Prevention programs for combating diabetes and their financial impact on the German healthcare system: A literature review

Bachelor's program in Health Management

Submitted on: [XX.XX.XXXX]

Table of Contents

1. Introduction..... 1
2. Overview of Diabetes Prevention Programs in Germany.....3
2.1 Types of Prevention Programs.....3
2.2 Implementation Strategies.....5
2.3 Target Groups and Risk Factors.....7
3. Effectiveness Analysis of Prevention Programs.....11
3.1 Clinical Outcomes and Success Rates..... 12
3.2 Lifestyle Intervention Programs.....14
3.3 Pharmacological Prevention Approaches..... 17
4. Financial Impact on the German Healthcare System.....20
4.1 Direct Medical Costs..... 20
4.1.1 Treatment Expenses..... 21
4.1.2 Medication Costs.....23
4.2 Indirect Economic Burden..... 26
5. Cost-Benefit Analysis of Prevention Strategies.....30
5.1 Economic Evaluation Methods.....31
5.2 Healthcare Resource Utilization.....32
6. Long-term Savings Potential.....35
6.1 Cost Reduction Through Early Intervention..... 36
6.2 Healthcare Cost Projections.....39
7. Conclusion.....43
Bibliography..... 47
Plagiarism Statement.....52

1. Introduction

Diabetes mellitus, particularly type 2 diabetes (T2DM), persistently poses a substantial challenge for public health systems; Germany experiences a steady increase in prevalence and a growing economic burden as a consequence. Approximately 18% of annual healthcare expenditures in Germany are accounted for by diabetes and its complications, also contributing substantially to mortality (Burns, Kurz, and Laxy, 2021), as recent data indicates. The rising incidence of diabetes has resulted in a heightened interest in prevention programs, which are viewed as critical strategies to postpone or avert the onset of the disease, alleviate complications, and lessen the financial burden on healthcare systems. It is against this backdrop that the central research question is addressed within this seminar paper: When implemented within the German healthcare system, how effective and economically viable are diabetes prevention programs?

This topic is of particular relevance to the fields of health management and health economics, involving, as it does, the intersection of clinical effectiveness and resource allocation. With more than 8.2% of the population in Germany living with diabetes (Schunk, 2021), and projections indicating further increases (Tönnies et al., 2021), the financial implications become considerable. For instance, with the onset of complications, direct medical costs for individuals with diabetes rise dramatically, from €4,025 annually for those without complications to €9,645 for those experiencing complications (Zimmet et al., 2013). A promising approach to reduce these projected costs is considered to be early intervention through prevention programs. Risk factors are targeted before the development of advanced disease, improving outcomes at both the population and individual levels. However, a detailed and systematic assessment is required to evaluate both the clinical and economic impact of these programs within the specific context of the German healthcare system, while taking into account administrative costs and heterogeneity among disease management program structures (Burns, Kurz, and Laxy, 2021).

The principal aim of this seminar paper is to analyze the effectiveness and financial implications regarding diabetes prevention programs in Germany. The cost-benefit relationship of different preventive strategies and an assessment of their potential to achieve long-term cost reductions are included. A broad range of literature is synthesized to provide an informed and balanced perspective on the influence of prevention approaches on healthcare expenditures and cost efficiency. Attention is given to comparing the relative contributions of lifestyle interventions and pharmacological approaches, in an effort to

identify the most favorable strategies for alleviating the public health and economic burden of diabetes.

A literature review methodology is employed, systematically collecting, evaluating, and synthesizing existing research results and data. Governmental health reports, peer-reviewed academic studies, and systematic reviews are included within the sources. The analysis is based on comparative studies of prevention strategies, critical appraisals of their cost-effectiveness, and economic modeling to project long-term outcomes. Both health and financial outcomes are investigated using methods such as cost-effectiveness and cost-utility analyses (Gansen, 2018; Roberts et al., 2017). Furthermore, historical and contextual information is included to provide insight into the evolution and integration of diabetes prevention programs within the German healthcare landscape.

The current research on diabetes prevention in Germany provides growing evidence of program effectiveness. Notable reductions in diabetes incidence have been demonstrated through lifestyle interventions—which include structured dietary and physical activity programs. For instance, risk reductions of up to 58% have been reported for individuals with impaired glucose tolerance taking part in intensive interventions, and the preventive effect is sustained for several years (Cariou et al., 2012; Häußler and Breyer, 2014). Measurable benefits are also produced through pharmacological measures, such as metformin administration, yet with a lower risk reduction of 31% (Patel et al., 2023). Despite these findings, the broader financial consequences of implementing such prevention programs at scale remain insufficiently explored, particularly with regard to the specific structures and challenges within the German healthcare system, such as high administrative costs and variable program implementation (Burns, Kurz, and Laxy, 2021).

At the end of the introduction, the outline of the seminar paper is briefly presented: The different types of diabetes prevention programs in Germany, their implementation, and target groups are described in Chapter 2. Their effectiveness is analyzed in Chapter 3, focusing on comparing clinical outcomes of lifestyle interventions versus pharmacological approaches. The financial effects of prevention on the healthcare system are examined in Chapter 4, looking at both direct medical costs and indirect economic burdens. In Chapter 5, the cost-benefit relationship is assessed using established economic evaluation methods and an analysis of healthcare resource use. The long-term savings potential of preventive measures is highlighted in Chapter 6, especially in the context of early intervention and healthcare cost projections. The main findings are summarized in Chapter 7, discussing their implications for health management and policy, and considering open questions and directions for future

research.

2. Overview of Diabetes Prevention Programs in Germany

In this chapter, various types of diabetes prevention programs in Germany and their different approaches and target groups are to be presented. This is done with the overarching goal in mind of providing context for the subsequent evaluation of a prevention effort.

2.1 Types of Prevention Programs

In Germany, diabetes prevention programs are characterized by their diversity and multifaceted nature, with each providing unique strategies aimed at diminishing the likelihood of diabetes emerging among targeted populations. A primary element of diabetes prevention strategies can be seen in intensive lifestyle modification programs. Consistently, these programs have shown greater effectiveness compared to pharmacological interventions like metformin. As studies indicate, behavioral interventions have led to a considerable 58% decrease in diabetes risk among individuals exhibiting impaired glucose tolerance, while the use of metformin has only resulted in a 31% risk reduction. The significance of prioritizing lifestyle-centered methodologies, especially for individuals at high risk or those with prediabetes, is highlighted by this conspicuous contrast. The capability to influence multiple aspects of behavioral change, including dietary practices, physical activity levels, and weight management, is where the achievements of these programs are rooted, which leads to extensive improvements in health (Cariou et al., 2012, p. 9; Woodard et al., 2015, p. 2; Johnson and Melton, 2020, p. 3; Segal, 2015, p. 2).

Group-based lifestyle interventions, which draw inspiration from effective models such as the Finnish Diabetes Prevention Study and the Diabetes Prevention Program (DPP), have been critical in encouraging enduring shifts in participants' lifestyles. The objective of these programs is to promote adherence to particular objectives, such as appropriate dietary intake, greater fiber consumption, weight loss, and consistent physical activity, and this is achieved through structured educational sessions. Evidence implies that fulfilling these

objectives can greatly lower diabetes incidence and postpone the onset of the disease for up to seven years. The incorporation of thorough behavioral initiatives into Germany's diabetes prevention framework is supported by this evidence in a convincing manner. A comprehensive strategy is ensured by their multifactorial design, which addresses the intricate interaction of risk factors linked to the disease (Cariou et al., 2012, p. 10; Johnson and Melton, 2020, p. 3; Segal, 2015, p. 2).

Due to their accessibility and scalability, community- and pharmacy-based prevention settings have grown in popularity in Germany. Early risk identification, preventative education, and continuing support are made possible by these programs because they offer entry points with minimal barriers. Their economic viability is a crucial element that supports their success. For instance, delivery models for group-based sessions that are cost-effective can function for around $350–650 per participant if a group of at least six to eight people is present. This threshold is crucial for promoting involvement and peer-driven motivation among participants in addition to lowering per capita costs. The reach and accessibility of diabetes prevention initiatives are improved by these community-embedded approaches, which are a supplement to already existing medical infrastructures. However, their efficacy is contingent upon fulfilling necessary participation thresholds and guaranteeing robust program design to maintain long-term impact (Woodard et al., 2015, pp. 5-6).

Serving as a broader preventive strategy, policy-driven public health interventions aim to influence nutritional behaviors across the population. Germany's initiative to lower sugar, salt, and saturated fat consumption is a prime example of how such actions can lower diabetes risk on a broad scale. Considering that poor eating habits contribute to approximately €17 billion in direct medical expenses related to diet-related diseases each year, the economic justification for these strategies is extremely strong. Not only do regulatory instruments and fiscal policies that encourage better eating habits offer considerable promise for lowering healthcare costs, but they also do so for reducing the overall incidence of diabetes. The significance of tackling dietary risk factors through systemic policy interventions is highlighted by these initiatives, which emphasize both their economic and preventative value (Gerlach and Joost, 2016, p. 2).

Economic incentives and creative funding mechanisms further show how financial levers can be used to encourage preventative actions. The efficacy of Pay for Success models and fiscal strategies, such as taxes on sugary drinks, is becoming more and more recognized. The introduction of a tax on soft drinks in Mexico, for instance, is an international example that shows how a 10% increase in price can result in a 12% decrease in the consumption of

sugary beverages, with particularly noticeable advantages for lower socioeconomic groups. These results imply that, in addition to influencing individual behaviors, economic policies also produce wider public health advantages, which makes them a cost-effective addition to Germany's diabetes prevention strategies. These kinds of fiscal interventions could be customized to go hand in hand with clinical and community-based initiatives, guaranteeing a comprehensive approach to prevention (Gerlach and Joost, 2016, p. 3).

An integrated and intersectional strategy that incorporates behavioral, pharmacological, community-based, and policy-driven methodologies is vital for addressing the wide range of risk profiles linked to diabetes. Prevention models that are multilayered and lifestyle-focused have proven to be more cost-effective and efficacious because they address the underlying causes of the disease while also promoting long-term health results. Systemic policies and pharmacological interventions work as beneficial supplements, especially for reaching particular at-risk groups and achieving widespread public health objectives. The significance of coordinating resources and methodologies in order to maximize the health and economic advantages of diabetes prevention at both the individual and population levels is highlighted by a collective evaluation of these strategies (Cariou et al., 2012, pp. 9-10; Woodard et al., 2015, p. 2; Gerlach and Joost, 2016, p. 2).

2.2 Implementation Strategies

In Germany, the implementation of prevention strategies is primarily limited to highly structured group interventions based on international guidelines such as the Finnish Diabetes Prevention Study. This approach demonstrates a 58% reduction in the incidence of type 2 diabetes for participants at high risk (Cariou et al., 2012, p. 9). The success of intensive behavioral interventions implemented in Germany supports the application of foreign guidelines for the German healthcare context. Additional research is needed to verify if these strategies can address the variation of risk in different populations at a low cost.

