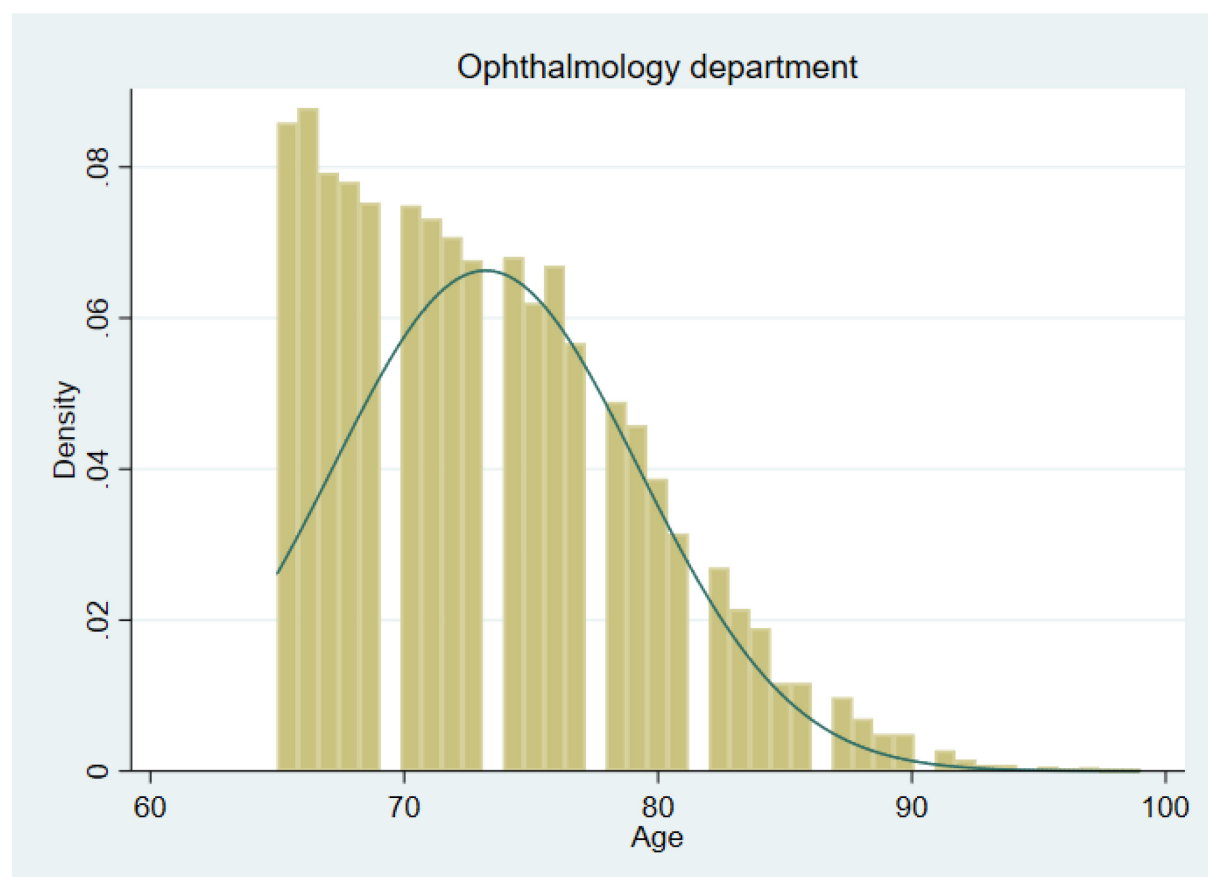


Figure 8. 2 The age distribution of elderly patients with diabetes who were treated in the General Medicine department from 2011-2013 in England (n= 33,809)

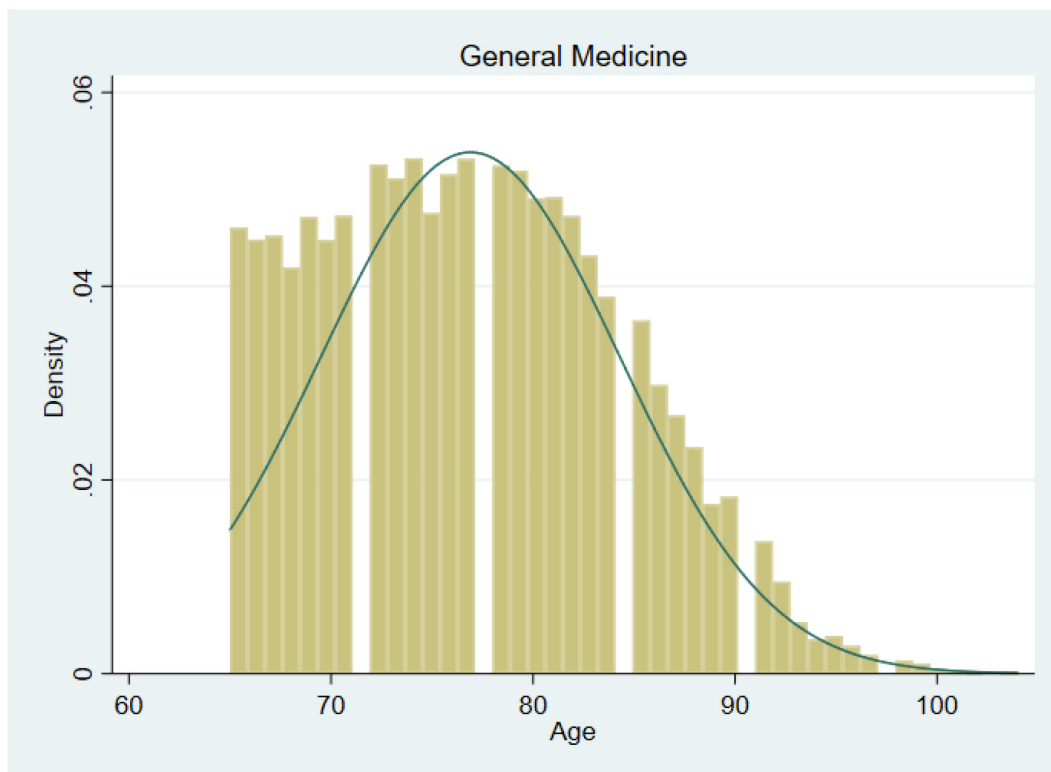
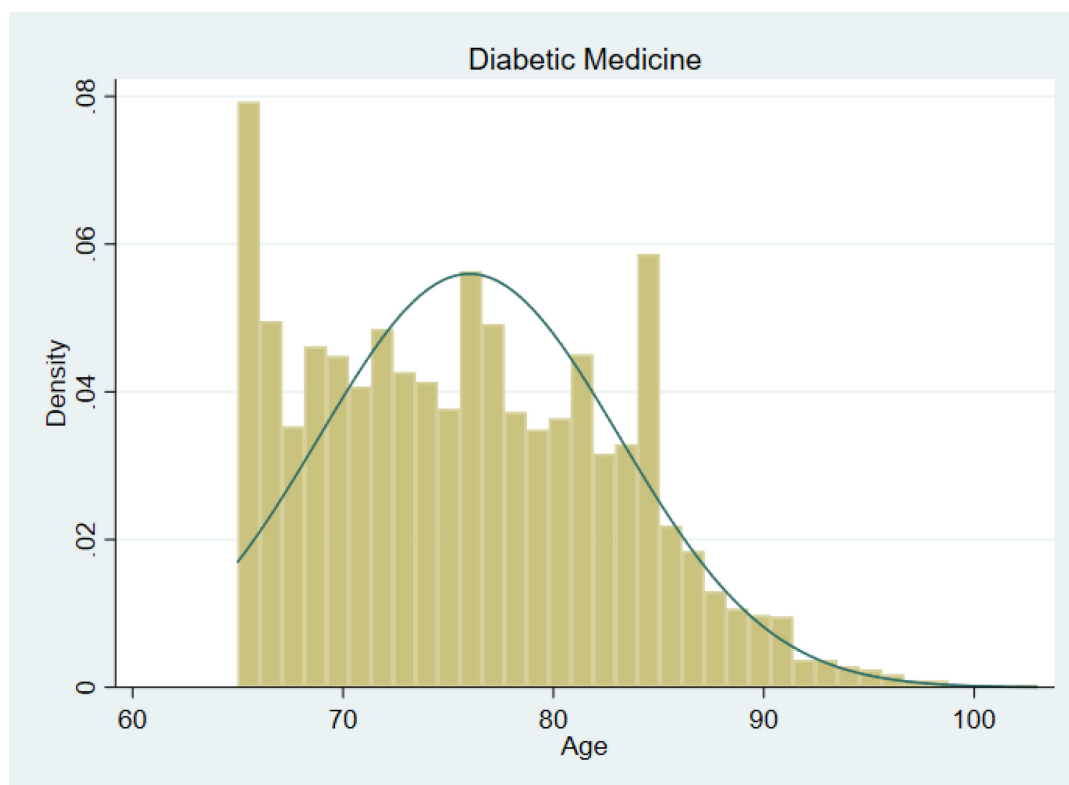


Figure 8. 3 The age distribution of elderly patients with diabetes who were treated in the Diabetic Medicine department from 2011-2013 in England (n= 4,376)



8.2.4.2 Socioeconomic inequalities

IMD is widely used in many studies to examine the association between socioeconomic deprivations and health (Woods et al., 2005, Coleman et al., 2004, Shack et al., 2008). Since the impact of socioeconomic status on patients' health was well studied in many studies and many studies conducted in European countries were also supported that finding that socioeconomic inequalities were a significant factor for mortality of patients (Mackenbach et al., 2003, Mackenbach et al., 1997, Huisman et al., 2004), the overall English IMD was used as the indicator to describe the relative socioeconomic status deprivation.

8.2.5 Statistical analysis

I used data from 2011-2014, for three financial years (April 2011 to March 2013). Missing data (620 patients without IMD data) were excluded in adjusted models. The number of eligible elderly patients who was treated in different units are given in each table. Patients in each covariate group were sub-grouped by patients' age (65 – 69 years old, 70 – 74 years old, 75 – 79 years old, 80 – 84 years old and ≥ 85 years old), gender (male and female), ethnicity (White, Black, Asian, and Mixed or Other) and quintiles of IMD based on patients' postcodes of residence.

The elderly patients who were treated in the three selected units were analysed separately. The actual number of elderly patients in each treatment unit was calculated as well as the percentage. In each treatment unit, patients were sub-grouped by the main covariate to estimate the hospital length of stay, the post-operation duration, and the mortality distribution among three disease category groups.

The descriptive results (the mean, standard deviation and the range) for spell duration among patients who were treated in the Ophthalmology department, General Medicine department, and Diabetic Medicine department were calculated respectively. Since only patients treated in the Ophthalmology department have the post-operation duration recorded, the post-operation duration descriptive results were only shown among patients in the Ophthalmology department.

To understand the mean difference of spell duration and post-operation duration among three disease category groups for elderly patients who were treated in the Ophthalmology department, General Medicine department, and Diabetic Medicine department, one-way analysis of variance (ANOVA) analyses were used.

Spell duration and post-operation duration are the outcome variables in this study to represent the hospital length of stay. Due to each unit having different treatment purposes; only the ophthalmology department had the post-operation duration recorded. Since the distribution of patients' spell duration in three treatment units was left-skewed with variance greatly exceeded the mean, negative binomial regression was used to compare the hospital length of stay (spell duration and post-operation duration) among elderly patients with diabetes having physical or mental comorbidities. Unadjusted and adjusted negative binomial regression models were performed respectively in this study. In the unadjusted regression model, only one covariate (one of the following covariates: disease category, patient's age, gender, ethnicity, and IMD) was put into the model without other covariates. In the adjusted regression model, all the covariates (disease

category, patient's age, gender, ethnicity, and IMD) were put into the model. To make the results of each model more easily understood, coefficients were converted to Incidence-Rate Ratio (IRRs). Further, 95% confidence intervals obtained from models are presented in the tables.

The other outcome variable was in-hospital mortality. Because the outcome variable, mortality, was binary, I built several multilevel logistic regression models to examine the associations between in-hospital mortality and the presence of physical or mental comorbidities and other potential predictors. In-hospital mortality for patients who were treated in General Medicine department and Diabetic Medicine department were calculated. Unadjusted and adjusted logistic regression models were performed respectively in this study. In the unadjusted logistic regression models, only one covariate (one of the following covariates: disease category, patient's age, gender, ethnicity, and IMD) was put into the models without including other covariates. In the adjusted logistic regression models, all the covariates (disease category, patient's age, gender, ethnicity, and IMD) were all put into the models at the same time. To make the results of each model easily understood, coefficients were converted to Odds ratios (OR); 95% confidence intervals obtained from models are presented in the tables.

