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# Weight change patterns and healthcare costs in patients with newly-diagnosed type-2 diabetes in Sweden

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ABSTRACT

*Aims:* To describe weight-change pathways in patients with type 2 diabetes (T2D) and associated healthcare costs using repeated BMI measurements and healthcare utilization data.
*Methods:* Patients with newly-diagnosed T2D with body mass index (BMI, kg/m$^2$) at diagnosis and subsequent measures at year 1–3 were identified. Based on three-year BMI change, patients were assigned to one of 27 BMI change pathways defined by annual BMI change: BMI↗ (≥1 BMI unit increase), BMI→ (<1 BMI unit change), and BMI↘ (≥1 BMI unit decrease). Mean annual and three-year cumulative healthcare costs were estimated for each pathway by combining Swedish unit costs with resource use from primary care and national patient registers.
*Results:* Cohort consisted of 15,819 patients; 44% women, mean age of 61 years, HbA1c of 6.7% (50 mmol/mol), BMI of 30.6 kg/m$^2$. Most common BMI pathways (mean costs): BMI→→→ (€5,311), BMI↘→→ (€5,461), and BMI→→↘ (€6,281). General trends: BMI→→→ linked to lowest, BMI↗→↗ linked to highest costs.
*Conclusion:* In patients with newly-diagnosed T2D, weight stability was the most common BMI change pattern over 3 years and associated with lowest healthcare costs. Relationship between weight change and healthcare costs appears complex warranting further investigation.



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## 1. Introduction

Obesity is reaching pandemic levels making it one of the biggest public health problems leading to severe health problems [1]. Being overweight is a major risk factor for the development of type 2 diabetes (T2D) and a major contributor to the increased risk for cardiovascular (CV) morbidity and mortality among patients with diabetes [2]. The global obesity pandemic and subsequently increasing prevalence of T2D not only raise clinical concerns but also exert pressure on healthcare systems and society as a whole [3–5]. The economic burden of T2D is substantial and is already notable from an early stage of disease — individuals with diabetes incur healthcare costs twice as high as matched patients without diabetes in the first year after diagnosis [6].

Although glycemic control is the major goal in diabetes, reducing body weight or preventing weight increase is important and potentially cost-effective approach in successful management of T2D [7]. The clinical benefits of weight loss are emphasized by a number of clinical studies showing that even a moderate reduction in weight significantly improves metabolic control [7–9]. Recent studies, yet few and limited by short study duration, have also identified a link between body weight changes and healthcare costs [4,10–13]. Yet, to identify the true relationship is difficult given the complexity of disease itself and diverse confounding factors. Therefore, different methods and more comprehensive approaches applying repeated BMI and cost measurements over several years are required to establish this link and define the economic burden that weight increase in T2D incurs. Hence, our study aims at comprehensively describing BMI change pathways and link them to healthcare costs by using data from Swedish clinical settings.

## 2. Material and methods

### 2.1. Study population

Data for this study were collected from 84 primary-care centers in Sweden between 1999 and 2009 and extracted from the ROSE (Retrospective Epidemiological Study to Investigate Outcome and Mortality with Glucose-lowering Drug Treatment in Primary Care) study [14]. The index date of diagnosis was defined by the diagnostic code in the registry data or the first prescription of a blood glucose-lowering drug. The population of newly diagnosed patients included in this study were those with a body mass index (BMI, $kg/m^2$) measurement at diagnosis of T2D (taken within a window of 450 days prior to and 45 days after diagnosis). This population was narrowed down to individuals whose BMI measurements were taken at 12, 24, and 36 months after diagnosis (within a time window of ±90 days as depicted in Fig. 1). Individuals having a shorter follow-up than 36 months were censored at the time of last available measurement. Due to increased risk for involuntary weight loss associated with comorbidities, individuals with BMI <18 $kg/m^2$ at baseline, active cancer or heart failure at index were excluded from the analysis. Description of recruitment and data extraction from primary care records and registers have been described in detail elsewhere [2]. The $HbA_{1c}$ was retrieved according to the Mono-S method unit and was calculated to be equivalent with DCCT standard (HbA1c (%) = 0.9569 × HbA1c (Mono S) (%) + 1.182) [15]. The article is based on previously conducted studies, and does not involve any new studies of human or animal subjects performed by any of the authors.

### 2.2. Weight change pathways

Three annual BMI change categories were defined based on annual BMI change: BMI↗ (≥1 BMI unit increase), BMI→ (less than 1 BMI unit increase or decrease), and BMI↘ (≥1 BMI unit decrease). At least 1 BMI unit change was chosen as it was linked to clinically and economically meaningful outcomes in previous research [8,11,16]. Based on the observed individual BMI change patterns over three years, patients were assigned to one of the 27 possible BMI change pathways depicted in Fig. 2.

### 2.3. Healthcare resource use and costs

Healthcare resource use was available for the 3 years of maximum follow-up after diabetes diagnosis. Data were collected from electronic patient records in primary care and national patient registers and linked via the unique Swedish personal identity number. Three main categories of healthcare resource were collected. Primary care contacts, subdivided into physician, nurse, and other primary care profession such as podiatrist were extracted from the electronic primary care records [17] and further categorized into actual visits to a primary care center, phone contacts, home visits, visits to take a laboratory test, and other contacts such as prescription renewal that do not require face-to-face interaction. Hospitalizations were extracted from the Swedish National Inpatient Register and clustered into 10 diagnosis-related groups based on ICD codes (Cardiovascular, Gastrointestinal, Urogenital, Cancer, Respiratory, Endocrine, Musculoskeletal, Neurological, Infectious disease, and other causes). The third category of healthcare resource use was laboratory tests. These were extracted from the electronic primary care records. All consumption of healthcare resources was considered, both diabetes and non-diabetes related.

Swedish unit costs were applied to the healthcare resource use to estimate the healthcare costs. All relevant unit costs (expressed in year 2012 values [€1 = SEK 8.7034] and inflated to year 2015 level with a Consumer Price Index of 1.02604) are presented in Table 1 and have been obtained from publically available price lists [18–22]. Costs of pharmaceuticals and consumables (needles, blood monitoring stripes, lancets) were not included in the study given lack of prescription data for the full study period.

Based on observed healthcare resource consumption, mean per patient annual and cumulative 3 year healthcare costs for each BMI change pathway were estimated. Given the descriptive approach of the study, 95% confidence intervals (CI 95%) derived by bootstrapping are presented rather than p-values for hypothesis tests.

Additionally, pathways were clustered together and average three year cumulative costs were estimated. Early BMI