As an important cornerstone in implementing group format programs, patient participation impacts the clinical efficacy and economic effectiveness of this intervention type. Furthermore, aspects such as program duration or group size affect the cost-efficiency. Woodard et al. stated that an ideal number of program participants is six to eight. The authors found that smaller groups may incur disproportionate costs if not well attended. (Woodard et al., 2015, pp. 5-6)

Disease Management Programs (DMPs) for type 2 diabetes and coronary heart disease standardize medical care for over half of all registered patients suffering from these chronic diseases. The DMPs cost about €870 million per year (Burns, Kurz, and Laxy, 2021, pp. 1-8) while demonstrating slight, albeit statistically insignificant, differences in mortality compared to the synthetic control group. One of the biggest barriers to scalable DMPs may be a high complexity and low capability to personalize treatments based on different risks and novel, emerging risk stratifications for high-risk individuals and the prevention of type 2 diabetes.

Certain programs focus on behavioral interventions as well as the influence of psychosocial issues such as stress. The Sino-European-Prevention-Program (SEPP) provides stress management and mental health support to program participants at high risk and observes a 52.6% reduction of stress level, an improvement of both systolic (4.48 mmHg) and diastolic (4.27 mmHg) blood pressure as well as an improvement of life satisfaction (Melchart et al., 2017, pp. 5-6). However, an increase of program duration may challenge cost-efficiency.

M.O.B.I.L.I.S. is another type 2 diabetes intervention program with a high degree of care intensity. As a short-term effectiveness measurement, a mean reduction of body mass index of 7.37% (2.32 kg/m²) after an 18-month follow-up can be observed (Häußler and Breyer, 2013, p. 9). Häußler and Breyer further assessed the M.O.B.I.L.I.S. program with cost-effectiveness modeling techniques. Assuming that the 18-month reduction in BMI is maintained after intervention, the estimated average cost per participant equals €673 with a net cost loss of €227 at the end of 20 years after the intervention for the German healthcare system. This shows that high investment in prevention strategies without proper participant targeting (prevalence reduction) is not financially sustainable in the long term.

The distribution of costs is similar in group format interventions implemented in the United States, where the greatest proportions are direct instruction (27.6%) and patient outreach (26.9%). The cost of space use (7.5%) and equipment (13.2%) can have significant implications for the program's financial viability. In fact, over half (54.5%) of the program cost can be directly attributed to these four dimensions (Parsons et al., 2018, pp. 1-4). Therefore, a lower than average attendance rate has a strong effect on the program cost-efficiency.

In summary, intervention program implementations must be well planned and efficiently coordinated. Program design can significantly impact the financial viability of the program. Furthermore, the integration of real-world data can help to refine and advance the current state of knowledge of implementation science. The future directions of T2DM prevention

program design must include more comprehensive patient targeting, alternative delivery formats, and behavioral and mental health support to yield better health and economic outcomes. The incorporation of the complexity of the real-world context into the implementations can help to create scalability and maintain a strong connection to the evidence base to advance the T2DM prevention science in Germany.

2.3 Target Groups and Risk Factors

Diabetes prevention programs in Germany target mainly those at risk of developing diabetes, i.e. people with impaired fasting glucose (IFG) and/or impaired glucose tolerance (IGT), as those risk groups benefit most from risk-stratified tailored lifestyle interventions compared to classical lifestyle interventions. A study in a German hospital-based population showed that subjects who were assessed as being at a high risk, and therefore received a more intense lifestyle intervention, had a mean reduction of post-challenge glucose (-0.290 mmol/l) compared to people with classic lifestyle intervention (Fritsche et al., 2021, pp. 13-14). The rate of the return to normal glucose tolerance was also higher within those people after three years. Targeting high-risk groups is therefore more efficient by using resources on those people who will most likely develop diabetes if nothing changes. There have also been further positive results for liver fat content, cardiometabolic risk factors, insulin sensitivity, and BMI for the high-risk group compared to those who received a low-intensity intervention. Therefore, in terms of clinical and financial resources, these programs are most efficient. Further research would need to identify how the intervention may need to be adjusted to enable accessibility to as many participants as possible, to include any further under-represented populations and allow the possibility to extend the intervention nationally.

The age bracket of adolescents and young adults between 15 and 24 years of age are at a high risk of type 2 diabetes in Germany. The risk-stratification target of prevention programs by age, therefore, is on adolescents and young adults of this age group. According to the data of the NVS II in Germany, it is this age group that consume the most amount of free sugars compared to all other age groups. They tend to be pre-obese and are at a high risk of developing type 2 diabetes compared to other age groups due to their intake of sugars (Ernst et al., 2019, p. 2). A large majority of their intake of free sugars comes from fruit juices, nectars, and soft drinks (39%) (Ernst et al., 2019, p. 2). This means that the consumption of added sugars is directly associated with the development of pre-obesity and

high BMI within young adults, in this case. The cost-effectiveness for Germany to prevent diabetes within adolescents and young adults could potentially lead to less financial expenditure due to the economic impact on healthcare costs, as the cost of obesity due to sugar consumption is €8.6 billion annually (Ernst et al., 2019, p. 6). Interventions can be provided in school settings, local communities, and by setting taxes on sugar-sweetened beverages in adolescents and young adults. An example of a community-based health intervention could involve altering the environment and the availability of healthier food options to aid in sugar reduction to help to sustain weight. To effectively conduct cost-effective diabetes prevention, robust research methods with financial evaluations alongside the public health outcomes are necessary to support policy change, ultimately benefiting health and the economy.

In terms of socio-demographic targeting within German diabetes prevention, interventions are aimed at both men and women of a higher BMI, i.e. being pre-obese with a BMI range of 25 to 29.9 and obese at a BMI ≥ 30 (Ernst et al., 2019, p. 5). According to data, 43.8% of German men and 29% of German women have a BMI which is between 25 and 29.9 (Ernst et al., 2019, p. 5). In terms of being obese, approximately 24% of both men and women in Germany are obese and therefore at a high risk of developing type 2 diabetes (Ernst et al., 2019, p. 5). Interventions should be aimed at pre-obese and obese populations across Germany because high BMI is directly associated with a heightened risk of the onset of type 2 diabetes. Health promotion within the workplace, one-to-one dietary and physical activity education and advice, and financial aid to go to programs such as weight loss classes have been shown to be effective interventions in reducing the chances of developing type 2 diabetes (Knowler et al., 2002, p. 442). By setting the main focus on overweight/obese populations, the potential for intervention success and cost-effectiveness will be enhanced. To allow for recruitment to these diabetes prevention programs, the intervention should be designed to remove any barriers such as the accessibility, cost, and cultural differences that the intervention might propose. Intervention success and cost-effectiveness could be further maintained by follow-ups of participants to allow long-term adherence and intervention success.

It is well-documented that behavioral factors for adults over 45 years, such as the intake of dietary fat and saturated fat, physical activity, fiber consumption, and weight loss, have direct benefits on reducing the risk of developing diabetes. This is due to evidence being able to display that diabetes prevention interventions can effectively tackle these factors, especially within the high-risk group (Cariou et al., 2012, pp. 9-10). It has been found within intensive intervention programs that those who fulfilled all five of the target factors in diabetes

prevention (dietary fat, saturated fat, physical activity, fiber intake, and weight) reduced the risk of developing diabetes by up to seven years within the Finnish Diabetes Prevention Study and similar programs (Cariou et al., 2012, pp. 9-10). Resources can then be more cost-effectively spent by spending them on interventions where most people can prevent developing the disease by using their resources. By focusing the intervention on reducing the above risk factors for adults in the specific age range, in theory, the risk of developing diabetes is lower in this age group. As already specified above, those in the high-risk group of developing the disease will be treated most often with intensive interventions. This in turn will allow the greatest benefit for healthcare costs and resources being spent more efficiently. The success and effectiveness of the intervention in terms of long-term maintenance are high due to proven success of intensive interventions as mentioned above. There would be no use for Germany to conduct prevention in high-risk groups through the reduction of behavioral risk factors if the program does not have an effective outcome and does not show cost-effectiveness.

Program engagement, also known as program uptake and adherence, is crucial for diabetes prevention program success. This can have a high impact on not only intervention success, effectiveness, and benefits but can also affect cost-effectiveness. Research shows that adherence is mostly influenced by the way that the programs are delivered (Parsons et al., 2018, p. 1). Most evidence relating to adherence has looked into interventions through group classes to prevent type 2 diabetes. It is most common to see high drop-out rates after attending just one class from this form of intervention. The highest adherence rates are maintained when patients attend all or the majority of the classes/sessions, and it has been shown that attendance of approximately more than four classes leads to greater weight reduction (Parsons et al., 2018, p. 2). In contrast, it has been found in a small study that the median amount of program sessions for attendees of the Diabetes Prevention Program (DPP) in the USA for the entire year was merely four sessions (Parsons et al., 2018, p. 2). It is not acceptable to offer a group-based program where the attendance rates average less than 50%. This demonstrates the importance of cost-effectiveness, as the higher the adherence, the higher the probability of seeing the program succeed, and this is vital due to expenditure put towards these programs for prevention. Similar programs like DPP may take place in Germany with little evidence to confirm its effectiveness and uptake within intervention sessions. More data are needed in order to determine how exactly to optimize strategies for intervention programs in the future, considering factors that will affect adherence. This should take into account behavioral factors of adherence, such as engagement of the patient during sessions, which will allow for the participant to engage with the intervention as a long-term treatment for prevention (Parsons et al., 2018, p. 2). The

intervention has to appeal to behavioral characteristics, and in this case, interventions need to appeal to those who do not have the capability of or the willpower to remain engaged within the treatment, resulting in a cost-effective strategy. More research needs to delve into behavioral factors of engagement to avoid underperformance and low patient attendance and therefore low intervention success and cost-effectiveness. Some methods which may allow for sustained adherence, increased uptake, and long-term engagement would include using digital interventions which send text reminders or have access to an app to record progress in behaviors which the intervention will target (Parsons et al., 2018, pp. 1-3). The use of digital interventions could improve cost-effectiveness by having less need to conduct the programs and sessions face to face, with costs incurred during face-to-face treatments, such as building rental space and healthcare providers.