To calculate the impact of the presence of physical and mental comorbidities, disease category was put into regression or logistic models. Since age, gender, ethnicity, and IMD were all necessary variables due to pieces of literature, main and other covariates were all put into models. In each model, disease category was tested to examine the difference between each patient group and the reference group was statistically significant. Tests for examining the effect of interactions between independent variables in adjusted models

were performed to understand the statistical significance of the actual overall effect of interactions.

Statistical analysis was conducted using Stata (version 12.1 & 15.1).

8.3 Results

Table 8.1 provides the descriptive results of the characteristics of the elderly patients who were included in this study. The entire study period is from 2011-12 to 2013-14 financial years (April 2011 to March 2013) in England. During the three financial years, 37,016 patients who were over 65 years old, admitted to the hospitals due to a primary diagnosis of diabetes mellitus and received treatments at either the Ophthalmology department (n=16,135), the General Medicine department (n=17,496), or the Diabetic Medicine department (n=3,385).

The average hospital length of stay for patients in the Ophthalmology department, General Medicine department, and Diabetic Medicine department were 0.03 days, 8.67 days, and 10.04 days respectively. The mean average post-operation duration for patients in the Ophthalmology department was 0.04 days (Table 8.2). The low length of stay might be because many patients in the ophthalmology department will be day cases, i.e. admitted and discharged on the same day. There were 625 patients from General Medicine department discharged from the hospitals because of death during the three financial years, on the other hand, there were just 61 patients discharged from the Diabetic Medicine department because of death.

8.3.1 Characteristics of the study population

8.3.1.1 Age, Gender, Ethnicity, and IMD

Table 8.1 shows the distribution of age, gender, ethnicity, and socioeconomic status of diabetic elderly treated in ophthalmology, General Medicine, and Diabetes Medicine.

Among the three treatment units, the number of male participants was all more than female participants (Male/Female: 55.9%/44.1% at Ophthalmology Department; 52.2%/47.8% at General Medicine Department; 59.5%/40.5% at Diabetic Medicine Department) . Patients in the 65-69 group have the highest percentage in both Ophthalmology department and Diabetic Medicine department. Among patients who were treated in General Medicine department, 70-74 age group has a higher percentage. Considering patients who were 85 years old or older, the General Medicine department has a higher percentage (15.8%) than the Ophthalmology department and Diabetic Medicine department. Patients in General Medicine department were relatively older than patients in the Ophthalmology department and Diabetic Medicine department (Figure 8.1 to Figure 8.3).

The ethnic distribution was similar in three departments. White ethnicity was the major ethnic group in this study. The percentages of white ethnicity among three departments were all over 82%.

The IMD distribution for patients among three departments had different trends. Patients from the Ophthalmology department lived in the less deprived areas compared to patients from Diabetic Medicine department.

There were 27.9% of patients treated in Diabetic Medicine department who lived in the most deprived areas. However, elderly patients from the General Medicine department were equally distributed in different social-economic status groups.

Table 8. 1 Characteristics of elderly patients with diabetes who were treated under three different units in England, April 2010 to March 2013 (OPH(n)=16,135; GM(n)=17,496; ED (n)=3,385)

	OPH (n)	OPH (%)	GM (n)	GM (%)	ED (n)	ED (%)
Gender						
Male ^a	9,015	55.9	9,128	52.2	2,014	59.5
Female	7,120	44.1	8,368	47.8	1,371	40.5
Age group						
65-69 ^a	5,303	32.9	3,720	21.3	795	23.5
70-74	4,624	28.7	3,892	22.3	791	23.4
75-79	3,664	22.7	3,816	21.8	787	23.3
80-84	1,799	11.2	3,305	18.9	590	17.4
>85	745	4.6	2,763	15.8	422	12.5
Ethnicity						
White ^a	13,353	82.8	14,716	84.1	2,841	83.9
Black	652	4.0	871	5.0	168	5.0
Asian	906	5.6	949	5.4	182	5.4
Mixed or Others ^b	1,224	7.6	960	5.5	194	5.7
IMD quintile						
1 - Least deprived ^a	3,497	21.7	3,497	20.0	630	18.6
2	3,279	20.3	3,393	19.4	543	16.0
3	3,425	21.2	3,359	19.2	663	19.6
4	3,196	19.8	3,603	20.6	606	17.9
5 - Most deprived	2,738	17.0	3,644	20.8	943	27.9
Total	16,135		17,496		3,385	

Notes: n=number eligible in each treatment unit; OPH=Ophthalmology; GM=General Medicine; ED: Diabetic Medicine; IMD=index of multiple deprivation; ^a Reference group. ^b Others - mixed background (White and Black Caribbean, White and Black African, White and Asian, Any other mixed background) and other ethnic group.

8.3.2 Characteristics of outcomes (Hospital length of Stay: Spell duration & Post-operation duration)

Hospital length of stay is one of the major outcomes in this chapter. Because one spell can consist of more than one episode, it is better to use a spell to represent the entire hospital length of stay than using the episode as the outcome variable. Among the three departments, only patients from the Ophthalmology department had the post-operation duration recorded.

Table 8.2 shows that the average spell duration for patients in the Ophthalmology department was 0.031 days and the average post-operation duration for patients in the Ophthalmology department was 0.037 days. For patients treated in the Ophthalmology department, the presence of mental comorbidities in elderly patients with diabetes (0.09 days, 95%CI: 0.067 to 0.113) had significantly highest mean spell duration compared with the group 1 and group 2 ($p < 0.05$), however, there were no significant differences on post-operation duration between three disease category groups.

Table 8. 2 Outcomes characteristics of diabetic elderly patients treated in ophthalmology department in England (2010-2013)

	n	min	MAX	mean	95% CI of mean	Standard deviation	P Value
Spell duration (n=16,135)							
All	16135	0	39	0.031236	(0.027, 0.034)	0.44	<0.05
Group 1: DM Only	586	0	2	0.008532	(0.004, 0.013)	0.11	
Group 2: DM+physical (no mental)	15250	0	39	0.030951	(0.027, 0.034)	0.45	
Group 3: DM+mental or DM+mental + physical	299	0	3	0.090301	(0.067, 0.113)	0.40	
Post-operation duration (n=14,994)							
Whole	14994	0	188	0.04	(0.023, 0.049)	1.56	0.8492
Group 1: DM Only	581	0	1	0.00	(0.001, 0.005)	0.06	
Group 2: DM+physical (no mental)	14125	0	188	0.04	(0.024, 0.051)	1.61	
Group 3: DM+mental or DM+mental + physical	288	0	3	0.06	(0.039, 0.078)	0.32	

Notes: n=number eligible; n=number in each group; min= minimum; MAX= maximum; DM=Diabetes Mellitus; physical=physical disorders other than diabetes; mental=mental disorders; IMD=index of multiple deprivation; ^a Reference group. ^b Others - mixed background (White and Black Caribbean, White and Black African, White and Asian, Any other mixed background) and other ethnic group.

Table 8.3 shows the mean of spell duration for patients who were treated in the General Medicine department and Diabetic Medicine department. The mean spell duration for the patients in the Diabetic Medicine department is 1.37 days longer than for the patients in the General Medicine department.

For patients treated in the General Medicine department, the mean spell duration of Group 3 (9.82 days, 95%CI: 9.576 to 10.05) is 7.45 days longer than the mean spell duration of Group 1 (2.37 days, 95%CI: 2.057 to 2.685). On average, elderly patients with diabetes and the presence of mental comorbidities stayed 4.14 times longer than elderly patients with diabetes only. The presence of mental comorbidities in elderly patients with diabetes had significantly highest mean spell duration ($p < 0.0001$) in the General Medicine department. (Table 8.3)

Patients treated in Diabetic Medicine department had similar results as patients in General Medicine department. The mean spell duration of Group 3 in Diabetic Medicine department (14.16 days, 95%CI: 13.24 to 15.07) was 11.47 days longer than the mean spell duration of Group 1 in the Diabetic Medicine department (2.69 days, 95%CI: 2.004 to 3.378), 4.33 days longer than the mean spell duration of Group 2 in the Diabetic Medicine department (9.83 days, 95%CI: 9.527 to 10.12). Elderly patients with diabetes and mental comorbidities spent 5.26 times longer than elderly patients with diabetes only in this department. The presence of mental comorbidities in elderly patients with diabetes had significantly highest mean spell duration ($p < 0.0001$) in the Diabetic Medicine department. (Table 8.3).

Table 8. 3 Outcomes characteristics (spell duration) of diabetic elderly patients treated in General Medicine & Diabetic Medicine department in England (2010-2013)

	n	min	MAX	mean	95% CI of mean	standard deviation	P Value
General Medicine (n=16,135)							
Whole	17496	0	379	8.669753	(8.559, 8.779)	14.58	<0.0001
Group 1: DM Only	382	0	64	2.371728	(2.057, 2.685)	6.14	
Group 2:							
DM+physical (no mental)	13470	0	379	8.537639	(8.410, 8.664)	14.70	
Group 3:							
DM+mental or DM+mental + physical	3644	0	236	9.818332	(9.576, 10.05)	14.59	
Diabetic Medicine (n=14,994)							
Whole	3385	0	289	10.04	(9.764, 10.32)	16.28	<0.0001
Group 1: DM Only	217	0	99	2.69	(2.004, 3.378)	10.12	
Group 2:							
DM+physical (no mental)	2640	0	171	9.83	(9.527, 10.12)	15.34	
Group 3:							
DM+mental or DM+mental + physical	528	0	289	14.16	(13.24, 15.07)	21.05	

Notes: n=number eligible; n=number in each group; min= minimum; MAX= maximum; DM=Diabetes Mellitus; physical=physical disorders other than diabetes; mental=mental disorders; IMD=index of multiple deprivation; ^a Reference group. ^b Others - mixed background (White and Black Caribbean, White and Black African, White and Asian, Any other mixed background) and other ethnic group.

8.3.2.1 Factors related to spell duration among diabetic elderly people treated in the Ophthalmology department

Table 8.4 shows the results of adjusted and unadjusted negative binomial regression analyses on spell duration among patients treated at the Ophthalmology department. There were 16135 patients included in this model. Although Table 8.4 shows, there was no significant difference between genders in either the unadjusted model (IRR: 1.34, 95%CI: 0.99 to 1.80) or the adjustment model (AIRR: 1.17, 95%CI: 0.85 to 1.58). Although Asians had a shorter spell duration compared to other ethnic groups in the adjusted model, there was no significant difference between ethnicities (AIRR: 0.97, 95%CI: 0.50 to 1.87).

The age factor in previous chapters showed a noticeable age-dependence effect. However, the ageing effect among elderly patients treated at the Ophthalmology department did not show the same age-dependence effect in either adjusted or unadjusted models. The 80-84 years old group had the highest IRR in both adjusted and unadjusted model, compared to the 65-69 years old group, it showed the statistically significant difference between groups (AIRR: 2.08, 95%CI: 1.26 to 3.44; IRR: 2.10, 95%CI: 1.28 to 3.44, respectively).

Having physical or mental comorbidities was still the major contributing factor in either adjusted or unadjusted models. Elderly patients having physical comorbidities had greater IRRs for spell duration compared to

elderly patients simply having diabetes in either adjusted or unadjusted models (AIRR: 0.97, 95%CI: 0.50 to 1.87; IRR: 1.10, 95%CI: 0.57 to 2.09, respectively).

Elderly patients having mental comorbidities had a greater IRR for spell duration than elderly patients having physical comorbidities. Having mental comorbidities for elderly patients with diabetes was the strongest contributing factor compared to other factors in all the adjusted or unadjusted models. Diabetic elderly patients with the presence of mental comorbidities had 15.01 times and 10.62 times statistically greater IRRs for spell duration compared to elderly patients with diabetes only in adjusted and unadjusted models respectively.

Interestingly, IMD quintile showed statistical significance between groups in Table 8.4. Compared to the least deprived group (IMD group 1), IMD group 2 to 5 were all had statistically greater IRRs for spell duration in either adjusted models or unadjusted models. Patients within the most deprived group had the longest spell duration in both adjusted and unadjusted models.

Table 8. 4 Adjusted and unadjusted multivariate negative binomial regression analysis on spell duration at Ophthalmology Department among diabetic elderly in England (2010-2013), n=16135

	n	% attendees	Spell Duration (Adjusted)			Spell Duration (Unadjusted)		
			AIRR	95% CI	P Value	IRR	95% CI	P Value
Gender								
Male ^a	9,015	55.87	1.00			1.00		
Female	7,120	44.13	1.17	(0.85, 1.58)	0.323	1.34	(0.99, 1.80)	0.055
Age group								
65-69 ^a	5,303	32.87	1.00			1.00		
70-74	4,624	28.66	1.38	(0.93, 2.03)	0.101	1.47	(1.00, 2.14)	0.049
75-79	3,664	22.71	1.18	(0.77, 1.81)	0.440	1.07	(0.70, 1.62)	0.758
80-84	1,799	11.15	2.08	(1.26, 3.44)	0.004	2.10	(1.28, 3.44)	0.003
>85	745	4.62	1.33	(0.63, 2.79)	0.444	1.27	(0.60, 2.65)	0.527
Ethnicity								
White ^a	13,353	82.76	1.00			1.00		
Black	652	4.04	1.36	(0.67, 2.76)	0.389	1.52	(0.74, 3.12)	0.253
Asian	906	5.62	0.97	(0.50, 1.87)	0.935	1.10	(0.57, 2.09)	0.775
Mixed or Others ^b	1,224	7.59	1.26	(0.71, 2.20)	0.426	1.08	(0.61, 1.89)	0.785

Disease category									
Group 1: DM Only ^a	586	3.63	1.00				1.00		
Group 2: DM+physical (no mental)	15,250	94.52	4.03	(1.34, 12.0)	0.013		3.62	(1.22, 10.7)	0.020
Group 3: DM+mental or DM+mental + physical	299	1.85	15.01	(3.54, 63.5)	<0.001		10.62	(2.51, 44.7)	0.001
IMD quintile									
1 - Least deprived ^a	3,497	21.67	1.00				1.00		
2	3,279	20.32	2.72	(1.67, 4.43)	<0.001		2.75	(1.70, 4.42)	<0.001
3	3,425	21.23	1.75	(1.05, 2.88)	0.029		1.57	(0.95, 2.57)	0.074
4	3,196	19.81	2.03	(1.22, 3.36)	0.006		1.92	(1.17, 3.14)	0.009
5 - Most deprived	2,738	16.97	3.29	(1.98, 5.44)	<0.001		3.15	(1.92, 5.14)	<0.001
Total	16,135								

Notes: n=number eligible; AIRR=adjusted incidence-rate ratio; IRR=incidence-rate ratio; 95%CI= 95% confidence interval; DM=Diabetes Mellitus; physical=physical disorders other than diabetes; mental=mental disorders; IMD=index of multiple deprivation; a Reference group. b Others - mixed background (White and Black Caribbean, White and Black African, White and Asian, Any other mixed background) and other ethnic group.

8.3.2.2 Factors related to spell duration among diabetic elderly people treated in the General Medicine department

Table 8.5 represents the findings of both adjusted and unadjusted negative binomial regression analyses on spell duration among patients treated at the General Medicine department. There were 17,496 patients included in these models. Among patients treated in General Medicine department, there was no statistically significant difference between genders on spell duration in both adjusted and unadjusted models (AIRR: 0.99, 95%CI: 0.95 to 1.02; IRR: 1.03, 95%CI: 0.99 to 1.096, respectively).

Among the elderly patients with diabetes treated in General Medicine, both Asian and Black ethnicity showed statistically lower IRR for spell duration than the white ethnicity in unadjusted models (IRR: 0.67 & 0.91, respectively). Only Asian ethnicity represented less spell duration compared to white ethnicity in the adjusted model with statistical significance in the adjusted model (AIRR: 0.70, 95%CI: 0.64 to 0.76).

Unlike patients treated in the Ophthalmology department, patients treated in the General Medicine department had a clear age-dependence response like studies conducted in Chapter 6 & 7. The 70-74 years old group, 75-79 years old group, 80-84 years old group and 85 years old above group had statistical higher spell duration compared to the 65-69 years old group in adjusted models (AIRR: 1.11, 1.29, 1.40, 1.44, respectively). Unadjusted models for Age also showed the age-dependency response with statistical significance.

Both physical and mental comorbidities were the relatively stronger contributing factor on spell duration than other factors. In either adjusted or unadjusted models, diabetic elderly patients with physical or mental comorbidities both had statistically greater IRRs for spell duration than elderly patients with diabetes only. Elderly patients having physical comorbidities had greater IRRs for spell duration compared to elderly patients simply having diabetes in either adjusted or unadjusted models (AIRR: 3.42, 95%CI: 2.97 to 3.93; IRR: 3.50, 95%CI: 3.05 to 4.02, respectively).

Same as Chapter 6, elderly patients with the presence of diabetes and mental comorbidities had significantly greater IRRs for spell duration compared to the elderly patients with diabetes only in both adjusted and unadjusted models (AIRR: 3.89, 95%CI: 3.36 to 4.49; IRR: 4.03, 95%CI: 3.49 to 4.69, respectively). Mental comorbidities for elderly patients with diabetes were the strongest contributing factor for having greater IRRs for spell duration compared to other factors in all the adjusted or unadjusted models. Diabetic elderly patients with the presence of mental comorbidities had 3.89 times and 4.03 times statistically greater IRRs for spell duration compared to elderly patients with diabetes only in adjusted and unadjusted models respectively.

IMD quintile between groups did not show a statistical significant difference among elderly patients treated in the General Medicine department (Table 8.5).

Table 8. 5 Adjusted and unadjusted multivariate negative binomial regression analysis on spell duration at General Medicine department among diabetic elderly in England (2010-2013), n= 17,496

Spell Duration (Adjusted)						Spell Duration (Unadjusted)		
	n	% attendees	AIRR	95% CI	P Value	IRR	95% CI	P Value
Gender								
Male ^a	9,128	52.17	1.00			1.00		
Female	8,368	47.83	0.99	(0.95, 1.02)	0.505	1.03	(0.99, 1.06)	0.123
Age group								
65-69 ^a	3,720	21.26	1.00			1.00		
70-74	3,892	22.25	1.11	(1.04, 1.17)	0.001	1.09	(1.03, 1.15)	0.002
75-79	3,816	21.81	1.29	(1.21, 1.36)	<0.001	1.29	(1.21, 1.36)	<0.001
80-84	3,305	18.89	1.40	(1.32, 1.48)	<0.001	1.43	(1.34, 1.51)	<0.001
>85	2,763	15.79	1.44	(1.35, 1.53)	<0.001	1.47	(1.38, 1.56)	<0.001
Ethnicity								
White ^a	14,716	84.11	1.00			1.00		
Black	871	4.98	0.96	(0.87, 1.04)	0.313	0.91	(0.83, 0.98)	0.024
Asian	949	5.42	0.70	(0.64, 0.76)	<0.001	0.67	(0.61, 0.72)	<0.001
Mixed or Others ^b	960	5.49	0.85	(0.78, 0.92)	<0.001	0.83	(0.75, 0.89)	<0.001

Disease category								
Group 1: DM Only ^a	382	2.18	1.00			1.00		
Group 2: DM+physical (no mental)	13,470	76.99	3.42	(2.97, 3.93)	<0.001	3.50	(3.05, 4.02)	<0.001
Group 3: DM+mental or DM+mental + physical	3,644	20.83	3.89	(3.36, 4.49)	<0.001	4.03	(3.49, 4.64)	<0.001
IMD quintile								
1 - Least deprived ^a	3,497	19.99	1.00			1.00		
2	3,393	19.39	0.98	(0.92, 1.03)	0.496	0.98	(0.92, 1.04)	0.56
3	3,359	19.2	1.11	(1.04, 1.18)	<0.001	1.09	(1.02, 1.15)	0.01
4	3,603	20.59	1.01	(0.95, 1.07)	0.649	0.97	(0.91, 1.03)	0.37
5 - Most deprived	3,644	20.83	0.97	(0.91, 1.03)	0.402	0.92	(0.86, 0.97)	0.01
Total	17,496							

Notes: n=number eligible; AIRR=adjusted incidence-rate ratio; IRR=incidence-rate ratio; 95%CI= 95% confidence interval; DM=Diabetes Mellitus; physical=physical disorders other than diabetes; mental=mental disorders; IMD=index of multiple deprivation; a Reference group. b Others - mixed background (White and Black Caribbean, White and Black African, White and Asian, Any other mixed background) and other ethnic group.

8.3.2.3 Factors related to spell duration among diabetic elderly people treated in Diabetic Medicine department

Table 8.6 describes the results of both adjusted and unadjusted negative binomial regression analyses on spell duration among patients treated at the Diabetic Medicine department. Although there were only 3,385 elderly patients included in these models, Diabetic Medicine departments have the third-largest patient number next to the Ophthalmology department and General Medicine department, among elderly patients, admitted to the hospitals because of diabetes as the primary diagnosis.

Among elderly patients treated in Diabetic Medicine departments where the first diagnosis was diabetes, there was no statistically significant difference in spell duration between genders in both adjusted and unadjusted models (AIRR: 1.00, 95%CI: 0.89 to 1.10; IRR: 1.02, 95%CI: 0.91 to 1.13, respectively).

Elderly diabetic patients treated in Diabetic Medicine departments, like patients treated in General Medicine departments, had a clear age-dependence response. Patients in 70-74 years old group, 75-79 years old group, 80-84 years old group and 85 years old above group had statistical higher spell duration compared to the 65-69 years old group in both adjusted and unadjusted models (AIRR: 1.22, 1.18, 1.36, 1.79; IRR: 1.20, 1.17, 1.36, 1.96, respectively).

Only Asian ethnicity showed as a protective factor on having lower IRR for spell duration compared to white ethnicity in both adjusted and unadjusted

model with statistical significance compared to white ethnicity (AIRR: 0.48; IRR: 0.44, respectively).

Not surprisingly, both physical and mental comorbidities were the relatively strongest contributing factors on spell duration compared to other factors included in my study models. Elderly patients with the presence of physical comorbidities and diabetes had greater IRRs for spell duration compared to elderly patients simply having diabetes in either adjusted or unadjusted models (AIRR: 3.50, 95%CI: 2.80 to 4.36; IRR: 3.62, 95%CI: 2.9 to 4.25, respectively).

On the other hand, elderly patients with the presence of mental comorbidities and diabetes had statistically much greater IRRs for spell duration compared to diabetic elderly patients without other comorbidities in both adjusted and unadjusted models (AIRR: 5.12, 95%CI: 3.99 to 6.56; IRR: 5.27, 95%CI: 4.10 to 6.76, respectively). Mental comorbidities for diabetic elderly patients treated in Diabetic Medicine departments were still the strongest contributing factor for having greater IRRs for spell duration compared to other factors among all the adjusted or unadjusted models. Diabetic elderly patients with the presence of mental comorbidities had 5.12 times and 5.27 times statistically greater IRRs for spell duration compared to diabetic elderly patients without other comorbidities in adjusted and unadjusted models, respectively.

There is no clear statistically significant difference between groups for IMD quintile among elderly patients treated in Diabetic Medicine department (Table 8.6).

Table 8. 6 Adjusted and unadjusted multivariate negative binomial regression analysis on spell duration at Diabetic medicine department among diabetic elderly in England (2010-2013), n= 3,385

Spell Duration (Adjusted)						Spell Duration (Unadjusted)		
	n	% attendees	AIRR	95% CI	P Value	IRR	95% CI	P Value
Gender								
Male ^a	2,014	59.5	1.00			1.00		
Female	1,371	40.5	1.00	(0.89, 1.10)	0.949	1.02	(0.91, 1.13)	0.676
Age group								
65-69 ^a	795	23.49	1.00			1.00		
70-74	791	23.37	1.22	(1.04, 1.41)	0.010	1.20	(1.03, 1.40)	0.017
75-79	787	23.25	1.18	(1.01, 1.37)	0.027	1.17	(1.00, 1.36)	0.041
80-84	590	17.43	1.36	(1.15, 1.59)	<0.001	1.36	(1.15, 1.60)	<0.001
>85	422	12.47	1.79	(1.49, 2.13)	<0.001	1.91	(1.59, 2.28)	<0.001
Ethnicity								
White ^a	2,841	83.93	1.00			1.00		
Black	168	4.96	1.52	(1.19, 1.92)	0.001	1.33	(1.04, 1.68)	0.020
Asian	182	5.38	0.48	(0.38, 0.61)	<0.001	0.44	(0.35, 0.56)	<0.001
Mixed or Others ^b	194	5.73	0.97	(0.78, 1.20)	0.788	0.99	(0.78, 1.23)	0.903

Disease category								
Group 1: DM Only ^a	217	6.41	1.00			1.00		
Group 2: DM+physical (no mental)	2,640	77.99	3.50	(2.80, 4.36)	<0.001	3.62	(2.90, 4.52)	<0.001
Group 3: DM+mental or DM+mental + physical	528	15.6	5.12	(3.99, 6.56)	<0.001	5.27	(4.10, 6.76)	<0.001
IMD quintile								
1 - Least deprived ^a	630	18.61	1.00			1.00		
2	543	16.04	1.07	(0.90, 1.27)	0.435	1.06	(0.89, 1.26)	0.497
3	663	19.59	0.66	(0.56, 0.78)	<0.001	0.63	(0.53, 0.75)	<0.001
4	606	17.9	0.87	(0.73, 1.03)	0.113	0.88	(0.73, 1.04)	0.134
5 - Most deprived	943	27.86	0.67	(0.57, 0.78)	<0.001	0.66	(0.56, 0.76)	<0.001
Total	3,385							

Notes: n=number eligible; AIRR=adjusted incidence-rate ratio; IRR=incidence-rate ratio; 95%CI= 95% confidence interval; DM=Diabetes Mellitus; physical=physical disorders other than diabetes; mental=mental disorders; IMD=index of multiple deprivation; a Reference group. b Others - mixed background (White and Black Caribbean, White and Black African, White and Asian, Any other mixed background) and other ethnic group.