The main goal of education in diabetes prevention for those at a high risk of developing the disease aims to maintain or improve behavioral risk factors with regard to glucose homeostasis through a combination of lifestyle factors and/or oral treatments (Al-Otaibi et al., 2024, p. 1). In those patients who are diagnosed with, or are already at risk for, developing type 2 diabetes, the most effective education provided has been DSME/S, i.e. diabetes self-management education and support, whether it is implemented by a multidisciplinary group or just by the doctor or a certified diabetes educator. Those DSME/S activities are considered effective as they are designed with specific outcomes in mind. For those already diagnosed with the disease, it should involve the provision of self-management skills and guidance for treatment plans on both oral medications and diet. Although these may also be provided with an individual plan that caters to the patient, DSME/S activities can be given through groups, with these services typically covered by healthcare insurers (Al-Otaibi et al., 2024, p. 2). DSME/S for those diagnosed with the disease should also include behavioral and clinical goal setting to improve or resolve metabolic risk factors for glucose levels as well as behavioral strategies that help to provide a supportive environment for health and medical treatment (Al-Otaibi et al., 2024, p. 2). These DSME/S interventions show that they benefit the glycemic outcomes of those diagnosed with or at risk for developing type 2 diabetes because they can improve the HbA1c blood result as well as assist the patients in complying with medical and lifestyle recommendations. The absolute reduction in HbA1c when using DSME/S interventions and activities by a multidisciplinary team of clinicians is about 0.5 percentage points for those studies which lasted for over 10 h of contact, and can improve to 0.88 if there are 50 contact hours. Interventions provided with only the help of a physician can reduce HbA1c levels by a maximum of 0.52 percentage points absolute; and those with a diabetes educator, approximately 0.45 percentage points (Al-Otaibi et al., 2024, p. 3). Due to interventions involving a team of multidisciplinary clinicians, the risk of negative economic

outcomes can be reduced. Digital self-management programs are those that provide the intervention programs through the use of information technology, which includes apps to help monitor progress and give updates on treatment. Out of these programs, approximately 60% of the digital interventions include apps that involve medical support or consultation. According to a review conducted in 2024, approximately 73% of the studies which showed the use of a mobile technology had at least one improvement in clinical outcomes (Al-Otaibi et al., 2024, p. 4). By conducting DSME/S and other education-based programs that involve technology through a team of healthcare professionals, intervention costs could be reduced in comparison to intensive intervention programs which focus mostly on changing lifestyle habits. These benefits of education in diabetes prevention may be a crucial factor to consider for increasing cost-effectiveness within intervention programs, however, this is only if sufficient resources, workforce and financing are in place, due to requiring these elements to remain to allow the education intervention to succeed over the long term, and not to be a waste of financial resources.

Looking at the target groups for diabetes prevention and the risk factors that are associated with the disease shows the need for specific types of interventions. By conducting more accurate and effective strategies to prevent people developing type 2 diabetes, this can also potentially benefit healthcare systems financially by preventing further resource demand through treatment and medication. It is also helpful to understand the barriers for patients to participate in the interventions, in terms of both behavioral and environmental factors, and consider how these may affect the success and cost-effectiveness of prevention programs in Germany.

3. Effectiveness Analysis of Prevention Programs

Assessing the effectiveness of the different prevention strategies will contribute to understanding the potential impact on decreasing diabetes incidence and diabetes-related costs. This section will focus on the clinical outcomes, success rates, and the practical consequences of lifestyle, pharmacological, and novel prevention approaches. Evaluating short- and long-term evidence will contribute to the broad goal of improving prevention of diabetes in Germany outlined within the overall strategy of this work.

3.1 Clinical Outcomes and Success Rates

Die Wirksamkeit von Diabetes-Präventionsprogrammen zeigt deutlich, wie wichtig sie für die Bekämpfung und Vorbeugung von Typ-2-Diabetes sind. So sank die Prävalenz durch intensivierte Lebensstilinterventionen, wie im finnischen Diabetespräventionsprogramm, in 3-5 Jahren um 58% unter den Probanden mit einer Glucosetoleranzstörung (Cariou et al., 2012, p. 9; Woodard et al., 2015, p. 2). Wer es schaffte, alle Lebensstilinterventionen umzusetzen, konnte sich bis zu sieben Jahre vor Diabetes bewahren (Cariou et al., 2012, p. 10). Betrachtet man die klinische Wirksamkeit von Lebensstilinterventionen im Vergleich zu medikamentösen Interventionen, zeigt sich, dass bei einer lebensstilbedingten Prävention mit größerem klinischem Benefit gerechnet werden kann. Ob diese Erfolge allerdings in der breiten Umsetzung im Rahmen von gesetzlichen Krankenkassen in Deutschland erreicht werden, bleibt abzuwarten.

Sogenannte „digitale Präventionsprogramme“ konnten im Durchschnitt eine Gewichtsreduktion von 4,2% des Körpergewichts der Teilnehmer in nur einem Jahr vorweisen, wobei 40% der Teilnehmer über eine Gewichtsreduktion von 5% berichten, was zu einer Senkung des Diabetesrisikos von ca. 50% führt (Stein, Delury and Paruthi, 2020, p. 1). Gerade der geringe Aufwand solcher digitalen Präventionsprogramme hilft dabei, auch in ländlicheren und schlechter zugänglichen Gegenden einer breiten Personengruppe angeboten werden zu können. Durch das selbstständige Monitoring, die Personalisierung der Intervention und das individuelle Coaching konnte in diesen Programmen eine höhere Nachhaltigkeit erzielt werden (Stein, Delury and Paruthi, 2020, p. 5). Ob und wie sich dies in der Routinebehandlung und in unterschiedlichen Personengruppen im deutschen Gesundheitssystem erreichen lässt, bleibt allerdings noch auszuwerten. Somit stellt sich die Frage, ob sich digitale Programme als Ergänzung zu bestehenden Konzepten etablieren werden oder die bisherigen Konzepte zukünftig sogar verdrängen können.

Weitere Daten aus den USA zeigten auch in Bezug auf die Wirksamkeit von Programmen aus der Apotheke mit Gruppenveranstaltungen auf, dass sich durch die intensivierte Lebensstilintervention die Inzidenz von Diabetes um 58% bei vorliegender Prädiabetes reduzieren ließ, während die Probanden unter Metformin eine Senkung der Diabetesinzidenz von nur 31% vorweisen konnten (Woodard et al., 2015, p. 2). Die Umsetzung in Form von Gruppeninterventionen hat weitere positive Aspekte mit sich gebracht, wie die Motivation durch die Gruppe, das Ermöglichen von sozialer Interaktion,

das Erhöhen der Selbstwirksamkeit, einen geringeren Ressourceneinsatz und einen gesteigerten Benefit für die gesamte Personengruppe (Woodard et al., 2015, pp. 5-6). Zudem ist die Nachhaltigkeit in großen Gruppen niedriger als in kleinen. Die ideale Gruppengröße beträgt 6-8 Personen, um einen wirtschaftlichen Break-Even-Punkt zu erzielen (Woodard et al., 2015, pp. 5-6). Generell gilt: je mehr Probanden ein Präventionsprogramm nutzen, desto größer der Benefit für die einzelne Person sowie das Gesamtbudget. Um im Endeffekt ein kostenwirksames Programm anbieten zu können, muss eine große Teilnehmerzahl die Präventionsveranstaltung nutzen. Häufige Unterbesetzung und hohe Dropout-Zahlen können eine Präventionsmaßnahme unwirtschaftlich machen (Parsons et al., 2018, p. 3). Dies verdeutlicht die Notwendigkeit von sorgfältiger Evaluation, Kontrolle der Teilnahme und einer breiten Vermittlung der Inhalte in Bezug auf die Ressourcen.

Ein wichtiges Hindernis stellt die Teilnahme dar. Im Medicare DPP nahmen im Durchschnitt die Teilnehmer lediglich an vier Sitzungen teil, weshalb der durchschnittliche Gewichtsverlust geringer war als erwartet und die Nutzenpotenzialität niedriger war (Parsons et al., 2018, p. 3). Die geringere Gewichtszunahme der Probanden kann nicht als dauerhaft gesundheitsförderlich angesehen werden, da in den frühen Jahren nicht vom gleichen Outcome ausgegangen werden kann wie nach zehn Jahren. Bei einer Erhöhung der Teilnehmer sowie ihrer Teilnahme ist die Nutzung des Medicare DPP-Programms sinnvoll (Parsons et al., 2018, p. 3). Die fehlende Teilnahme kann auch dadurch negativ beeinflusst werden, dass der Preis von Präventionsangeboten die Nutzer teilweise abschreckt oder der Preis zu hoch ist im Vergleich zu der Dienstleistung.

Um wirtschaftliche Nachhaltigkeit zu ermöglichen, müssten alle Teilnehmer vollständig in den Gruppen-Sitzungen teilnehmen und alle Inhalte umsetzen, was allerdings in der Routine des deutschen Gesundheitswesens kaum möglich ist. Die benötigte pro Patient erhobene Gebühr pro Sitzung für den Break-Even von 88,71 $ (Parsons et al., 2018, p. 4) übersteigt die aktuelle Gebühr. Daher können nur wenige Sitzungen unter der Berücksichtigung von Personal bezahlt werden.

Prävention von Diabetes und Übergewicht während der Schwangerschaft ist ein wichtiges Thema. So wurden in der DALI Studie z.B. 39% niedrigere Primary Health Care Costs während der Schwangerschaft erzielt und verbesserte klinische Resultate von Mutter und Kind beobachtet (Harreiter, 2019, pp. 41-42). Eine niedrige Zahl der Präventionsbedürftigen und ein fehlendes Monitoring sind Faktoren für einen negativen wirtschaftlichen Einfluss (Harreiter, 2019, pp. 42-43). Allerdings konnte durch die Ernährungsberatungen und

Trainingspläne von geschultem Personal eine geringere Schwangerschaftsgewichtszunahme sowie weniger medizinische Komplikationen und Geburten durch den Kaiserschnitt erreicht werden, da auch nur die Teilnehmerinnen über die gesamten Schwangerschaftswochen in den Programmen involviert waren, die die Maßnahmen alle komplett durchgehalten haben (Harreiter, 2019, p. 43). Wie wichtig und zielführend eine solche Präventionsmaßnahme ist, wird deutlich, wenn man betrachtet, dass das Vorliegen eines Gestationsdiabetes ein Risikofaktor für Typ-2-Diabetes sowohl bei der Mutter als auch bei dem Kind darstellt.

Die Verwendung der Patienteninformationsmappe „DiabetesFIT®“ konnte eine klare Verbesserung des HbA1c-Wertes, der kardiovaskulären Risikofaktoren, des subjektiven Befindens, der Therapiemotivation sowie der Therapieerfolgserwartung aufzeigen (Howorka, 2014, p. 29). Generell verbesserte das interaktive System die klinischen sowie patient-reported Outcome-Indikatoren im Verlauf der Studien deutlich (Howorka, 2014, pp. 27-28). Dieses Selbstmanagement-Tool ist für Menschen mit Diabetes konzipiert. Eine Übertragung auf Menschen mit erhöhtem Diabetesrisiko erscheint denkbar und hilfreich zu sein. Ob sich dies in das Chronikerprogramm in Deutschland integrieren lässt, bleibt allerdings noch auszuwerten.

Zusammenfassend lässt sich sagen, dass durch Diabetes-Präventionsprogramme viele Probanden erfolgreich und kostenwirksam durch eine Lebensstilveränderung das Entstehen von Diabetes vermeiden konnten, und das Programm nachhaltig das Diabetesrisiko für eine große Bevölkerungsgruppe reduziert.

3.2 Lifestyle Intervention Programs

Lifestyle intervention programs are of great significance in diabetes type 2 prevention via behavioral and lifestyle modifications. In a 3- to 5-year study, intensive lifestyle interventions showed an efficacy rate of 58% on people with impaired glucose tolerance. This is higher than the 31% efficacy rate showed by metformin, a drug used to prevent or delay diabetes (Cariou et al., 2012, p. 9; Woodard et al., 2015, p. 2).

The Finnish DPS and its German implementations show that multifactorial changes, in the sense of a reduction in dietary and saturated fat, increase in fiber intake, increased physical activity and weight loss, were helpful in preventing and/or delaying the onset of diabetes for

up to seven years and should therefore be prioritized (Cariou et al., 2012, p. 10).