8.3.2.4 Factors related to post-operation duration among diabetic elderly people treated in the Ophthalmology department

Table 8.7 shows the results of adjusted and unadjusted negative binomial regression analyses on post-operation duration among patients treated at the Ophthalmology departments. A total of 14,994 patients received at least one surgery and admitted to the Ophthalmology department.

Although Table 8.4 shows there was no significant difference on spell duration between genders after adjustment (AIRR: 1.17, 95%CI: 0.85 to 1.58), Table 8.7 clearly shows Females spent 1.7 times and 2.7 times greater IRRs for post-operation duration in the adjusted model and unadjusted model, respectively. Gender difference in post-operation duration has statistical significance and a female group showed 1.7 times and 2.7 times greater IRRs for post-operation duration in the adjusted model and unadjusted model, respectively.

There was no clear age-dependence effect on post-operation duration among patients admitted at the Ophthalmology departments. Only the 70-74 years old group showed a statistically significant difference with 2.36 times or 3.7 times greater IRRs for post-operation duration compared to the 65-69 years old group in the adjusted model or unadjusted model, respectively (AIRR: 2.36, 95%CI: 1.50 to 3.70; IRR: 3.7, 95%CI: 2.39 to 2.72, respectively). However, in other age groups (75-79 years old, 80-84 years old & 85 years old above), there was no significant difference in post-operation compared to the reference group (65-69 years old).

Asian and Black ethnicity had less post-operation duration compared to white ethnicity, but there was no significant difference in both the adjusted models or the unadjusted models.

As in previous tables, both physical and mental comorbidities were significant contributing factors on post-operation duration in either adjusted or unadjusted models. Elderly patients with the presence of physical comorbidities and diabetes spent 8.86 times and 10.86 times greater IRRs for post-operation duration compared to elderly patients with diabetes only in both adjusted and unadjusted models respectively (AIRR: 8.86, 95%CI: 1.79 to 43.7; IRR: 10.86, 95%CI: 2.18 to 53.9).

Among elderly patients with diabetes and receiving surgery at Ophthalmology departments, those patients having mental comorbidities can spend 18.58 times or 17.18 times greater IRRs for post-operation duration than elderly patients with diabetes only in either adjusted models or unadjusted models respectively (AIRR: 18.58, 95%CI: 2.66 to 129; IRR: 17.18, 95%CI: 2.32 to 127). Mental comorbidities were the strongest factors on contributing to post-operation duration compared to other factors examined in both adjusted and unadjusted models.

IMD quintile did not show a statistical trend in either the adjusted or unadjusted models. Social deprivation did not show a significant difference between groups among diabetic elderly patients receiving surgery in the Ophthalmology department. However, numerically, there is a trend that the more deprived population can have greater IRRs for post-operation duration.

Table 8. 7 Adjusted and unadjusted multivariate negative binomial regression analysis on post-operation duration at Ophthalmology department among diabetic elderly in England (2010-2013), n= 14,994

			Post-operation (Adjusted)		Duration	Post-operation (Unadjusted)		Duration
	n	% attendees	AIRR	95% CI	P Value	IRR	95% CI	P Value
Gender								
Male ^a	8,361	55.76	1.00			1.00		
Female	6,633	44.24	1.70	(1.18, 2.45)	0.004	2.70	(1.90, 3.82)	<0.001
Age group								
65-69 ^a	4,981	33.22	1.00					
70-74	4,303	28.7	2.36	(1.50, 3.70)	<0.001	3.70	(2.39, 5.72)	<0.001
75-79	3,371	22.48	1.12	(0.67, 1.84)	0.666	1.30	(0.79, 2.12)	0.305
80-84	1,649	11	1.17	(0.63, 2.17)	0.611	1.29	(0.69, 2.41)	0.424
>85	690	4.6	1.28	(0.54, 2.97)	0.571	1.58	(0.66, 3.74)	0.301
Ethnicity								
White ^a	12,353	82.39	1.00			1.00		
Black	630	4.2	0.48	(0.19, 1.19)	0.116	0.50	(0.18, 1.30)	0.155
Asian	879	5.86	0.51	(0.24, 1.06)	0.074	0.83	(0.38, 1.79)	0.639
Mixed or Others ^b	1,132	7.55	1.20	(0.62, 2.29)	0.590	0.78	(0.39, 1.55)	0.483

Disease category								
Group 1: DM Only ^a	581	3.87	1.00			1.00		
Group 2: DM+physical (no mental)	14,125	94.2	8.86	(1.79, 43.7)	0.007	10.86	(2.18, 53.9)	0.004
Group 3: DM+mental or DM+mental + physical	288	1.92	18.58	(2.66, 129.)	0.003	17.18	(2.32, 127.)	0.005
IMD quintile								
1 - Least deprived ^a	3,188	21.26	1.00			1.00		
2	3,033	20.23	1.66	(0.95, 2.90)	0.075	1.61	(0.91, 2.82)	0.100
3	3,117	20.79	1.47	(0.83, 2.59)	0.183	1.29	(0.73, 2.28)	0.378
4	3,022	20.15	3.54	(2.03, 6.16)	<0.001	5.23	(3.06, 8.93)	<0.001
5 - Most deprived	2,634	17.57	2.01	(1.12, 3.58)	0.018	1.94	(1.09, 3.45)	0.024
Total	14,994							

Notes: n=number eligible; AIRR=adjusted incidence-rate ratio; IRR=incidence-rate ratio; 95%CI= 95% confidence interval; DM=Diabetes Mellitus; physical=physical disorders other than diabetes; mental=mental disorders; IMD=index of multiple deprivation; a Reference group. b Others - mixed background (White and Black Caribbean, White and Black African, White and Asian, Any other mixed background) and other ethnic group.

8.3.3 Characteristics of outcomes (in-hospital mortality)

8.3.3.1 Factors related to in-hospital mortality among diabetic elderly patients treated in General Medicine department

Table 8.8 shows the results of both adjusted and unadjusted logistic regression analyses on in-hospital mortality among elderly diabetic patients treated at the General Medicine department. There were 33,498 patients included in the analyses.

Among elderly patients treated in General Medicine department, there was no significant difference on in-hospital mortality between male and female in both adjusted and unadjusted models (AOR: 0.92, 95%CI: 0.78 to 1.07; OR: 1.09, 95%CI: 0.92 to 1.27).

The elderly patients treated in General Medicine departments had a clear age-dependence effect on in-hospital mortality in either adjusted or unadjusted models. The 70-74 years old group, 75-79 years old group, 80-84 years old group and 85 years old above group had 1.35 times, 1.79 times, 2.58 times, 3.79 times higher in-hospital mortality compared to the 65-69 years old group in adjusted models with statistical significance respectively (AOR: 1.35, 1.79, 2.58, 3.79). On the other hand, unadjusted models in each

age group also revealed the clear age-dependence effect on in-hospital mortality with statistical significance compared to the reference group, the 65-69 years old group.

Among the elderly patients treated in General Medicine departments due to the first diagnosis of diabetes, were both Asian and Black ethnicity who were less likely to experience in-hospital mortality but did not show any significant in-hospital mortality difference compared to the white ethnicity in both the adjusted models and unadjusted models.

Both physical and mental comorbidities had a higher likelihood to be observed with in-hospital mortality compared to other included factors either in adjusted or unadjusted models. However, elderly patients with the presence of physical comorbidities and diabetes did not show any statistical significance on in-hospital mortality compared to the reference group in either adjusted or unadjusted models (AOR: 2.5, 95%CI: 0.79 to 7.8; OR: 2.96, 95%CI: 0.94 to 9.25, respectively).

Unlike elderly patients having physical comorbidities, elderly patients with the presence of diabetes and mental comorbidities were observed with 3.71 times and 4.69 times higher in-hospital mortality compared to the elderly patients with diabetes only with statistical significance in adjusted and unadjusted models respectively (AOR: 3.71, 95%CI: 1.18 to 11.6; OR: 4.69, 95%CI: 1.49 to 14.7).

IMD quintile among elderly patients treated in General Medicine department did not show a significant difference in in-hospital mortality (Table 8.8).

Table 8. 8 Adjusted & unadjusted logistic regression analyses on in-hospital mortality at General Medicine department among diabetic elderly in England (2010-2013), n=33,498

			In-hospital mortality (Adjusted)			In-hospital mortality (Unadjusted)		
	n	% attendees	AOR	95% CI	P Value	OR	95% CI	P Value
Gender								
Male ^a	17,561	52.42	1.00			1.00		
Female	15,937	47.58	0.92	(0.78, 1.07)	0.303	1.09	(0.92, 1.27)	0.312
Age group								
65-69 ^a	6,515	19.45	1.00			1.00		
70-74	7,228	21.58	1.35	(0.97, 1.88)	0.073	1.33	(0.95, 1.85)	0.090
75-79	7,462	22.28	1.79	(1.31, 2.44)	<0.001	1.80	(1.31, 2.45)	<0.001
80-84	6,609	19.73	2.58	(1.90, 3.48)	<0.001	2.61	(1.93, 3.52)	<0.001
>85	5,684	16.97	3.79	(2.81, 5.08)	<0.001	3.92	(2.92, 5.23)	<0.001
Ethnicity								
White ^a	28,446	84.92	1.00			1.00		
Black	1,696	5.06	0.57	(0.35, 0.92)	0.023	0.58	(0.36, 0.91)	0.019
Asian	1,635	4.88	0.80	(0.52, 1.24)	0.325	0.70	(0.45, 1.06)	0.097

Mixed or Others ^b	1,721	5.14	1.33	(0.96, 1.83)	0.086	1.27	(0.92, 1.73)	0.146
Disease category								
Group 1: DM Only ^a	516	1.54	1.00			1.00		
Group 2: DM+physical (no mental)	25,635	76.53	2.50	(0.79, 7.80)	0.116	2.96	(0.94, 9.25)	0.062
Group 3: DM+mental or DM+mental + physical	7,347	21.93	3.71	(1.18, 11.6)	0.025	4.69	(1.49, 14.7)	0.008
IMD quintile								
1 - Least deprived ^a	6,608	19.73	1.00			1.00		
2	6,468	19.31	1.05	(0.81, 1.34)	0.709	1.01	(0.78, 1.30)	0.914
3	6,516	19.45	1.03	(0.80, 1.33)	0.797	0.96	(0.74, 1.23)	0.733
4	6,909	20.63	1.14	(0.88, 1.45)	0.317	1.01	(0.78, 1.29)	0.938
5 - Most deprived	6,997	20.89	1.05	(0.81, 1.36)	0.701	0.88	(0.68, 1.13)	0.333
Total	33,498							

Notes: n=number eligible; AOR=adjusted odds ratio; OR=odds ratio; 95%CI= 95% confidence interval; DM=Diabetes Mellitus; physical=physical disorders other than diabetes; mental=mental disorders; IMD=index of multiple deprivation; a Reference group. b Others - mixed background (White and Black Caribbean, White and Black African, White and Asian, Any other mixed background) and other ethnic group.

8.3.3.2 Factors related to in-hospital mortality among diabetic elderly patients treated in Diabetic Medicine department

Table 8.9 shows the results of both adjusted and unadjusted logistic regression analyses on in-hospital mortality among elderly diabetic patients treated at Diabetic Medicine department. There were 4,357 patients included in the analyses.

Among the elderly patients treated in Diabetic Medicine departments, there was no significant difference between genders on in-hospital mortality in both adjusted and unadjusted models (Adjusted model, AOR: 0.64, 95%CI: 0.37 to 1.10; Unadjusted model, OR: 0.77, 95%CI: 0.45 to 1.30).

The elderly patients treated in Diabetic Medicine department did not show the clear age-dependence effect on in-hospital mortality in either adjusted or unadjusted models, compared to elderly patients treated in the General Medicine department. Only the eldest group, 85 years old above, had 3.25 and 3.74 times higher in-hospital mortality with statistical significance compared to the 65-69 years old group in both adjusted models and unadjusted models respectively (Adjusted model, AOR: 3.25, 95%CI: 1.37 to 7.65; Unadjusted model, OR: 3.74, 95%CI: 1.61 to 8.64).

For the elderly patients treated in Diabetic Medicine department, there was no statistical significance in in-hospital mortality between ethnicities in both adjusted models and unadjusted models.