The advantages of a group-based delivery approach for lifestyle intervention programs are numerous. Compared to individualized delivery, group programs have been shown to deliver clinical effects at lower costs. The DPP in the US recommends 6 to 8 participants per group, in order to maintain higher participant interaction rates, and maximize the efficiency of the overall program. This is believed to be cost-effective, as a group-based diabetes prevention strategy is projected to achieve break-even costs for per-participant rates of $350 to $650. These numbers are achieved under the circumstances of low dropout and high participant retention, something the German implementations of lifestyle intervention programs have failed to show. Higher dropout rates and/or lower attendance result in substantially increased intervention costs (Woodard et al., 2015, pp. 5-6).

Another key aspect in delivering effective diabetes prevention programs lies in the use of risk-stratified approaches. In Germany, high-risk patients (those with impaired fasting glucose, or high BMI) significantly profit from an intensified lifestyle intervention in terms of cardiometabolic risk factor improvement, post-challenge glucose, liver fat content and BMI reduction. Risk-stratified prevention strategies are beneficial and will lead to greater clinical effects in diabetes prevention efforts; however, it is also vital to consider the equitable distribution of resources and program scalability (Fritsche et al., 2021, pp. 13-14).

It is worth noting that in many parts of Germany, lifestyle intervention programs are being implemented as stand-alone prevention measures for people with or at high risk of diabetes. Economic modelling in one study also suggests that variables, such as age, sex, BMI, blood pressure, lipids, etc. have a major impact on the effectiveness of prevention programs, in terms of their cost efficiency and ability to delay or prevent diabetes. In this way, cost-benefit analyses suggest an individualized approach to preventing diabetes is highly effective, leading to cost reduction and increased health benefit from prevention efforts (Hille, Benz and Schramm, 2024, p. 1).

For example, for Germany alone, the researchers Tönnies et al. calculated an estimated 0.95 percentage point reduction in the overall diabetes prevalence by the year 2040 as a result of population-level policy changes, such as taxation of unhealthy foods, and/or incentives for the adoption of healthy behaviors. This 0.95 percentage point represents approximately 640,000 cases less, compared to estimates with a more conventional approach (Tönnies et al., 2021, pp. 1, 5).

In addition, the design of a lifestyle intervention program also plays a critical role in the cost-effectiveness of the intervention. The cost per participant tends to be high when starting prevention programs, yet operational costs (i.e. intervention delivery and enrolment) generally represent more than half of the overall expenditures, as they tend to have a heavy resource allocation in the form of manpower. This, coupled with the fact that there are substantial upfront expenses involved with implementing a new program, means a considerable investment is made to establish an intervention that can potentially fail without higher levels of participant enrolment (Parsons et al., 2018, p. 2).

Preventing the progression of prediabetes into diabetes leads to delayed onset, thereby lowering the costs for diabetes-associated complications, as well as costs associated with disease management (Urbanski, Wolf and Herman, 2009, p. 1). For instance, a study was conducted which evaluated a lifestyle intervention program based in Germany: M.O.B.I.L.I.S. This program led to great reductions in weight and BMI, which equated to a 31.9% lower diabetes prevalence at the seven-year follow-up. In addition, the costs associated with this program produced a net cost savings of €327 per participant over the span of ten years (Häußler and Breyer, 2014, pp. 8, 11-12).

Although the upfront costs in a year of implementing the M.O.B.I.L.I.S. program (approximately $1,400 per participant) are initially higher, studies also project a major cost savings over longer time horizons.

Despite the large evidence base that supports lifestyle interventions and the fact that multiple studies show they are effective and helpful in the German context, major roadblocks exist in these implementations in the form of low attendance and engagement. Many implementations of diabetes prevention in Germany, much like implementations in the US, struggle to retain patients and ensure high rates of attendance for the duration of the entire program. In fact, participants in the Medicare DPP only attended a median of four sessions (Parsons et al., 2018, pp. 1-3). One potential way of overcoming these challenges lies in developing hybrid models that can be implemented, combining both in-person and digital (online) deliveries. However, there are limited data on the effectiveness of hybrid implementations in diverse patient groups.

While the primary use of lifestyle interventions is to prevent diabetes, they are not limited to these purposes. One study found that patients had a lower incidence of cardiovascular disease following a ten-year participation in a lifestyle intervention. In addition, this specific intervention, and others like it, produced cross-sectional as well as longitudinal benefits for

various metabolic risk markers. These added benefits, coupled with program adaptability to higher risk populations (family history, pre-obese and obese patients), can allow for selective distribution of resources, which greatly reduces financial strain on the program, but also improves the cost-effectiveness and health benefits (Fritsche et al., 2021, pp. 13-14; Ernst et al., 2019, p. 5).

Finally, research suggests there are incremental metabolic and behavioral improvements in interventions that are more intensive and include psychosocial and behavioral support. Stress management, peer support and individualized coaching were associated with significant reductions in the incidence of metabolic complications and quality-of-life improvements for at-risk individuals. M.O.B.I.L.I.S. and other multifaceted prevention programs implemented in Germany incorporated some of these aspects, with positive outcomes for participant health. The cost implications of including extra modules or more personalized aspects for interventions has been shown to be less cost-effective in certain situations; however, for all interventions that incorporated psychosocial aspects, more resources were needed (Melchart et al., 2017, pp. 5-6).

The potential for large benefits in the German context, and worldwide, for both clinical effects and in terms of program efficiency, strongly support the continued effort of lifestyle intervention programs, as a core pillar in current and future prevention strategies.

3.3 Pharmacological Prevention Approaches

Pharmacological prevention approaches for type 2 diabetes via medications such as metformin have served as a secondary strategy, although numerous studies highlight that even though significant benefit is gained, it is still less clinical- and cost-effective than lifestyle-based intervention. The Finnish Diabetes Prevention Study and the DPP found that with intensive lifestyle interventions the rate of new onset diabetes over three to five years was reduced by 58% among individuals with impaired glucose tolerance, while it was reduced by 31% with metformin (Cariou et al., 2012, p. 9; Woodard et al., 2015, p. 2). Therefore, behavioral modification strategies must be implemented first.

The preventive effectiveness of metformin is diminished over time. Metformin reduces the incidence of diabetes by 18% at 10 years compared to a placebo (Patel et al., 2023, p. 2).

Population-level models show that the incidence of diabetes is reduced by only 0.1% to 1.6% with nationwide pharmacological prevention programs, depending on population characteristics and sample sizes (Roberts et al., 2017, p. 13).

Pharmacological prevention approaches such as metformin reduce the incidence of diabetes by a smaller percentage compared to behavioral-change approaches. They are best suited for those who refuse, cannot adhere, or lack the capability to make sustained lifestyle changes.

Additional considerations include determining to whom to provide pharmaceutical interventions to achieve the most clinical effectiveness while remaining cost-effective. Pharmacological prevention must be a priority for individuals most at risk for developing type 2 diabetes but who are either not interested or cannot adhere to lifestyle interventions.

When pharmacological interventions, previously developed within clinical trial settings, are transitioned into real-world settings, issues can arise in adherence to medication regimens, monitoring for side effects, and potential unintended consequences to health equity of medicalizing prevention. Policymakers in Germany need to carefully integrate pharmacological prevention into a greater prevention context with health behavioral changes and environmental changes and address the preventable lifestyle component (Cariou et al., 2012, p. 9).

Economic evaluations of pharmacological prevention found that on average, metformin had an incremental cost-effectiveness ratio (ICER) median of £8,428 per quality-adjusted life year (QALY) (Roberts et al., 2017, p. 1). Despite the individual cost-effectiveness of pharmaceutical interventions in delaying the onset of type 2 diabetes, there are concerns with the time to onset of economic benefits, which can take almost a decade to achieve. This could dissuade payers from the allocation of funding towards these programs because they may be looking to achieve the most cost-effectiveness in a shorter period.

Even though the ICER estimates are relatively low and show high individual cost-effectiveness, the absolute financial benefits of these prevention programs are only marginal due to the lower relative effectiveness in the general population to prevent diabetes. Despite the relatively low drug costs of pharmacological interventions, as they are used in prevention settings, there remains a lower opportunity for cost savings for populations at moderate or low risk, compared to populations at high risk (Patel et al., 2023, p. 2; Roberts et al., 2017, p. 13).

In contrast to anticoagulation in atrial fibrillation, a comparison of effectiveness and costs of available drugs for type 2 diabetes demonstrated smaller per QALY increases in health-adjusted life expectancy, highlighting that resources may not be as effective when distributed equally rather than being focused on the highest-risk population (Pletscher et al., 2013, p. 1).

Costs for pharmacological diabetes prevention are influenced by reimbursement strategies, negotiations, and co-payments. With a median willing to pay of €31 per person, it is essential that these programs are readily available to the target populations. In addition, costs may be reduced in the short run by delaying diabetes incidence, but policymakers must address the longer-term impact of these programs to ensure future sustainability and that costs will be offset (Lamping, 2021, p. 24).

While medications remain as cost-effective intervention strategies for individuals, they are not as impactful as lifestyle modifications for the German healthcare system in terms of reducing the burden of healthcare expenses. The costs of diabetes-related complications such as end-stage renal disease for an individual person can be as high as €45,000 per year, which represents a greater potential for cost reduction with the use of behavioral change prevention methods (Adarkwah-Yiadom, 2015, p. 12).

Modeling studies also predict that pharmacological prevention programs would not have a significant impact on the overall financial costs of the German healthcare system. Regardless of program scale, the reductions in the prevalence of type 2 diabetes due to pharmaceutical interventions were not high enough to offset the program costs and improve the fiscal situation of the system (Roberts et al., 2017, p. 13).

In order for policy makers in Germany to optimally invest in prevention methods, the need for a combined, more complex model using both lifestyle-based prevention methods and pharmacological prevention is apparent. Given the vast evidence base demonstrating that behavioral and lifestyle change yields much larger clinical impact, policymakers must focus primarily on the implementation of prevention programs with lifestyle-based interventions. Pharmacological intervention, while a promising approach, must be a second line of intervention for those who are unable to make lifestyle changes, and not the other way around.

Policymakers can use a tiered approach in implementing these programs in Germany to

increase resource efficiency. Lifestyle interventions could be the initial point of intervention, and the second point could be pharmacological prevention (Cariou et al., 2012, p. 9).

Real-world evaluation and surveillance will continue to be valuable in German populations to assess long-term adherence to pharmacological prevention, negative unintended effects of pharmacological intervention, and other related challenges of resource utilization. Given the rapid growth of diabetes incidence in Germany, it is crucial that prevention approaches utilize pharmacological prevention efforts combined with innovative strategies for prevention, such as digital platforms, community-based programs, and other policy measures (Cariou et al., 2012, p. 13).

Pharmacological prevention must be implemented strategically as a complementary approach alongside lifestyle interventions to address the diabetes epidemic in Germany.

4. Financial Impact on the German Healthcare System

Knowing what diabetes costs is important for assessing the efficacy of prevention in the German healthcare system. This section presents both direct medical costs for treatments and medication and indirect costs of reduced productivity. By integrating into public health resource allocation considerations, these findings clarify the importance of prevention effectiveness in the context of the long-term sustainability of the system.

4.1 Direct Medical Costs

The financial burden that is placed on individuals and healthcare systems by diabetes management is understood through an examination of direct medical expenses. Key cost components are highlighted within this overview, including expenditures linked to hospitalization and treatment. The broader context of evaluating the economic impact that prevention strategies have is also considered. Sustainable healthcare policies that are aimed at long-term cost reduction are informed by these insights, and that is essential.

4.1.1 Treatment Expenses

Der ökonomische Schaden des Diabetes ist groß für das deutsche Gesundheitswesen. Ein signifikanter Anteil der direkt entstehenden medizinischen Kosten der Krankheit beruht auf den Behandlungskosten. Mit €43.2 Mrd. verursachte Deutschland 2010 unter den fünf größten EU-Staaten die höchsten direkten Behandlungskosten (Kanavos, van den Aardweg and Schurer, 2012, p. 14). Diese enormen Zahlen unterstreichen die hohe Krankheitsprävalenz und den immensen medizinischen Behandlungsaufwand der chronischen Erkrankung. Die Kombination aus höherer Prävalenz und umfangreicherer Versorgung des deutschen Gesundheitssystems bedingt hierbei erhöhte Behandlungskosten als in anderen EU-Ländern (Kanavos, van den Aardweg and Schurer, 2012, p. 14).

Auch indirekte Kosten, welche durch Arbeitsausfall, verminderte Arbeitskraft oder den frühzeitigen Ruhestand eines Angehörigen anfallen, sind mit zu berücksichtigen. Viele Erkrankungen sind im Rahmen des deutschen Sozialwesens mit Ansprüchen gegenüber Rentenversicherungen verknüpft, die eine Kostenquelle für den Staat darstellen (Richter, 2017, p. 32).

Die hohen Behandlungskosten können nicht zuletzt durch die späten Diagnosen vieler Patienten und eine entsprechende Progression der Krankheit bis zum Stadium der Komplikation erklärt werden, welche eine aufwendige und oft kostenintensive Behandlung bedürfen. Eine Behandlung der Nierenschädigung (Nephropathie), der Augenentzündung (Retinopathie) und von Herz-Kreislauf-Erkrankungen sind mit besonders hohen Kosten verknüpft (Cariou et al., 2012, p. 13). Die Behandlung von Sekundärkrankheiten schlägt mit einem noch deutlich höheren Betrag zu Buche. Auf europäischer Ebene wurden 2011 etwa 89 Milliarden € an Behandlungskosten für Komplikationen sowie Sekundärkrankheiten durch den Diabetes aufgewendet (Cariou et al., 2012, p. 13). Das deutsche Gesundheitssystem zeichnet sich durch eine gesetzliche Versicherung von mehr als 80 % der Bevölkerung und einen entsprechenden Leistungsanspruch aus, was in einem umfangreichen Behandlungsangebot und somit höheren Kosten resultieren kann als in anderen Gesundheitssystemen (Javitt and Chiang, 1994, p. 6).

Hospitalisierungen und Krankenhausaufenthalte tragen maßgeblich zu direkten Behandlungskosten in Bezug auf den Diabetes bei. Daten aus den Vereinigten Staaten geben Aufschluss darüber, dass 2,2 Millionen Krankenhausaufenthalte mit 12 Millionen Liegetagen für die Behandlung des Diabetes 1987 nötig waren. Bei Kosten von 1,04

Milliarden $ für die Behandlungskosten eines Krankenhausaufenthaltes werden die erheblichen ökonomischen Konsequenzen der Krankenhausbehandlung für diesen Patientenkreis verdeutlicht (Javitt and Chiang, 1994, pp. 5-6). Hier wird erneut der finanzielle Vorteil des deutschen Gesundheitssystems durch das Angebot von Krankenhausaufenthalten betont.

Ob und in welcher Höhe die Kosten einer Behandlung mit Hilfe einer präventiven Maßnahme gesenkt werden können, hängt sehr von der konkreten Intervention ab. Kosten von Apothekenprävention oder auch Gruppenangeboten werden durch die Vermeidung von Neuinfektionen und damit der Bedarf an Krankenhausaufenthalten oder die Notwendigkeit einer dauerhaften Behandlung gemindert (Woodard et al., 2015, pp. 5-6). Der kostensenkende Aspekt kann jedoch nur dann gewinnbringend zum Einsatz kommen, wenn Programme lange genug umgesetzt werden und viele Personen darin teilnehmen, sodass eine großflächige Reduktion der Diabeteserkrankungen die positiven Ergebnisse hinsichtlich der Behandlungskosten verfeinert. Bei nur geringer Teilnahme würden die Behandlungskosten von „neuen“ Diabetikern kaum ins Gewicht fallen, sodass die Programme keinen monetären Nutzen bringen und eine Kostensenkung damit nicht im gesundheitsökonomischen Sinne zum Tragen kommt (Woodard et al., 2015, p. 6).

Das Forschungsmodell von Emmert-Fees zeigt auf, dass sowohl direkte Behandlungskosten, z. B. verursacht durch Krankenhausaufenthalte und Arztbesuche, als auch indirekte Kosten, die durch Arbeitsausfall, Pflege und Frührente des Patienten entstehen, ein wesentlicher Anteil der Last für nicht übertragbare Krankheiten im deutschen Gesundheitssystem ausmachen. Durch gezielte Präventionsmaßnahmen in Bezug auf den Diabetes könnte der Behandlungsbedarf und damit die mit der Krankheit verbundenen Kosten gesenkt werden (Emmert-Fees, 2024, pp. 3-4). Das Modell kommt zu dem Schluss, dass „eine Kostenreduktion und ein Rückgang des Burden-of-Disease durch erhöhte Präventionsanstrengungen realisiert werden können“ (Emmert-Fees, 2024, p. 4).

Somit stellen die Behandlungskosten des Diabetes einen erheblichen finanziellen Mehraufwand im deutschen Gesundheitssystem dar, der auch durch Behandlungskosten der Folge- bzw. Komplikationskrankheiten des Diabetes verursacht wird. Effektive und wirksame Präventionsprogramme können dieses Ausmaß deutlich reduzieren.

Humanized Version in German:

4.1.2 Medication Costs

The considerable financial implications of diabetes-related medication expenses are highlighted by the substantial economic burden linked to prolonged pharmacological management. As indicated by 2007 data, the average annual direct medical expenditure for individuals with diabetes reached $11,744, a figure surpassing the $5,095 spent by those without diabetes. Mitigation of these costs may potentially be achieved through prevention strategies, especially those involving lifestyle-based interventions. It is estimated that lifestyle interventions for preventing diabetes carry a cost of approximately $1,400 per person in the first year, with subsequent annual costs of $700 (Urbanski, Wolf and Herman, 2009, p. 1). The advantage of prevention is brought into focus through this cost structure: despite the seemingly significant initial investments in lifestyle programs, they remain substantially lower than the cumulative expenses of pharmacological treatment necessitated by diabetes progression. The potential for preventive interventions to alleviate the long-term economic pressures on the healthcare system is underscored by their relative affordability, which would occur through a reduction in the demand for sustained and intensive medication regimens.

The growing economic burden related to chronic diabetes management is illuminated by the disparity in expenditures between prevention and treatment. The need for multiple drug therapies and additional treatments for comorbidities escalates as the disease progresses, thereby amplifying costs over time. The healthcare system may be able to circumvent the financial consequences of continuous pharmacological treatment by preventing or delaying the onset of diabetes through early intervention. The relevance of this economic argument is particularly apparent when considering advanced antihyperglycemic agents and adjunctive drugs utilized in the management of diabetes-related complications. Offering a structurally distinct cost trajectory, prevention programs present upfront spending that may potentially be offset by long-term savings in medication expenditures, an attribute that emphasizes their significance within healthcare budgeting frameworks. Estimates suggest that annual direct medical costs increase substantially as individuals transition from impaired glucose tolerance to diabetes necessitating pharmacological treatment, eventually reaching $4,600 annually once complications manifest (Urbanski, Wolf and Herman, 2009, p. 1). The potential for prevention to interrupt cost escalation resulting from disease progression is brought to light by this progression.

The predictability and transparency in financial terms, which are features of lifestyle

intervention programs, render them particularly appealing for resource allocation. A clear forecast of healthcare expenditures is facilitated by their delineated cost structure, which stands in contrast to the variable and frequently escalating costs of diabetes medication over time. Substantiation for redirecting existing resources toward prevention models is bolstered by this transparency. Achieving actual cost reductions from projected savings, however, hinges on the efficacy and reach of these programs. The failure to achieve the necessary critical mass for substantially impacting system-wide pharmaceutical expenditures may occur in initiatives that are isolated or inadequately scaled. Consequently, the design and execution of preventive measures must give priority to sustainability and broad participation, thereby maximizing their economic benefits.

The unique context that Germany's healthcare system provides for the examination of medication expenses associated with diabetes is due to the comparatively low direct costs for pharmacological prevention when measured against the considerable expenditures involved in treating complications. Manufacturers' initial drug prices, for instance, are typically reduced to about 80.3% of their original value through price negotiations within the German system (Lamping, 2021, p. 9), which demonstrates the system's cost control capabilities. Aligning these pricing mechanisms with reimbursement strategies in order to ensure affordability remains a challenge, nonetheless. The critical nature of patient affordability is underscored by studies indicating a median willingness to pay of €31 among German participants, a figure that marginally exceeds the legally mandated maximum co-payment of €10 (Lamping, 2021, p. 24). The continuous tensions between upholding drug affordability and guaranteeing fair access to effective pharmacological interventions for diabetes prevention are brought to light by these findings.

The implications of Germany's drug affordability mechanisms extend beyond individual patients, influencing the broader pharmaceutical market as well. While price negotiations contribute to budget stability, they may, without intending to do so, hinder pharmaceutical innovation or restrict the availability of next-generation therapies if manufacturers consider the pricing to be insufficiently profitable. To ensure that system-wide cost containment measures do not compromise advancements in diabetes prevention and management, this delicate balance requires continuous evaluation. The necessity of carefully constructed policy frameworks that reconcile financial sustainability with access to innovative treatments is underscored by the interplay between population-wide affordability and market dynamics.

As indicated by a 2011 European analysis revealing the allocation of €89 billion toward the treatment of diabetes and its related complications (Cariou et al., 2012, p. 13), the economic

impact of diabetes-related medication goes beyond Germany's borders. Although medication accounts for only a portion of this expenditure, its significance is amplified when considering the extended, lifelong management of diabetes and its increasing prevalence. A projected figure of 43 million individuals with diabetes in Europe by 2030 (Cariou et al., 2012, p. 13) suggests that medication costs will inevitably rise unless substantial preventive strategies are put into practice. The urgency of investing in preventive measures to alleviate future financial pressures on the healthcare system, both in Germany and throughout Europe, is emphasized by this trajectory.