In both the adjusted models and unadjusted models, unlike elderly patients treated in the Ophthalmology department and General Medicine department had statistical significance between groups, elderly patients from the Diabetic Medicine department had 5.04 times higher in-hospital mortality rate for patients with the presence of mental comorbidities group but without statistical difference compared to patients with diabetes only group in adjusted model (Adjusted model, AOR: 5.44, 95%CI: 0.66 to 38.0; Unadjusted model, OR: 7.07, 95%CI: 0.94 to 52.8).

The same situation as patients with the presence of physical comorbidities group, this group had 2.02 higher in-hospital mortality rate compared to patients with diabetes only group, however, there was no statistical significance between groups (Adjusted model, AOR: 2.02, 95%CI: 0.27 to 14.9; Unadjusted model, OR: 2.83, 95%CI: 0.38 to 20.6).

IMD quintile among elderly patients treated in Diabetic Medicine department did not show a significant difference in in-hospital mortality between groups (Table 8.9).

Table 8. 9 Adjusted & unadjusted logistic regression analyses on in-hospital mortality at Diabetic medicine department among diabetic elderly in England (2010-2013), n= 4,357

			In-hospital mortality (Adjusted)			In-hospital mortality (Unadjusted)		
	n	% attendees	AOR	95% CI	P Value	OR	95% CI	P Value
Gender								
Male ^a	2,591	59.47	1.00			1.00		
Female	1,766	40.53	0.64	(0.37, 1.10)	0.113	0.77	(0.45, 1.30)	0.325
Age group								
65-69 ^a	968	22.22	1.00			1.00		
70-74	1,000	22.95	0.85	(0.30, 2.36)	0.756	0.84	(0.30, 2.33)	0.742
75-79	993	22.79	2.17	(0.92, 5.07)	0.074	2.09	(0.89, 4.87)	0.086
80-84	801	18.38	1.62	(0.64, 4.07)	0.306	1.67	(0.66, 4.16)	0.275
>85	595	13.66	3.25	(1.37, 7.65)	0.007	3.74	(1.61, 8.64)	0.002
Ethnicity								
White ^a	3,703	84.99	1.00			1.00		
Black	195	4.48	0.42	(0.05, 3.14)	0.400	0.35	(0.04, 2.53)	0.298
Asian	210	4.82	0.45	(0.06, 3.34)	0.437	0.33	(0.04, 2.39)	0.272
Mixed or Others ^b	249	5.71	1.71	(0.72, 4.05)	0.224	1.68	(0.71, 3.95)	0.231

Disease category									
Group 1: DM Only ^a	243	5.58	1.00				1.00		
Group 2: DM+physical (no mental)	3,374	77.44	2.02	(0.27, 14.9)	0.489		2.83	(0.38, 20.6)	0.306
Group 3: DM+mental or DM+mental + physical	740	16.98	5.04	(0.66, 38.0)	0.117		7.07	(0.94, 52.8)	0.057
IMD quintile									
1 - Least deprived ^a	882	20.24	1.00				1.00		
2	724	16.62	1.43	(0.70, 2.89)	0.327		1.39	(0.68, 2.80)	0.358
3	807	18.52	0.75	(0.32, 1.73)	0.494		0.65	(0.28, 1.49)	0.313
4	775	17.79	0.80	(0.34, 1.86)	0.606		0.68	(0.29, 1.56)	0.362
5 - Most deprived	1,169	26.83	0.70	(0.31, 1.56)	0.386		0.55	(0.25, 1.20)	0.133
Total	4,357								

Notes: n=number eligible; AOR=adjusted odds ratio; OR=odds ratio; 95%CI= 95% confidence interval; DM=Diabetes Mellitus; physical=physical disorders other than diabetes; mental=mental disorders; IMD=index of multiple deprivation; a Reference group. b Others - mixed background (White and Black Caribbean, White and Black African, White and Asian, Any other mixed background) and other ethnic group.

8.4 Discussion

In this Chapter, I analysed diabetic elderly patients who were treated in the major treatment settings to understand the impact of physical and mental comorbidities for diabetic elderly patients who were receiving different treatments on both hospital length of stay and in-hospital mortality.

8.4.1 Elderly patients admitted to the ophthalmology department

In this chapter, elderly patients who received ophthalmology surgery and admitted to the ophthalmology department were both evaluated. During the study period, 16,135 patients were admitted to the ophthalmology department, and 14,994 patients were admitted due to eye surgery. It implied 92.9% of elderly patients who were admitted in the hospital were because of eye surgery. Therefore, the factors that can affect post-operation duration would significantly influence the overall elderly patients who were admitted to the ophthalmology department.

My findings show that female had 1.7 times and 2.7 times greater IRRs for post-operation duration in the adjusted model and unadjusted model, respectively. On the other hand, age was not a significant factor for post-operation duration and there was no clear age-dependence effect among patients admitted at the Ophthalmology department due to operation.

In adjusted models, elderly patients with the presence of physical comorbidities and diabetes had 8.86 times greater IRRs for post-operation duration compared to elderly patients with diabetes only as well as those patients having mental comorbidities had 18.58 times greater IRRs for post-operation duration than elderly patients with diabetes only. Since both physical and mental comorbidities were significant contributing factors on post-operation duration in either adjusted or unadjusted models compared to other factors, for patients with physical or mental comorbidities, it might be important to carefully follow up their comorbidities status before an operation to reduce the hospital length of stay and the cost.

Among elderly patients with diabetes and receiving surgery at the Ophthalmology departments, those patients having mental comorbidities can spend 18.58 times or 17.18 times greater IRRs for post-operation duration than the elderly patients with diabetes only in

either adjusted models or unadjusted models respectively (AIRR: 18.58, 95%CI: 2.66 to 129; IRR: 17.18, 95%CI: 2.32 to 127). Mental comorbidities were the strongest factors on contributing to post-operation duration compared to other factors examined in both adjusted and unadjusted models.

8.4.2 Elderly patients admitted to the General Medicine department

Table 8.5 shows that there was no statistically significant difference between genders on spell duration. For male and female patients who were treated in the General Medicine department, the disease severity between genders might not have differences. However, age was a significant factor for spell duration. Patients treated in the General Medicine department had a clear age-dependence response in both the adjusted and unadjusted models. It might be because elder patients compared to younger patients have a long history of diabetes. Probably due to a cognitive function, the glycaemic control among the elderly patients might be poorer than among the younger patients.

Like other models presented before, the physical and mental comorbidities were still the relatively strongest contributing factors

on spell duration compared to other factors like gender, age, gender and social-economic status. Table 8.5 clearly shows diabetic elderly patients with physical or mental comorbidities both had statistically greater IRRs for spell duration compared to elderly patients with diabetes only. However, unlike elderly patients treated in Ophthalmology departments who have huge AIRR difference between physical and mental comorbidities, the AIRR values between physical and mental comorbidities are similar in both adjusted and unadjusted models (AIRR: 3.42 and 4.02 respectively).

Mental comorbidities for elderly patients with diabetes was still the strongest contributing factor for having greater IRRs for spell duration compared to other factors in all the adjusted or unadjusted models. Diabetic elderly patients with the presence of mental comorbidities had 3.89 times and 4.03 times statistically greater IRRs for spell duration compared to elderly patients with diabetes only in adjusted and unadjusted models respectively.

Table 8.8 shows that among elderly patients treated in General Medicine departments, gender was not a risk factor for in-hospital mortality in both adjusted and unadjusted models (AOR: 0.92, 95%CI: 0.78 to 1.07; OR: 1.09, 95%CI: 0.92 to 1.27). Regarding the relationship between ethnicity, both Asian and Black ethnicity had fewer odds ratio

but did not show significant in-hospital mortality difference compared to white ethnicity in both the adjusted models and unadjusted models. Asian and Black ethnicity were protective factors for elderly patients who were admitted to the General Medicine department.

With there was a similar trend regarding the in-hospital length of stay for elderly patients treated in General Medicine, the clear age-dependence effect on in-hospital mortality in either adjusted or unadjusted models was also shown in Table 8.8. Similar reasons might apply that due to having a long history of diabetes among much elder patients, the poor cognitive function may contribute to the poor glycaemic control and it will cause more complications or comorbidities.

Most importantly, both the physical and mental comorbidities were still the major risk factors for elderly patients on in-hospital mortality compared to other including factors. Although the elderly patients with the presence of physical comorbidities did not show the significance compared to the patients with diabetes only, elderly patients with the presence of diabetes and mental comorbidities, like the elderly patients in Chapter 7 or other treatment units, have 3.71 times and 4.69 times higher in-hospital mortality compared to the elderly patients with diabetes only with statistical significance in

adjusted and unadjusted models respectively (AOR: 3.71, 95%CI: 1.18 to 11.6; OR: 4.69, 95%CI: 1.49 to 14.7).

Therefore, in a comprehensive comparison, when I disassembled the department for analyses, I found that in the ophthalmology department, General Medicine department and the Diabetic Medicine department, the patient combined with mental disorders and physical disorders for the hospital length of stay (whether it is spell duration or post- Operation duration), both significantly greater in IRRs. However, mental disorders and physical disorders did not significantly increase in-hospital mortality for patients in the General Medicine department and the Diabetic Medicine department.

Interestingly, Asians accounted for 5% of the total number of patients, and a similar proportion in most treatment units. In my study, there was no statistically significant difference in in-hospital mortality between different ethnicities. However, in the in-hospital length of stay, although there is no statistically significant shorter spell duration or post-operation duration in ophthalmology, it has significantly shorter spell duration in the General Medicine department and the Diabetic Medicine department for Asian ethnicity. It is not clear whether it is because Asians are more likely to be discharged earlier than other ethnic groups when receiving non-surgical treatments.

Therefore, whether it is overall or separate treatment units, age is always an essential factor in the in-hospital length of stay or in-hospital mortality. The higher the age, the greater the IRRs for the hospital stay in the hospital compared to the lower age group, and the higher the in-hospital mortality.

8.5 SUMMARY

From Chapter 6 to Chapter 7, there is an undeniable trend, that is, patients with mental disorders, whether in-hospital length of stay or in-hospital mortality, have statistically significant differences, higher than patients with physical disorders or patients with diabetes only.

In this chapter, the findings showed that in the ophthalmology department, especially when the patient has mental disorders, there is a statistically significant difference for the hospital length of stay (whether spell duration or post-operation duration). When patients have mental disorders, hospital length of stay is 15 times higher than patients with diabetes only. Compared with patients with mental disorders in General Medicine or diagnostic medicine department, the AIRR value is only 3-5 times higher. This means that when an ophthalmologist treats diabetic patients with mental disorders, it can be expected that there will be a greater IRR for hospital length of stay compared to other treatment units.

Why is this phenomenon seen in the ophthalmology department alone?

In this study, 16,135 patients were admitted to the ophthalmology department, as well as 14,994 patients, were admitted due to ophthalmological surgery. It totally, 92.9% elderly patients with diabetes admitted in the ophthalmology department was because of

an eye-related surgery. In this study, the results showed that factors affecting the length of hospital stay in patients after surgery will, directly and indirectly, affect the overall length of hospital stay. In contrast, other departments, because the departmental characteristics are mainly medical treatment (non-surgical treatment), there is no such significant gap between the physical disorders group and the mental disorders group.

Asians account for about 5% of all treatment units, but in the General Medicine departments and the diagnostic medicine departments, which are mainly used in medical treatment, Asians have a significantly shorter hospital stay. The actual related reasons need further study. In this study, the results reflected that age is an important factor regardless of any treatment units. The higher the age, the greater the IRR for the hospital stay and the higher the in-hospital mortality rate.

As for the diabetic elderly with mental illness in the three major departments that treat diabetic elderly, compared with those who have diabetes alone, there is a statistically higher trend in the in-hospital mortality rate.

IMD quintile is related to the socioeconomic factor. Socioeconomic status has always been an essential factor that all research in public health must discuss. In this study, only in the spell duration of the ophthalmology department, it was observed that the subgroups with a lower socioeconomic status had more extended hospital stays and had statistical significance. As for other departments, the subgroups with different socioeconomic status have no statistical significance in terms of hospital stays. However, no statistical significance was found concerning hospital mortality between different socioeconomic subgroups in different treatment units.

8.5.1 Strengths & Limitations

The research in this chapter is specifically aimed at the treatment departments of older adults with diabetes and analyses whether the critical factors affecting the number of hospital stays in different departments and the crucial factors affecting hospital mortality are different. Due to different treatments, patients with diabetes will be admitted to different treatment departments. Therefore, the research in this chapter is mainly to analyse whether the number of hospital stays in the department and the in-hospital mortality rate is different after receiving different treatments if diabetes is combined with other medical or physical disorders in patients.

This chapter clearly shows that in the three departments that mainly treat in-patients with diabetes: ophthalmology, General Medicine, & diabetic medicine, elderly diabetic patients admitted to the ophthalmology department will have more extended hospital stays if they have a mental illness. Moreover, in the ophthalmology department, the number of days of hospitalisation of diabetic elderly with mental illness is 15 times greater IRR than that of diabetic elderly. More than 92% of the elderly diabetic patients admitted to the ophthalmology department were hospitalised because they needed surgery. As for patients who were admitted to the General Medicine or Diabetic Medicine department, diabetic patients with mental illness had significantly more extended hospital stays than those with diabetes only. Therefore, it can be known that in different treatment departments, if the elderly with diabetes have a mental illness, the difficulty and cost of medical care are greater.

Same as the previous chapters, the actual blood sugar data of each patient was not recorded in the database. Hence, the severity of diabetes, as well as physical or mental disorders for elderly patients with diabetes, cannot be examined in this study. The English IMD, the indicator of patients' socioeconomic status, was provided at the residential area level, not at the patient level. Individual exact socioeconomic status cannot be evaluated.

Although the MHA report showed that most older adults live in their own homes, however, there is still a certain percentage of older people living in specialist retirement housing or care homes (4% of people over 65; 15% of people over 85). Moreover, among the elderly living in care homes, up to 40% of the elderly suffer from dementia. It means that in the IMD data, a small number of older adults come from geographical clusters. It may explain why the socioeconomic status difference cannot be shown as a risk factor for higher IRR for spell duration or in-hospital mortality among elderly patient with diabetes.

All the possible confounding factors that I can obtain from Hospital Episode Statistics data were all put into statistical models to be controlled. However, there might be some other confounding factors that should be monitored but were not recorded in HES dataset.

Chapter 9. Discussion & Conclusions

9.1 Introduction

9.1.1 Diabetes is a critical burden around the world

Due to the advancement of medical technology, the improvement of the medical care system, and the popularization of public health plans, the average life expectancy of human beings has been continuously extended no matter in developing or developed countries. However, people's living habits, environment and work style were also changed at the same time, the prevalence and incidence of diabetes are increasing year by year due to changes in living habits and the ageing of the entire population. When the high prevalence of diabetes and an ageing society, the two most vital issues of 21st century have emerged, it has become one of the most critical public health topics for all the health authorities in many countries.

No matter in developed or developing countries, the prevalence or incidence of diabetes are rapidly increasing, according to the World Health Organization's estimation. The WHO report revealed that there would be more than 300 million diabetic patients in the world by 2025, most importantly, the proportion of T2DM in all diabetes patients will

continue to rise (Zhou et al., 2016). Although most of the diabetic children are T1DM, due to changes in children's eating habits, it is estimated that the proportion of T2DM in diabetes children will also gradually increase (Fagot-Campagna, 2000).

According to a 2019 report released by Statistia, the top three countries with the most diabetes patients are China, India, and the United States (statista, 2019). Among the top three countries, the United States has the highest prevalence of diabetes, according to a report from the International Diabetes Federation (Nam Han Cho (chair), 2015). The Third National Health and Nutrition Examination Survey (NHANES III) in the United States reported that the prevalence of diabetes for male and female over 60 years old are 20% (male) and 18% of (female).

The treatment of diabetes is complicated, and possible complications can cost a lot of medical resources because it requires long-term treatment. It is also because the treatment of diabetes requires the use of a large number of medical resources, the effective prevention of diabetes and its related complications, and the reduction of excessive use of medical resources, whether in developing or developed countries, are the most critical public health issues. According to the IDF research report, the current global per capita diabetes cost is

about USD 2000, and the total cost can reach about 1 trillion US dollars. About 70% of spending is concentrated in North America and Europe. North America has the world's highest per capita diabetes expenditure, with an average of approximately USD 8,000 per patient (da Rocha Fernandes et al., 2016).

Diabetes can cause acute or chronic complications in patients. When these complications invade vital organs, patients will face physical or mental disorders / disabilities. Because the organs are affected by hyperglycemia, blindness, amputation or complete loss of organ function and eventually leading to death are the common sequelae for diabetic patients. Therefore, the IDF report also showed that OECD countries are spending around 5% to 20% of health expenditures to treat diabetes and its complications.

Although now there are lots of medical treatments for diabetes: oral hypoglycemic agents, insulin injections, however, lifestyle interventions, including nutrition treatment exercise, and weight loss, is considered a more cost-effective way to prevent or control diabetes for individual perspectives. Furthermore, to reduce the risks for cardiovascular-related complications, closely monitor and control HbA1C, blood pressure and blood lipids are the cost-effective way to prevent diabetic patients from the leading cause of death.

9.1.2 Ageing is an unstoppable global trend

The United Nations and most of the countries around the world are all consider the rapid ageing population is the vital public health concern. It was estimated that there were around 700 million elderly adults over 65 years old in 2017, and this number will double by 2050, reaching 1.5 billion people, nearly 16% of the global population.

According to the World Population Review, Japan has the longest life expectancy in the world in 2019 (World Population Review, 2019). In recent decades, Japan has consistently ranked among the best in the world in terms of life expectancy. Inevitably, the Japanese government must also face the highest proportion of the elderly population in the world, with 10 million diabetic patients. It was estimated that among the elderly population over the age of 70, around 40% of elderly adults have diabetes.

The UK is also facing the same public health situation like Japan, an ageing society with a growing T2DM percentage among the elderly population. The burden of diabetes for the UK government due to the growing elderly population and the increasing diabetes proportion.

Furthermore, according to the United Nations' World Population Ageing report, because of the low total fertility rate and longer life expectancy in most of the countries, the old-age support ratio (ratio of 15-64 years old/65+ years olds) has dropped from 12 (in 1950) to 8 (in 2013). It is expected that this number might gradually bottom out. By 2050, the global old-age support ratio will be only 4 (United Nations, 2015). So it means the financial burden for either the working ageing population or the government will be stricter than the current situation.

Many studies have proved that T2DM is a proper indicator for quality of care for primary care. Good T2MD management and access to primary care can reduce government spending on healthcare. Moreover, to provide effective preventive measures, analyzing the contributing factors that lead to longer hospital length of stay is an essential first step.

9.1.3 Mental disorders for elderly is a vital public health issue

Ageing can cause nervous system deterioration and lead to mental

disorders for elderly adults. The common mental illnesses for the elderly population are dementia, depression, anxiety, and substance abuse. However, many reports showed that around 40% of older adults have more than one chronic disease. Diabetes is the primary chronic disorder that elderly adults have. Some studies had reported the association between mental disorders and microvascular circulatory abnormalities, insulin resistance and inflammatory cytokines due to diabetes (Baumeister et al., 2014).

Because of the high correlation between diabetes and the occurrence of mental illness, the elderly also have a higher chance of developing diabetes and mental disorders. Therefore, when caring for people with diabetes, the simultaneous assessment of diabetic elderly adults' mental state is necessary to the quality of care in older people.

In conclusion, in the care of diabetic elderly patients, psychological and physiological disorders are the vital factors to predict the outcomes of elderly patients with diabetes.

9.2 Summary of main findings

9.2.1 The impact of mental or physical disabilities on medical utilisation and cost for diabetic elderly patients

In Chapter 4, a systematic review was conducted. I found that there are only a few articles reporting the association between physical or mental disabilities, versus medical utilisation and cost among the diabetic elderly patients. Even fewer studies analysed mental disabilities impact on medical utilisation or cost for diabetic elderly adults.

Among the existing limited works of literature, regarding the mental disabilities and diabetes association, I found that diabetic elderly patients with schizophrenia have less medical utilisation but higher mortality rate compared to elderly diabetic patients without schizophrenia.

Concerning the association between physical disabilities and medical

utilisation, one study reported that diabetic patients with physical or visual disabilities had higher medical utilisation compared to diabetic patients without physical or visual disabilities. However, another article provided contrary evidence, reported the positive association between ADL score and medical utilisation. Patients with a better ADL score could have more medical utilisation, although diabetic patients were also found to have higher medical utilisation and cost compared to non-diabetic patients.

9.2.2 Factors related to hospital length of stay for elderly adults with diabetes

The impact of gender, age, ethnicity, social-economic status, and physical or mental disorders on hospital length of stay were analysed in Chapter 6. By accessing HES database and using the negative binomial regression models, I found that male gender, increasing age, white ethnicity, patients lived in more deprived areas, and patients with mental or physical disorders, on average, have a higher risk for longer hospital length of stay. Male diabetic elderly patients had a 10% higher Adjusted IRR for spell duration compared to female diabetic elderly patients. 85 years old above diabetic patients had a 2.12 times

greater Adjusted IRR for spell duration than 65 years old group. Patients who lived in the most deprived areas had a 12% higher IRR for spell duration compared to the patients lived in the least deprived areas. The Asian also found to have a 34% less Adjusted IRR for spell duration compared to the White ethnicity. Most importantly, the group of diabetic elderly with mental disorders were found to have the greatest Adjusted IRR (5.88 times higher) for spell duration among all the other predictors.

Although diabetes elderly adults with mental disorders were reported to the highest IRR for longer hospital length of stay; however, different types of mental illness have also shown different IRR results in my analyses. In both unadjusted and adjusted models, diabetic elderly patients with organic mental disorders (F00-F09) or mood disorders (F30-F39) reported being the top two subgroups with 5.77 and 6.54 times greater Adjusted IRRs for hospital length of stay compared to the reference group.

9.2.3 Factors related to in-hospital mortality for elderly adults with diabetes

Chapter 7 reported the impact of gender, age, ethnicity, social-economic status, and physical or mental disorders on in-hospital mortality among elderly patients with diabetes. By accessing HES database and using the logistic regression models, I found that male gender, increasing age, white ethnicity, and patients with mental or physical disorders, in both adjusted or unadjusted models, showed statistically higher risks for in-hospital mortality.

Female diabetic elderly patients had a 14% lower Adjusted OR for in-hospital mortality compared to male diabetic elderly patients. 85 years old above diabetic patients had a 4.93 times risk in-hospital mortality compared to 65 years old group. The Black ethnicity and Asian ethnicity showed a 48% and 34% fewer risks for in-hospital mortality the White ethnicity.

Regarding the impact of mental disorders and physical disorders, diabetic elderly patients with physical disorders had 5.65 times higher risk compared to the reference group. Furthermore, diabetic elderly patients with mental disorders had a 10.96 times risk for in-hospital mortality, the highest Adjusted Odds Ratio value among all the other predictors.

Subgroup analyses for diabetic patients with mental disorders were performed; surprisingly, some types of mental illness have shown much higher ORs. Diabetic elderly patients with organic mental disorders (F00-F09) found to have an extremely higher risk, 13.9 times higher risk for in-hospital mortality than the reference group. Diabetic elderly patients with mood disorders (F30-F39) also reported having an 8.45 times greater risk for in-hospital mortality compared to diabetic elderly patients without mental disorders. Both groups, Diabetic elderly patients with organic mental disorders (F00-F09) and Diabetic elderly patients with mood disorders (F30-F39) showed the top two highest risk group for in-hospital mortality.

9.2.4 Factors affecting hospital length of stay or in-hospital mortality when patients are treated in different treatment units

9.2.4.1 Elderly patients with diabetes in the ophthalmology department

Spell duration

The age-dependence effect on hospital length of stay was not shown

among elderly patients treated at Ophthalmology departments. However, the 80-84 years old group had the 2.08 times higher IRR for spell duration compared to the reference group. Furthermore, diabetic elderly patients with mental disorders showed a surprising high IRR for spell duration, 15.01 times higher IRR for hospital length of stay compared to the reference group. For patients with physical disorders alone, the IRR is only 4 times higher compared to the reference group. Compared to patients living in the least deprived areas, patients from more deprived areas had statistically higher IRRs for spell duration in both adjusted models or unadjusted models.

Post-operation duration

Female diabetic elderly patients were found to have a 70% statistically higher IRR for post-operation duration in the adjusted models. I did not see an apparent age-dependence effect on post-operation duration for patients admitted at Ophthalmology departments. Only the 70-74 years old group showed a 2.36 times higher IRR for post-operation duration compared to the reference group in adjusted models. Patients who lived in the more deprived areas were observed to have higher IRRs for post-operation duration compared to the patients from the least deprived areas.

9.2.4.2 Elderly patients with diabetes in the General Medicine department

Spell duration

There was no statistically significant difference between genders in either adjusted or unadjusted models. Asian ethnicity had 30% less IRR for spell duration compared to white ethnicity with statistical significance in adjusted models. Patients within this department had a clear age-dependence response. The older age, the higher IRRs for spell duration. Not surprisingly, with the presence of physical or mental disorders were the stronger contributing factors on spell duration in either adjusted or unadjusted models. Diabetic elderly patients with physical disorders had a 3.42 times higher IRR for spell duration, at the same time, diabetic elderly patients with mental disorders were observed to have 3.89 times higher IRR for spell duration compared to the reference group in adjusted models.