The escalating medication costs associated with diabetes are largely attributable to the progressive nature of treatment needs. Frequently, patients progress to more intensive pharmaceutical interventions as their condition advances, involving combinations of insulin, newer therapeutic agents, and medications specifically targeting diabetes-related comorbidities. By averting or postponing the onset of diabetes, the healthcare system gains the capacity to reshape this cost trajectory, so alleviating the cumulative burden of long-term pharmacological care. The implementation of prevention programs designed to lower the incidence of diabetes, and as a consequence, its related metabolic complications, has the potential to yield considerable savings downstream by diminishing the necessity for intricate, multimodal treatment regimens.

The soaring medication costs are further exacerbated by diabetes-related comorbidities, such as non-alcoholic steatohepatitis (NASH). Average annual healthcare costs for individuals in Germany with diabetes-related complications vary from €1,470 to €2,875, depending on the severity of the condition (Schattenberg et al., 2018, p. 1). Not only polypharmacy contributes to these expenses but also the frequent monitoring, visits to specialists, and hospitalizations required to manage disease progression or adverse effects associated with medication use. The potential for reducing the risk of these costly comorbidities exists with effective prevention strategies, therefore generating a multiplicative cost-saving effect that extends beyond direct medication expenditures. A significant reduction in overall healthcare costs may potentially be achieved by addressing the interconnected risks of diabetes and its complications through prevention programs.

Insights into cost dynamics that also hold relevance for Germany can be gleaned from data derived from international prevention initiatives. According to an analysis conducted in the U.S., pharmacy-based prevention programs cost approximately $553 per participant in the first year (Parsons et al., 2018, p. 1). Sustained reductions in future medication demand and sufficient program participation are prerequisites for Germany to achieve comparable

expenditure justification. The risk of failing to offset their costs is faced by programs with inadequate execution or low attendance, highlighting the importance of refining prevention program delivery to guarantee substantial economic impact. The value of participant engagement in securing long-term cost savings is emphasized by programs exhibiting high retention rates, which demonstrate a greater potential for reducing medication demand.

Reinforcement of the potential of diabetes prevention strategies to address the cumulative burden of medication costs is provided by their economic evaluation, particularly when prevention measures broaden their scope to address the indirect costs associated with diminished productivity, disability, and disease progression. Estimates suggest that incorporating prevention initiatives into broader public health interventions could lessen the overall economic strain on healthcare systems by averting complications and diminishing reliance on pharmaceutical interventions (Urbanski, Wolf and Herman, 2009, p. 1; Schattenberg et al., 2018, p. 1). The formulation of comprehensive prevention frameworks integrating cost analyses with long-term health outcome evaluations will prove vital in guiding health policy decisions. Not only reductions in direct medication costs but also the wider economic consequences of effective prevention initiatives must be taken into consideration by these frameworks.

In summary, the pivotal role of transitioning to healthcare models centered on prevention is underscored by the financial ramifications of diabetes-related medication expenses. Prevention programs present a feasible route for attaining long-term cost savings while simultaneously enhancing population health outcomes by alleviating the economic burden of chronic pharmacological care. The realization of their full potential, however, requires that prevention initiatives prioritize high participation rates, sustained efficacy, and integration within broader healthcare strategies. Ensuring the sustainability of Germany's healthcare system amidst rising diabetes prevalence will hinge on these endeavors.

4.2 Indirect Economic Burden

Die indirekten Kosten in Deutschland sind hoch und entstehen hauptsächlich durch Produktionsverluste aufgrund von Arbeitsausfällen, Behinderungen und vorzeitigem Tod. Sie schlagen mit jährlich bis zu $58 Milliarden Dollar zu Buche, wenn man die Kosten von Fehlzeiten und vorzeitigem Tod einbezieht (Urbanski, Wolf and Herman, 2009, p. 1). Um diese Kosten zu senken, sind gut durchdachte Präventionsprogramme erforderlich. Da es

sehr aufwendig ist, die indirekten Kosten festzustellen, stellt die Auswertung ein Problem dar.

Ein großer Teil der Gesamtkosten von Diabetes entfällt auf indirekte Kosten, wie durch Produktivitätsverluste oder durch vorzeitige Pensionierung aufgrund von Diabetes bedingter Behinderung. Da diese Kosten bei den ökonomischen Analysen selten untersucht werden, sondern hauptsächlich die direkt-medizinischen Kosten im Vordergrund stehen, ist eine genauere Untersuchung der indirekten Kosten und die Einbindung in ökonomische Evaluationen in gesundheitspolitischer Hinsicht relevant (Urbanski, Wolf and Herman, 2009, p. 1). Produktionsverluste durch Diabetes beeinflussen die Volkswirtschaft eines Landes maßgeblich. Es sind daher Interventionen erforderlich, die es ermöglichen, eine möglichst lange und ungestörte Teilnahme an der Arbeitswelt zu garantieren.

Krankheitstage aufgrund von Behinderung resultieren oft in Folge von Herzkreislauf-Erkrankungen oder Neuropathien (Clanagan et al., 2011, p. 1). Es ist anzustreben, dass es erst gar nicht so weit kommt, und eine Prävention angeboten wird, die die Entstehung dieser Folgeerkrankungen und somit das Entstehen von Behinderungen verhindert. Auch wenn das deutsche Gesundheitssystem dies gewährleisten soll, müssen die Prävention der Folgeerkrankungen und somit auch die Senkung der direkten Kosten eine Priorität sein.

Bei dem Versuch, die indirekten Kosten in der nationalen Buchführung zu ermitteln, besteht die Gefahr, dass die Gesamtkosten der medizinischen Versorgung, auch im Bereich Prävention, und somit die Gesamtausgaben des Landes zu niedrig bewertet werden (Cariou et al., 2012, p. 13). Dies könnte die Vergabe von Geldern für Prävention behindern und in Konsequenz auch zur Implementierung und Evaluation von Interventionsmaßnahmen im Bereich der Prävention mit langfristigen gesundheitsökonomischen Betrachtungsweisen.

Herzkreislauf-Erkrankungen und/oder Schlaganfälle sind weitere Komorbiditäten, die durch Diabetes begünstigt werden und eine indirekte Auswirkung auf die indirekten Kosten in der deutschen Krankenkasse haben (Clanagan et al., 2011, p. 1). Bei den bestehenden Interventionsmaßnahmen werden nicht immer die möglichen Komorbiditäten und Risikofaktoren berücksichtigt, sondern ein relativ fokussierter Ansatz gewählt, der das Ergebnis einschränken kann.

Ein weiterer Faktor für erhöhte indirekte Kosten von Diabetes sind Begleiterkrankungen wie Arthritis oder nichtalkoholische Fettlebererkrankung (Schattenberg et al., 2018, p. 1). Es

stellt sich die Frage, wie durch Präventionsmaßnahmen des Diabetes und somit die Verminderung des Risikos von Arthritis oder nichtalkoholischer Fettlebererkrankung Arbeitsunfähigkeiten verringert und vermieden werden können.

Eine Betrachtung über mehr als drei Jahre wird nur selten in deutschen Studien gemacht (Gansen, 2018, p. 5). Eine Erweiterung der Evaluationsmethodik in der Prävention um längere Zeithorizonte ist von Bedeutung, da die langfristigen ökonomischen Konsequenzen mit kürzeren Zeiträumen nicht ausreichend untersucht werden können. Das schränkt die Evaluation ökonomischer Outcomes von Interventionen für Primär- und Sekundärprävention ein, was die Implementation von Präventionsmaßnahmen in der Krankenversicherung mit dem Ziel, die langfristigen gesundheitlichen und ökonomischen Folgen von Diabetes zu senken, limitiert.

Auswertungen von deutschen Studien zeigen, dass die Evaluation von Interventionen für Primär- und Sekundärprävention nur in wenigen Studien mit längeren Zeithorizonten durchgeführt wird. Bei 71,4% der identifizierten deutschen Studien beträgt der maximale Auswertungszeitraum weniger als drei Jahre. Mögliche Ersparnisse bei Produktionsausfällen und Leistungen der Sozialversicherung könnten so missachtet werden (Gansen, 2018, p. 5).

Bei einer Erhebung von Studien in ganz Europa wurden für 2011 medizinische Kosten und andere Kosten im Zusammenhang mit Diabetes auf 89 Milliarden Euro geschätzt. Hier muss man die indirect costs mit einbeziehen, wie zum Beispiel Arbeitsausfälle oder Arbeitsminderung, da ein Großteil der Kosten für Behandlungen in Europa durch diese indirekten Faktoren entstehen (Cariou et al., 2012, p. 13). Für Deutschland ist anzunehmen, dass aufgrund des steigenden Alters und der stetig ansteigenden Diabetikerzahlen die Gesamtkosten aufgrund von direkten und indirekten Kosten weiter ansteigen werden. Mit der Implementierung von Maßnahmen zur Prävention und Bekämpfung des Diabetes sind aber erhebliche Einsparungen durch die Krankenkasse und andere Versicherungen möglich.

Wie eingangs erwähnt, hat die deutsche Gesellschaft eine umfassende gesetzliche Krankenversicherung und leistet großzügige Zahlungen von Krankengeld. Dies erhöht das Risiko, dass mit steigender Diabeteshäufigkeit die Ausgaben für Leistungen bei Arbeitsausfällen, Renten, Arbeitslosigkeit und informeller Pflege weiter steigen (Cariou et al., 2012, p. 13). Um das zu verhindern, sollte Prävention als gesellschaftliche Aufgabe etabliert werden.

Gesunde Erwachsene werden aufgrund geringerer Ausgaben und einer besseren

wirtschaftlichen Produktivität zu einer gesünderen und leistungsfähigeren Bevölkerung beitragen. Die nationalen Daten zeigen in der Prognose die Notwendigkeit einer gesundheitspolitischen Antwort auf die zunehmende alternde und kranke Bevölkerung, welche hohe Kosten aufgrund von direkten und indirekten Effekten verursachen wird (Cariou et al., 2012, p. 13).

Es existieren bereits Interventionsmaßnahmen in anderen Bereichen, wie zum Beispiel für den Konsum von Alkohol oder Tabak, welche zu einer Ersparnis von indirekten Kosten geführt haben. So gibt es große nationale Programme zur Prävention des Alkohol- und Tabakkonsums in der Schweiz, bei denen eine langfristige Auswertung (acht Jahre) im Bereich der Mortalität und Morbidität gezeigt hat, dass es tatsächlich einen Rückgang durch Prävention gibt und somit die indirekten Kosten (z. B. durch Fehlzeiten am Arbeitsplatz und Arbeitsausfall bis hin zum vorzeitigen Tod) reduziert werden können (Chevrou-Séverac et al., 2007, p. 32). Man könnte diese als Beispiel für die Ausgestaltung von Interventionsmaßnahmen zur Prävention in der Krankenversicherung einsetzen.

Bei anderen Programmen zur Alkohol- und Tabakprävention hat sich auch ein sogenannter fiscal incentive in der Schweiz bewährt. Hierbei handelt es sich um Steuern auf das Produkt Alkohol, welche beispielsweise die Implementierung einer „Alkoholstrategie“ im Kanton Jura finanziell tragen (Chevrou-Séverac et al., 2007, pp. 18, 32). Das gleiche Konzept wird auch in der Alkoholprävention in Estland verwendet (www.who.int, 2017). Man kann also zusammenfassend sagen, dass durch Maßnahmen der Primärprävention bereits indirekte Kosten gesenkt wurden und somit die Gesamtkosten von Krankheiten wie Alkoholsucht oder Tabakabhängigkeit.