In-hospital mortality

There was no statistically significant difference in in-hospital mortality between genders. An apparent age-dependence effect on in-hospital mortality can be observed in both adjusted or unadjusted models. The older age groups had higher in-hospital mortality compared to the reference group. The oldest age group, the 85 years

old above group, had 3.79 times higher in-hospital mortality compared to the 65-69 years old group. Elderly diabetic patients with mental disorders were reported to have 3.17 times higher in-hospital mortality rate compared to the reference group. However, both ethnicity and social-economic status were not found to be the risk factors for in-hospital mortality in both adjusted or unadjusted models.

9.2.4.3 Elderly patients with diabetes in the Diabetic Medicine department

Spell duration

Even though gender was not a contributing factor to have a longer hospital length of stay for patients admitted in this department, age was still a significant factor for a longer hospital length of stay. There was a clear age-dependence response on hospital length of stay. The 85 years old above group had a 79% higher IRR for spell duration compared to the 65-69 years old group.

Compared to other predictors within my analyses, with the presence of mental disorders is still the most dominant contributing factor for spell duration. In the adjusted model, diabetic elderly patients with

mental disorders were found to have 5.12 times higher IRR for spell duration compared to the reference group.

Asian ethnicity group had a 52% less IRR for spell duration; on the other hand, Black ethnicity group had a 52% higher IRR for spell duration compared to White ethnicity group. Interestingly, patients who lived in the more deprived areas had lower IRRs for spell duration.

In-hospital mortality

There was no statistical difference in in-hospital mortality between genders. The age-dependence effect on in-hospital mortality was not found either. The older age groups had higher in-hospital mortality compared to the reference group. However, the eldest group, the 85 years old above group, had 3.25 times higher in-hospital mortality compared to the 65-69 years old group. Neither ethnicity nor social-economic status can be recognised as the risk factors for in-hospital mortality in both adjusted or unadjusted models. Diabetic elderly patients with mental disorders had 5.04 times higher in-hospital mortality rate compared to the reference group, but without statistical significance in both adjusted and unadjusted models.

9.3 Strengths and limitations of this work

Through the systematic review (Chapter 4), I found that there were very few articles that studied the impact of physical or mental disability on medical utilisation for elderly patients with diabetes. Studies related to mental disabilities were even less.

Chapter 4 shows that there are some hospital level studies, but only very few national-level studies have been published. The possible reasons maybe because it is easier to carry out research at the hospital level to obtain data on the actual disability of patients. However, if the study is to be extended to the national level, it is difficult to obtain disability data of patients if there is no disability registration data available or the disability database and the national database are not linked. Therefore, it is difficult to assess the association between disabilities and medical use among diabetic patients.

Older adults usually suffer from more than one of chronic physical or mental disorders in the real-world setting. However, most existing researches studied the effect of single disorder on medical utilisation or mortality. In order to answer the impact of multiple chronic physical

disorders, or even a combination of physical and psychological diseases among diabetic elderly patients, my work provides the robust evidence by evaluating the impact of multiple disorders including diabetes, physical and mental on hospital length of stay and mortality among elderly adults.

Since there are a few hospital hospital-level existing literature, but only limited national-level evidence on this topic. In the HES database I analysed, there is no data about the patients' physical or psychological disability. Therefore, I use the national data to assess the association between physical or mental disorders and medical use or in-hospital mortality.

I conducted a national level study to evaluate the impact of mental or physical disorders on medical utilisation, cost and mortality. The results of this study can provide a guide for the policymakers and healthcare providers to initiate early preventative intervention programs on reducing diabetic elderly patients with high-risk factors for the higher medical utilisation, cost and mortality.

Since there is only limited evidence reported the impact of the presence of physical or mental disorders on hospital length of stay among patients with diabetes, Chapter 6 provides the robust

quantified facts that diabetic elderly patients with other physical disorders can have a higher risk for longer hospital length of stay. Moreover, diabetic elderly patients with mental disorders can even stay longer in the hospital than diabetic elderly patients with physical disorders.

The association between predictors and diabetic patients' in-hospital mortality was evaluated in Chapter 7. This chapter provides convincing evidence that the presence of physical disorders among elderly patients with diabetes can lead to higher in-hospital mortality. The statistical impact of mental comorbidities on in-hospital mortality is much higher than patients with physical comorbidities. Diabetic patients with the presence of dementia (F00-F03) and depressive episodes (F32) have significant associations with in-hospital mortality. Increasing age, gender (male), and ethnicity (white people) also lead to higher in-hospital mortality among elderly patients with diabetes. Socioeconomic inequality was not considered as a risk factor for in-hospital mortality in the analyses.

Chapter 8 is specifically aimed at the treatment departments of older adults with diabetes and analyses whether the critical factors affecting the number of hospital stays in different departments and the crucial factors affecting hospital mortality are different. Elderly patients with

diabetes will be admitted to different treatment departments to receive different treatments. Therefore, Chapter 8 provides the robust evidence to understand whether the number of hospital stays in the department and the in-hospital mortality rate is different after receiving different treatments if diabetes is combined with other medical or physical disorders in patients.

Chapter 8 clearly presents that in the three departments that mainly treat in-patients with diabetes: ophthalmology, General Medicine, & diabetic medicine, elderly patients with diabetes admitted to the ophthalmology department will have more extended hospital stays if they have a mental illness. In the HES database, more than 92% of the elderly diabetic patients admitted to the ophthalmology department were hospitalised because they needed surgery. Moreover, in the ophthalmology department, the number of days of hospitalisation of diabetic elderly with mental illness has 15 times greater IRR for spell duration than that of diabetic elderly.

As for patients who were admitted to the General Medicine or Diabetic Medicine department, diabetic patients with mental illness had significantly more extended hospital stays than those with diabetes only. Therefore, it can be known that in different treatment departments, if the elderly with diabetes have a mental illness, the

difficulty and cost of medical care are greater.

Regarding the in-hospital mortality, diabetic elderly patients with mental disorders were found to have 3.71 times and 5.04 times higher in-hospital mortality for those who were admitted in the General Medicine department and Diabetic Medicine department, respectively.

Any database has its limitations, and the HES database is no exception. The HES database records the patient's disease diagnosis in as much detail as possible, but elderly adults might have too many complications or comorbidities, the relevant personnel does not record the not significant complications. Besides, some independent hospitals are not part of the NHS system, and patient records in these hospitals cannot be registered in the HES database.

Because HES does not provide with the actual blood sugar levels of diabetic patients, the severity of diabetes and the levels of diabetes control cannot be evaluated. Same as the severity of patients' physical or mental disorders, HES does not obtain the related information. The English IMD was used as the indicator of patients' socioeconomic status, but IMD was provided at the residential area level, not at the patient level. Hence, IMD might not truly reflect the exact socioeconomic status of patients.

Although the Methodist Homes (MHA) report showed that most older adults live in their own homes, nevertheless, there is still a certain percentage of older people living in specialist retirement housing or care homes (4% of people over 65; 15% of people over 85). Moreover, for those elderly patients living in care homes, around 40% of them suffering from dementia. It means that a small number of older adults come from geographical clusters in the IMD data. This could be one of the reasons why this study cannot show the effect of differences in socioeconomic status on the medical utilisation of older people.

My study is a secondary analysis of HES which is routinely collected data, therefore, my study is an observational study as I was not involved in primary data collection. Since the HES database has its limitations, I can only choose cross-sectional study designs for analyses. Although cross-sectional research has its advantages such as it can be completed within a specified period, and it is also suitable for various types of in-depth research and analysis. However, cross-sectional research also has its disadvantages, such as: unable to understand causal relationships and lack of dynamic and continuous observation. In my study, whether elderly patients get mental or physical diseases before or after they got diabetes, the order of illnesses cannot be confirmed. Besides, how long does it take to suffer

from mental illness to cause an increase in medical utilisation, and an increase in in-hospital mortality, the impact of the mental disorder exposure time cannot be estimated.

All the possible confounding factors that I can obtain from HES data were all put into statistical models to be controlled. However, there might be some other confounding factors that should be controlled but were not recorded in HES dataset.

All database analyses will face the problem of missing data. Since some patients do not have complete records, they cannot be included in the analysis. However, the rate of missing data in the elderly patient data that I analysed is tiny. Missing data should not affect the results of my research.

Besides, older patients are often faced with the problem of bed management when they are discharged from the hospital, which leads to older patients having to stay in the hospital longer than younger patients. If elderly patients need to be referred to the long-term care facility in the community to continue to receive long-term treatment, these patients will also need to stay in the hospital for a more extended period before they can find a suitable shelter. However, this factor resulting in more extended hospital stays due to

operational attempts made by the NHS cannot be distinguished in my research. However, since my research group is senior citizens, chances of experiencing longer hospitalisation time caused by this operational factor should be similar among all senior citizens. Therefore, this factor should not seriously affect my research conclusions.

9.4 Implications for policy and practice

The results of this study will be helpful for future primary, secondary and tertiary prevention, both in terms of policy and medical practice. The goals of current secondary prevention of diabetes are early diagnosis of diabetes, early active treatment allows patients to obtain optimal control, and avoid or reduce the deterioration of diabetes; furthermore, prevent diabetes complications.

The UKPDS and Diabetes Control and Complications Trial (DCCT) proved that in addition to blood sugar level (HbA1C level less than 7.5%), strictly controlling blood lipids and blood pressure (below 144/82 mmHg), will delay or reduce the future complications of diabetic patients (UK Prospective Diabetes Study (UKPDS) Group,

1998). However, these indicators are physiological indicators. My work confirms that, in addition to the physiological indicators that need to be taken seriously and treated, mental illness also needs treatment in order to effectively reduce the number of hospital stays and mortality of patients.

Chapter 6 suggests that male gender, increasing age, white ethnicity, living in the deprived areas, and patients with mental disorders, on average, have higher hospital length of stay. Chapter 7 shows that male gender, increasing age, white ethnicity are risk factors for diabetic elderly patients' in-hospital mortality. Most importantly, diabetic elderly patients with organic mental disorders (F00-F09) found to have 13.9 times as well as diabetic elderly patients with mood disorders (F30-F39) were reported having an 8.45 times higher risk for in-hospital mortality than the reference group. Chapter 8 reported that diabetic elderly patients with mental disorder has 15 times greater IRR for spell duration.

Therefore, for the treatment of diabetic elderly adults, the simultaneous assessment of patients' mental state is of great help in the success of early treatment and prevention of longer hospital length of stay as well as in-hospital mortality.

9.4.1 Clinical practice related applications

9.4.1.1 Diagnosis and evaluation of mental illness before admission

As the evidence in this study shows, when elderly patients with diabetes have a mental illness at the same time, when they are hospitalized, they need to be marked as a high-risk group to provide exceptional care. When elderly patients with diabetes are admitted to hospital, they are generally hospitalized due to poor physical conditions.

Therefore, it is recommended that in addition to the routine examination of physiological indicators, it is also suggested that patients receive a psychiatrist's consultation at least once to perform mental illness assessments to check whether elderly patients are suffering from dementia, mood disorders or other mental disorders. There are several published psychological measurements and scales for diabetes patients (Clare Bradley, 1994). If the diagnosis is confirmed, it is recommended that in addition to treatments for physical disorders, therapies for mental disorders are also required.

9.4.1.2 Self-care capability evaluation during hospitalization

Besides, it is also recommended to evaluate the patient's ability to live alone and self-care during the hospital stay. Patients with chronic diseases need to take medications regularly. However, for patient with dementia, it is very difficult. Studies had reported that dementia patients have self-care neglect due to memory loss (Feil et al., 2011). If the patients have poor drugs adherence or over-dose due to mental disorders, the quality of diabetes care will be significantly reduced. Some evidence has proved that solitary elderly male patients have poorer nutritional and health status than non-solitary elderly patients (Hsieh et al., 2010). Also, the primary caregiver needs to be instructed on how to determine whether the patient has proper drug compliance and whether the patient needs to see the doctor promptly. If the patient is an older adult living alone, it is recommended that relevant government units put such patients under control and regularly dispatch medical staff for home visits.

9.4.1.3 Pre-discharge risk assessment

Before the patient is discharged from the hospital, it is also recommended to perform relevant risk assessments to

comprehensively assess the patient's possible future medical utilization and mortality to determine the frequency of patients' hospital visits after discharge. Whether it is a regular visit at the clinic or a regular visit to the medical centre. Although there is evidence to prove that more frequent visits had better diabetes control (Kaufman et al., 1999), too frequent visits could be a huge burden for the healthcare system. Therefore, if we only focus on those high-risk groups could be a cost-effective solution. Some studies also reported that risk assessment can be helpful for quality of care (Giles et al., 2001). Furthermore, mortality risk assessments have been widely used in many diseases (Lankeit and Konstantinides, 2011).