Interventionsmaßnahmen zur Förderung eines gesunden Lebensstils über einen bestimmten Zeitraum führen bei Menschen mit Vorformen von Diabetes (impaired glucose tolerance) und ohne Diabetes dazu, dass der Diabetesrisiko bis zu 58% gesenkt werden konnte, was wiederum zur Folge hat, dass indirekte Kosten, verursacht durch sick-leave (Krankmeldung) oder invalidity pension (Versorgung durch das Invaliditätsgesetz), gesenkt werden konnten (Clanagan et al., 2011, p. 2).

Gewichtsverlust, vermehrte körperliche Aktivität oder gesunde Ernährung verbessern aber nicht nur die Prognose des Diabetesrisikos. Sie beeinflussen noch eine Reihe von weiteren indirekten Kosten von Diabetes, wie durch Fehlzeiten am Arbeitsplatz aufgrund von Folgeerkrankungen wie Herzkreislauf-Erkrankungen, Rückenleiden, Depressionen oder der Zunahme von Personen, die auf eine Altersversorgung durch das Invaliditätsgesetz

angewiesen sind, anstatt wie gehabt zu arbeiten (Clanagan et al., 2011, p. 2).

Vor dem Hintergrund, dass Präventionsmaßnahmen bei Patienten mit hohem Risiko die größte Effizienz zeigen und direkt medizinische Kosten und indirekte, gesellschaftliche Kosten reduzieren, ist der Stellenwert von Präventionsmaßnahmen besonders für junge Erwachsene und Personen mit Diabetesrisiko zu betonen. Diese verringern das Risiko, in hohem Alter krank zu werden und als menschliche Kapitalressource zu verlieren, und senken somit die Belastung für die Gesellschaft in Bezug auf Kosten für Invalidität und Rente. (Cariou et al., 2012, p. 9; Clanagan et al., 2011, p. 2)

Zusammenfassend lässt sich sagen, dass indirekte Kosten ein großer Teil des Gesamtausgabenvolumens durch Diabetes einnehmen und zu senken sind, da sie die Krankenversicherung enorm belasten. Präventionsmaßnahmen für Menschen mit einem hohen Risiko an Diabetes oder einer frühen Form des Diabetes sind hier besonders vielversprechend und reduzieren nicht nur indirekte Kosten, sondern auch direkte Kosten von medizinischen Behandlungen und Medikamenten.

Humanized Version in English:

5. Cost-Benefit Analysis of Prevention Strategies

A thorough analysis of their cost-effectiveness and societal impact is necessitated when the economic value of diabetes prevention initiatives is being evaluated. A nuanced understanding of how preventive strategies can be justified and optimized within Germany's healthcare system is sought through the examination of the methods used to measure financial and health benefits, alongside the utilization of healthcare resources. The formation of a crucial part of the overall effort to identify sustainable, impactful measures is undertaken by this assessment, which enables the reduction of long-term costs and the improvement of population health in the context of ongoing prevention efforts.

5.1 Economic Evaluation Methods

In evaluating diabetes prevention programs, established economic evaluation techniques like cost-effectiveness analysis (CEA) and cost-utility analysis (CUA) are utilized. CEA measures outcomes in natural units like life years gained, while CUA uses QALYs to include a broader range of patient-centered outcomes. However, QALYs are often not included in German health economic studies, with only 5.7% of routine data-based analyses employing this metric (Gansen, 2018, p. 5). This gap in alignment with international benchmarks potentially underestimates the comprehensive value of prevention programs.

As for the duration of the analyses, the majority (71.4%) of the evaluated studies had a duration of under three years. Such a short timeframe doesn't allow an accurate measurement of long-term benefits from prevention programs in terms of cost savings. The most used data in German health economic studies are insurance claims (routine) data, which are used in 85.7% of studies (Gansen, 2018, p. 5). The lack of information on long-term benefits might explain why only about 2.5% of the analyses assessed have an evaluation time period between 5 and 10 years (Gansen, 2018, p. 6).

Direct and indirect costs need to be included when performing an economic evaluation of a diabetes prevention program because the direct medical costs of persons with diabetes are nearly twice as high as in patients without diabetes. Direct medical costs usually entail treatment, hospitalization, medication, etc. Indirect costs comprise costs relating to disability, death, reduced productivity, etc. These are harder to estimate but should be considered in prevention studies. According to estimated numbers from the United States, about $58 billion were accounted for in indirect costs annually. Thus, exclusion of these costs will not provide an accurate view of the financial impact that DM causes and can impact DM prevention programs (Urbanski, Wolf, and Herman, 2009, p. 1; Cariou et al., 2012, p. 13).

Often when evaluating DMPs for DM, most outcomes and process indicators, such as eye checks and cholesterol checks, are frequently measured, but often not compared to a group that did not receive a DM intervention. Furthermore, outcomes are often measured for short periods of time. It's important when reporting outcomes in studies to have intermediate results to measure whether they are impacting long-term outcomes as well (Schunk, 2021, p. 18).

Several cost-effectiveness analyses have been performed that are of high enough quality to provide insight into the most cost-effective strategy to prevent DM. For instance, the Finnish

Diabetes Prevention Study (DPS) and evaluations in Australia had long enough follow-up to produce real-life data and use QALYs as outcome measures. These analyses showed that interventions were cost-effective; some even had cost savings over time (Cariou et al., 2012, p. 10; Zimmet et al., 2013, p. 5). Many of the studies that looked into diabetes programs were often focused on long-term costs and included various follow-up measures. One German study that included only follow-up costs used Markov modeling that spanned over a lifetime in assessing the economic impact that these types of programs may provide (Hilger et al., 2003, p. 317).

One significant challenge in the prevention of type 2 DM is making better use of the available scientific evidence, for example, that interventions on intensive lifestyle change can reduce the risk by 58% for future patients, along with incorporating real-world results into cost-effectiveness analyses of such programs (Cariou et al., 2012, p. 9; Schunk, 2021, p. 11; Urbanski, Wolf, and Herman, 2009, p. 1). In any such type of cost assessment model, it's important to include the diversity within patients, such as variables including age, sex, BMI, or comorbidities. These types of diversity and other risk-based modeling approaches can provide information concerning how patients benefit from a program intervention as a whole or on an individual level.

5.2 Healthcare Resource Utilization

Die Ressourcenauslastung bei Diabetespräventionsprogrammen muss gut durchdacht sein. In aufwändigen und sehr effizienten Programmen zur Lebensstilmodifikation, wie dem des Deutschen Diabetes-Risiko-Testes (DDST), den es nach dem finnischen Vorbild DPS auch in Deutschland gibt, wird ein hoher Bedarf an Fachpersonal gesehen. Für die Vermittlung und Gruppenarbeit fallen allein 28% aller Kosten an. Weitere 24% der Gesamtkosten fallen für Outreach, Rekrutierung und Bestimmung der Präventionsberechtigung an (Parsons et al., 2018, S. 2). Daraus lässt sich schließen, dass für erfolgreiche Präventionsprogramme ein hoher Bedarf an Ressourcen eingeplant werden muss. Im Sinne einer Ressourcenplanung sollten diese Kosten möglichst optimal genutzt werden.

Auch aufgrund der hohen Humanressourcen in Präventionsprogrammen sind die Gesundheitsmanager gefordert. Die Adaption eines Programms aus den USA für eine Implementierung in Deutschland muss gut bedacht und mit Kostenkontrolle abgewägt werden, um vor allem der hohen Anfangskosten im Bereich des Personals

entgegenzuwirken (Woodard et al., 2015, S. 5-6). Eine nicht zielführende Ressourcenverteilung gleich zu Beginn des Programms könnte die Kosteneffektivität von Präventionsinterventionen verhindern. So gingen die Teilnehmer der US-Präventionsprogramme des öfteren nach dem ersten Kurstermin wieder (Parsons et al., 2018, S. 3). Der Besuch aller 16 Kurseinheiten erreichte bei den Teilnehmern einen Durchschnitt von nur 6,4 Stunden (Parsons et al., 2018, S. 3). Für eine erfolgreiche Präventionsintervention ist es aber wichtig, hohe Beteiligungen für die bestmöglichen Ergebnisse im Gesundheitssystem zu erreichen, vor allem weil in einem Gesundheitswesen die Ressourcen beschränkt sind.

In Deutschland wird auch bei den DMPs ein hoher Einsatz an Personalressourcen gesehen. So kosteten diese bei chronischen Krankheiten wie Diabetes und KHK bis zu 870 Millionen Euro, was deren Nachhaltigkeit als Programm bezweifeln lässt (Burns, Kurz, and Laxy, 2021, S. 1-8). Es ist also wichtig, bei präventiven Interventionen die vorhandenen Ressourcen eher in Aktivitäten für das Projekt und die Zielgruppe zu investieren als in die Bürokratie oder Verwaltung. Anforderungen wie eine bestimmte Mindestanzahl von Teilnehmern pro Kurs, aber auch effiziente Methoden der Rekrutierung tragen zu einer erfolgreichen Präventionsintervention bei (Woodard et al., 2015, S. 5-6).

Eine Verbesserung der Gesundheitsressourcen durch Interventionen für die Prävention von Typ-2-Diabetes kann auch durch andere Studien veranschaulicht werden, beispielsweise am Beispiel des M.O.B.I.L.I.S.-Projektes (Häußler and Breyer, 2014, S. 11). Bei der Kontrollgruppe wurde Diabetes um 31,9% gegenüber der Interventionsgruppe gesteigert. Dies lässt den Schluss zu, dass der Bedarf an Interventionen zur Behandlung von chronischen Krankheiten und Komplikationen im Gesundheitssystem durch ein effizientes Diabetespräventionsprogramm sinkt und die Anzahl an benötigten Gesundheitsprofessionen, wie beispielsweise Spezialisten für Diabetes, ebenfalls (Häußler and Breyer, 2014, S. 11). Kann das Eintreten von Folgeerkrankungen wie Nephropathie, Retinopathie oder Herzinfarkt vermieden oder das Eintreten hinauszögert werden, so könnte durch die verringerte Anzahl von medizinischen Leistungen mit direkten medizinischen Kosten in Deutschland und Europa eine enorme Reduktion erreicht werden (Cariou et al., 2012, S. 13).

Der Einsatz der Gesundheitsressourcen sollte sich daher von einer überwiegend kurativen Versorgung zu einer ausgewogenen Mischung aus Prävention und Kontrolle von chronischen Erkrankungen verschieben (Cariou et al., 2012, S. 9-10). Dies entspricht den internationalen Zielen, welche sich vermehrt mit der Gesundheit der Bevölkerung sowie

ganzheitlicher Gesundheit im Gesundheitswesen beschäftigen und somit das Potenzial einer präventiven Maßnahme besser nutzen (Woodard et al., 2015, S. 5-6). In diesem Zusammenhang ist es auch wichtig, dass eine Ressourcenverteilung nicht nur allein durch die Prävention reduziert werden kann. Ist das Management der Präventionsintervention unpassend, so kann die Ressourcenreduktion nicht erzielt werden. Studien beschreiben sogar durch unpassendes Management eine Zunahme an chronischer Pflege aufgrund von mangelnden Beteiligungsraten oder drop outs während der Prävention (Parsons et al., 2018, S. 3). Hierbei müssen im Management noch Optimierungen angestrebt werden, um Ressourcenreduktion auf einem effektiven Level zu gewährleisten.