It is realistic to establish a risk assessment model for diabetic elderly patient with mental disorders to reduce the mortality rate of these patients. Besides, the primary caregiver must also be assessed to understand whether the caregiver is capable of caring for the patient and whether the patient's condition has deteriorated. If the patient does not have a primary caregiver, regular visits by a district caregiver are recommended.

If these can be done, it will be expected to reduce medical costs and predictable future mortality effectively.

9.4.2 Policy applications

As my research has confirmed, if older adults with diabetes have specific mental illnesses such as dementia or mood disorders, the risk of hospitalization and death will increase significantly. Therefore, if there is a community care network, these high-risk groups who suffer from both diabetes and specific mental illnesses have special health management programs. If there are regular public health nurses or pharmacists to visit patients, as well as telephone interviews, to understand the current status of patients' self- chronic disease management, according to some public health initiatives reports, these patient-centred care programs can greatly improve the quality of treatment for diabetic patients, and all physiological indicators are also significantly improved (Edwards et al., 2012).

Besides, we can consider developing an App that assists patients with dementia or their primary caregivers to remind patients to take medication regularly, which will also help diabetes management in patients with dementia. Some studies have proved that App can be used for T1DM and T2DM control (Fukuoka et al., 2015, Cafazzo et al., 2012). However, whether these Apps can be used by patients with mental disorders, more studies would be needed.

For these high-risk groups, if there is a unique central database, all relevant clinical reports and treatment records of all patients during hospitalization and treatment at the clinic can be entirely recorded. Moreover, this database can be provided to physicians who treat these high-risk groups of patients, so that physicians can immediately obtain the patient's past treatment and examination records, which will help physicians to adjust treatment plans promptly. A study reported that to new technology to have a real-time patient centred treatments can be helpful for physicians and patients (Martin, 2008). There is evidence to show that a comprehensive database can improve the quality of care (Martin, 2008). Also, this database will help further research in the future.

9.5 Unanswered questions and future research

In this study, because the HES database is a national-level database, hospital-level data was not included, so the relevant biochemical data during the patient's hospitalisation were not recorded in the HES database. Therefore, the length of hospital stay and the cause of death in the hospital cannot be accurately explained through the HES database alone. Besides, whether the patient is disabled was not

recorded in the HES database. Also, since most patients are taken care of by the community clinics after they are discharged from the hospital, the treatment and examination data in the community clinics cannot be obtained from the HES database.

Therefore, in the future, I hope to use the HES database to connect to the hospital-level database to obtain biochemical examination data during the hospitalisation of patients, and understand why patients with dementia or mood disorders have such a high risk for longer hospital length of stay and in-hospital mortality. See if it is related to poor diabetes control? Or is it caused by the patient's mental illness poor management? Or does it make it difficult for patients to control chronic diseases due to mental illness? Besides, which biochemical factors are key indicators that can predict the number of days of hospitalisation and in-hospital mortality in these older diabetic patients with mental illness.

Therefore, in the future, I will hope to use the HES database to connect with Clinical Practice Research Datalink (CPRD) or other country-level databases or other emerging datasets such as SNOMED to fully understand when patients begin to have symptoms, what treatments they receive, why their condition improves or worsens, and even leading cause and contributing factors of death. In the future, I can link

to relevant social welfare agencies and other databases to understand whether the patient lives alone or lives with family members to understand whether family companion factors are also a critical prognostic factor if patients with chronic diseases suffer from dementia or mood disorders.

If I can use mobile phones to design some apps for recording patients' diet, exercise, and even consumption behaviours, and understand which behavioural factors are risk factors; it will also allow future public health programs to more accurately target different risk factors, and provide high-risk patients personalised prevention strategies.

9.6 Conclusions

No matter in developing or developed countries, diabetes is a heavy burden for governments around the world, and it will only get worse because the prevalence and incidence of diabetes are increasing year by year, the life expectancy of human beings has been continuously extended. It is also because the long-term treatments for diabetes are complicated, and possible complications can even cost more medical resources. According to the WHO report's estimation, there will be more than 300 million diabetic patients in the world by 2025, and the

proportion of T2DM among diabetes patients will keep increasing. Furthermore, the trend of increasing T2DM proportion will also occur in children, although T1DM has been the primary type of diabetes in children.

The United Nations estimated that there were around 700 million elderly adults over 65 years old in 2017. By 2050, this number will double, reaching 1.5 billion people, nearly 16% of the global population. Japan, as the country with the longest life expectancy in the world, has to face the population with the highest proportion of elderly adults. According to statistics, there are around 40% of elderly adults have diabetes among the elderly population over the age of 70. In total, Japan has about 10 million diabetic patients currently.

The increasing proportion of older adults in the population is a joy. We cannot avoid ageing, but we can prevent diabetes in older people or delay the progression of diabetes. Since diabetes can lead to acute or chronic diabetic complications, if the complications affect vital organs, patients have to suffer from physical or mental disorders/disabilities. According to my study, elderly patients with physical or mental disorders would spend more medical cost and have higher in-hospital mortality, therefore, having the effective prevention programs for diabetic elderly patients to reduce the excessive use of medical

resources, whether in developing or developed countries, is a very meaningful public health approach. Notably, due to the decreasing old-age support ratio, the working ageing population in most of the countries are facing the financial burden; therefore, effective programs to reduce medical cost are urgent.

There is only limited evidence presented the impact of the presence of physical or mental disorders on hospital length of stay and in-hospital mortality among diabetic elderly patients. This work provides robust quantified facts to prove that diabetic elderly patients with mental or physical disorders can have a higher risk for longer hospital length of stay and in-hospital mortality. Moreover, diabetic elderly patients with mental disorders have the most substantial impact on hospital length of stay and in-hospital mortality among all the predictors, including age, gender, ethnicity, and social-economic status. Most importantly, my work identifies explicitly that diabetic patients with dementia (F00-F03) or depressive episodes (F32) have significant associations with longer hospital length of stay and in-hospital mortality.

By considering the critical factors affecting the number of hospitals stay in different departments and the crucial factors affecting hospital mortality are different, my work provides the robust evidence to prove that elderly diabetic patients with mental disorders treated in

Ophthalmology department can have 15 times greater IRR for spell duration than that of diabetic elderly. The same trend for having longer hospital length of stay was also observed for elderly diabetic patients admitted to the General Medicine or Diabetic Medicine department. Within the three treatment units, diabetic patients with dementia (F00-F03) or depressive episodes (F32) were found to be significantly associated with higher in-hospital mortality.

Because the presence of mental disorders is such an essential factor for elderly diabetic patients' consequence, it is suggested that patients have better to receive a psychiatrist's consultation before hospital admission check whether elderly patients are with dementia, mood disorders or other mental disorders. During the hospitalisation period, patients' self-care capability should be assessed to understand whether they can manage their diabetes well by themselves. Otherwise, home visits by healthcare professionals are needed. Furthermore, before discharging from the hospitals, diabetic elderly patients with mental disorders are suggested to receive risk assessment. Patients with higher risk should visit hospitals or clinics frequently. Alternatively, for those disable patients, home visits should be arranged accordingly.

If we can develop some Apps to assist these patients, the burden of primary caregivers might be reduced. From the government perspectives, screening and early detection to those high-risk groups are cost-effective public health initiatives to prevent patients from higher hospital length of stay and mortality. However, further studies and data collection would be needed to provide a better patient-centred prevention program.

The results of this study can provide the evidence for the policymakers and healthcare providers before initiating effective, efficient and early preventative intervention programs on reducing diabetic elderly patients with high-risk factors for the higher medical utilisation, cost and mortality.

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Appendices

NEWCASTLE - OTTAWA QUALITY ASSESSMENT SCALE CASE CONTROL STUDIES

Note: A study can be awarded a maximum of one star for each numbered item within the Selection and Exposure categories. A maximum of two stars can be given for Comparability.

Selection

- 1) Is the case definition adequate?
 - a) yes, with independent validation *
 - b) yes, eg record linkage or based on self reports
 - c) no description
- 2) Representativeness of the cases
 - a) consecutive or obviously representative series of cases *
 - b) potential for selection biases or not stated
- 3) Selection of Controls
 - a) community controls *
 - b) hospital controls
 - c) no description
- 4) Definition of Controls
 - a) no history of disease (endpoint) *
 - b) no description of source

Comparability

- 1) Comparability of cases and controls on the basis of the design or analysis
 - a) study controls for _____ (Select the most important factor.) *
 - b) study controls for any additional factor * (This criteria could be modified to indicate specific control for a second important factor.)

Exposure

- 1) Ascertainment of exposure
 - a) secure record (eg surgical records) *
 - b) structured interview where blind to case/control status *
 - c) interview not blinded to case/control status
 - d) written self report or medical record only
 - e) no description
- 2) Same method of ascertainment for cases and controls
 - a) yes *
 - b) no
- 3) Non-Response rate
 - a) same rate for both groups *
 - b) non respondents described
 - c) rate different and no designation

NEWCASTLE - OTTAWA QUALITY ASSESSMENT SCALE COHORT STUDIES

Note: A study can be awarded a maximum of one star for each numbered item within the Selection and Outcome categories. A maximum of two stars can be given for Comparability

Selection

- 1) Representativeness of the exposed cohort
 - a) truly representative of the average _____ (describe) in the community *
 - b) somewhat representative of the average _____ in the community *
 - c) selected group of users eg nurses, volunteers
 - d) no description of the derivation of the cohort
- 2) Selection of the non exposed cohort
 - a) drawn from the same community as the exposed cohort *
 - b) drawn from a different source
 - c) no description of the derivation of the non exposed cohort
- 3) Ascertainment of exposure
 - a) secure record (eg surgical records) *
 - b) structured interview *
 - c) written self report
 - d) no description
- 4) Demonstration that outcome of interest was not present at start of study
 - a) yes *
 - b) no

Comparability

- 1) Comparability of cohorts on the basis of the design or analysis
 - a) study controls for _____ (select the most important factor) *
 - b) study controls for any additional factor * (This criteria could be modified to indicate specific control for a second important factor.)

Outcome

- 1) Assessment of outcome
 - a) independent blind assessment *
 - b) record linkage *
 - c) self report
 - d) no description
- 2) Was follow-up long enough for outcomes to occur
 - a) yes (select an adequate follow up period for outcome of interest) *
 - b) no
- 3) Adequacy of follow up of cohorts
 - a) complete follow up - all subjects accounted for *
 - b) subjects lost to follow up unlikely to introduce bias - small number lost - > ____ % (select an adequate %) follow up, or description provided of those lost) *
 - c) follow up rate < ____ % (select an adequate %) and no description of those lost
 - d) no statement

Newcastle-Ottawa Scale adapted for cross-sectional studies

Selection: (Maximum 5 stars)

1) Representativeness of the sample:

- a) Truly representative of the average in the target population. * (all subjects or random sampling)
- b) Somewhat representative of the average in the target population. * (non-random sampling)
- c) Selected group of users.
- d) No description of the sampling strategy.

2) Sample size:

- a) Justified and satisfactory. *
- b) Not justified.

3) Non-respondents:

- a) Comparability between respondents and non-respondents characteristics is established, and the response rate is satisfactory. *
- b) The response rate is unsatisfactory, or the comparability between respondents and non-respondents is unsatisfactory.
- c) No description of the response rate or the characteristics of the responders and the non-responders.

4) Ascertainment of the exposure (risk factor):

- a) Validated measurement tool. **
- b) Non-validated measurement tool, but the tool is available or described. *
- c) No description of the measurement tool.

Comparability: (Maximum 2 stars)

1) The subjects in different outcome groups are comparable, based on the study design or analysis. Confounding factors are controlled.

- a) The study controls for the most important factor (select one). *
- b) The study control for any additional factor. *

Outcome: (Maximum 3 stars)

1) Assessment of the outcome:

- a) Independent blind assessment. **
- b) Record linkage. **
- c) Self report. *
- d) No description.

2) Statistical test:

- a) The statistical test used to analyze the data is clearly described and appropriate, and the measurement of the association is presented, including confidence intervals and the probability level (p value). *
- b) The statistical test is not appropriate, not described or incomplete.

This scale has been adapted from the Newcastle-Ottawa Quality Assessment Scale for cohort studies to perform a quality assessment of cross-sectional studies for the systematic review, “Are Healthcare Workers’ Intentions to Vaccinate Related to their Knowledge, Beliefs and Attitudes? A Systematic Review”.

We have not selected one factor that is the most important for comparability, because the variables are not the same in each study. Thus, the principal factor should be identified for each study.

In our scale, we have specifically assigned one star for self-reported outcomes, because our study measures the intention to vaccinate. Two stars are given to the studies that assess the outcome with independent blind observers or with vaccination records, because these methods measure the practice of vaccination, which is the result of true intention.

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