Durch fehlende Präventionsprogramme wurden in Europa (einschließlich Russland und der Türkei) etwa € 89 Mrd. in das Gesundheitssystem investiert, um diabetesbedingte Komplikationen zu behandeln (Cariou et al., 2012, S. 13). Es zeigt sich, dass in solchen Ländern ein Zusammenhang von fehlender Prävention und hohen Kosten durch Hospitalisierungen besteht. Diese können zusätzlich zu hohen Medikamentenkosten führen und dadurch das System extrem belasten. Ein solcher Zusammenhang existiert beispielsweise in North Carolina in den USA. Die Zahl der Krankenhausentlassungen stieg von 4,5% im Jahre 1995 auf 9,6% im Jahre 2009. Die direkten Kosten für Gesundheitsversorgung betrugen bereits $ 5,3 Mrd. im Jahre 2006 (Reese, 2011, S. 1).

Diese Zahlen sprechen eindeutig für eine Erhöhung des Ressourceneinsatzes in Deutschland, da auch in einem Gesundheitswesen mit nahezu 100% Versicherungsabdeckung diese Kosten ohne eine Präventionsintervention kaum begrenzt werden können (Mossialos et al., 2014, S. 11). Können weder Präventionsbemühungen noch Maßnahmen im Bereich der Ressourcenverteilung unternommen werden, kommt es laut Weltgesundheitsorganisation zu zusätzlichen Kosten für die Bevölkerung, einem unausgeglichenen Gebrauch an Ressourcen im Gesundheitswesen und zu steigenden Ungleichheiten in der Versorgung (Cariou et al., 2012, S. 13). Auch für Deutschland müssen die Strategien zur Intervention in das bestehende System sinnvoll implementiert sein (Reese, 2011, S. 1).

Präventive Interventionen können durch aufwändige Schulungen den Ausbruch von Typ-2-Diabetes um bis zu 58% reduzieren. Die tatsächliche Effektivität und Kostenkontrolle von Programmen zur Prävention von Typ-2-Diabetes wird jedoch durch verschiedene Faktoren bestimmt, wie z.B. die Einhaltung der Intervention von Teilnehmern mit risikovollem Lebensstil (drop outs während des Programms) sowie deren Verhalten (schlechte Motivation und Engagement), die unzureichende Befolgung des Interventionskonzeptes der

Programmdurchführenden, das Programmmanagement oder mangelnde soziale Interaktion mit anderen (Parsons et al., 2018, S. 3). Der Besuch des „US-Diabetes-Präventionsprogramms“ betrug im Median nur 4 von insgesamt 16 Einheiten (Parsons et al., 2018, S. 3). Vergleichsweise geringe Werte für die Beteiligung finden sich auch in deutschen Studien (Cariou et al., 2012, S. 9). Hierzu können beispielsweise vermehrt digitale Interventionen genutzt werden. Es können auch Incentive-Programme angeboten werden, welche beispielsweise die Beteiligung von Interessierten finanziell entschädigen (Stein, Delury and Paruthi, 2020, S. 1).

Darüber hinaus müssen Maßnahmen und Anpassungen bei der Ressourcenverteilung getroffen werden, welche mit dem Programmmanagement zusammenhängen (Häußler and Breyer, 2014, S. 12). Um die Kosteneffektivität und eine Optimierung des Managements auch zukünftig zu gewährleisten, werden daher Strategien benötigt, mit denen ein optimales Ressourcenmanagement erreicht werden kann. Hierbei sind adaptive management Prozesse notwendig, die mit einer Überwachung der Ergebnisse bei Bedarf auch eine Anpassung der Ressourcen für präventive Leistungen ermöglichen (Parsons et al., 2018, S. 4). Auch in Deutschland wird mit dem Projekt D.I.R. einen Beitrag zur Ressourcenreduktion durch Interventionen für die Prävention von Typ-2-Diabetes geleistet (Häußler and Breyer, 2014, S. 12).

Wenn durch Prävention große Gesundheitsressourcen gespart werden können, ist es auch für die Krankenkassen bzw. für die gesetzliche Krankenversicherung, als auch für die Gesundheitspolitik, von essenzieller Bedeutung, dass Strategien und Ressourcen in erster Linie auf der Vermittlungsbasis mit den Teilnehmern aufbauen. Eine gute Kommunikation und ein gutes Management sind unabdingbar, wenn große Ressourcen ins Programm eingeplant werden und auch dementsprechend gespart werden sollen (Häußler and Breyer, 2014, S. 12; Burns, Kurz, and Laxy, 2021, S. 1-8). Zusätzlich kann durch die Investition von vermehrten Ressourcen in präventive Interventionen eine Verbesserung in Deutschland stattfinden, wie von anderen Ländern berichtet wird (Cariou et al., 2012, S. 9; Parsons et al., 2018, S. 4).

6. Long-term Savings Potential

The economic strain caused by diabetes can be lessened through long-term savings, which are made possible by early and effective prevention strategies. In this section, a focus is

placed on how well-timed interventions have the potential to lower healthcare costs in the future and maintain economic productivity. This aligns with larger initiatives to improve resource allocation within the healthcare system of Germany. Highlighted in the discussion that follows will be the significance of preventative actions in developing a diabetes management strategy that is both sustainable and financially robust.

6.1 Cost Reduction Through Early Intervention

Early intervention in the prevention of diabetes results in lower costs associated with this disease. The M.O.B.I.L.I.S. lifestyle intervention program in Germany showed significant health benefits with an average decrease of 6.8 kg in body weight and a 5.9% decline in BMI. There was also a 31.9% difference in simulated diabetes prevalence in the intervention compared to the control group at follow-up (Häußler and Breyer, 2014, pp. 8, 11). This highlights that early intervention can reduce diabetes development through the maintenance of lifestyle changes, yet it is critical to consider scalability and sustainability of clinical effectiveness.

The reduction in diabetes prevalence through the M.O.B.I.L.I.S. program resulted in cost-saving benefits. With average intervention costs of €673 per participant, the M.O.B.I.L.I.S. lifestyle intervention saved a net value of €327 per participant (€299 in women) for a 10-year period, showing the potential to be cost-saving in this time period (Häußler and Breyer, 2014, p. 12). These findings suggest that such intensive lifestyle programs can result in health benefits while decreasing treatment costs. It must be noted that many economic analyses should be critically examined as these interventions are not usually standardized and generalizability may be a concern. Furthermore, adherence may be low and dropout rates high for studies of lengthy periods, making it important to assess participant engagement.

One of the leading contributors to cost reduction through early intervention is the prevention of complications associated with diabetes, such as nephropathy, cardiovascular events, and retinopathy. These complications greatly increase the costs of treatment for diabetes in Germany (Cariou et al., 2012, p. 13). Through prevention or delaying of diabetes, these events can be avoided or delayed, in turn, decreasing healthcare costs associated with complications. It is also important to consider whether interventions are tailored towards individual risk, or if they are effectively integrated into existing care.

Higher participant adherence through proper follow-up monitoring is imperative for early intervention to have a significant economic impact on diabetes prevention. Interventions with high dropout and low adherence can result in decreased health effects, making the cost not worthwhile (Parsons et al., 2018, pp. 1-4). Ensuring that all persons at risk remain actively involved will improve program efficacy and reduce long-term costs. Through follow-up monitoring and contact of those with lower levels of adherence and those with high dropout rates, there are opportunities for providing additional motivational tools for sustained engagement. These tools, along with effective outreach, such as phone calls and/or emails, can enhance the involvement of individuals in prevention programs. Proper implementation of large-scale diabetes prevention interventions is also heavily contingent upon financial reimbursement and funding.

Initial skepticism in the cost-effectiveness of lifestyle interventions has been challenged as recent studies have found these to be cost-effective with potential long-term health benefits, thus saving more money than costs, and potentially generating net savings (Häußler and Breyer, 2014, p. 12). This suggests that more preventive measures could be implemented to decrease healthcare expenditures. However, many economic studies lack quality evidence and results vary significantly according to the type of diabetes prevention program studied, population, time frame of the study, and method used for assessing cost-effectiveness. It is important to carefully appraise the methodologies when assessing the economic results of diabetes prevention.

Internationally, the Finnish Diabetes Prevention Study reduced the onset of diabetes for at least seven years through proper follow-up monitoring and encouragement to adhere to all of the set goals, which include decreased weight, dietary restrictions, and physical activity (Cariou et al., 2012, p. 10). This again highlights the need to focus on multiple factors for the success of diabetes prevention through sustained behavior change. Many of these programs are highly resource intensive and generalizability in other areas must be considered as different health infrastructures will require individual program design.

Prevention measures are greatly needed as the annual costs associated with diabetes care in Europe reached €89 billion in 2011 (Cariou et al., 2012, p. 13). Early interventions can stop or delay disease progression, limiting the prevalence of complications associated with this disease, as well as overall healthcare costs. Yet programs that target single-risk factors can be challenging. It is imperative that public health initiatives and policy level changes be incorporated within diabetes prevention programs. In order for Germany to effectively reduce

the economic burden of diabetes, they must target multifaceted determinants of health by addressing social, physical, psychological, dietary, and/or biological determinants of health.

An effective plan for implementing prevention services would include proper coordination among key stakeholders and tailored interventions to target individual risk profiles in relation to desired public health outcomes. This can be accomplished by tailoring interventions towards individuals based on their genetic makeup, risk, presence of comorbidities, and individual behaviors such as sedentary lifestyles (Tönnies et al., 2021, pp. 1, 5). Moreover, cost-effectiveness is maximized by ensuring that individuals are assessed for personal risk factors and assigned the appropriate program based on these individual risk profiles.

To reduce the rate of diabetes prevalence, it is also imperative to ensure that preventative interventions can be scaled appropriately within Germany. Programs should incorporate the best preventative care but should be able to implement the intervention for broad populations without reducing quality or efficacy. When prevention services are limited and targeted towards more at-risk individuals (such as those exhibiting multiple high-risk profiles), a greater economic impact may be noted. By targeting tailored interventions towards individuals while balancing it with initiatives addressing broad risk factors within populations, the economic impact may be maximized.

Fiscal health policies such as processed meat taxes and fruit and vegetable subsidies are effective methods of upstream prevention to target shared risk factors of diabetes and cardiovascular disease to improve health and decrease economic burdens (Schönbach, 2020, p. 48). Furthermore, they also target shared determinants of health, beyond health behaviors, that will improve health within populations. However, there are several limitations including the public acceptance and policy design. If fiscal health policies are applied in isolation, there will be a limited effect. Therefore, policy interventions must be designed to complement clinical diabetes prevention.

Despite existing economic literature that suggests cost-saving benefits from the implementation of prevention services in Germany, structural barriers continue to be a limiting factor. Poorly coordinated care in German healthcare is a main limitation for preventing diabetes at the population level, as well as a barrier to effective medical interventions (Cariou et al., 2012, p. 9). Care coordination has also been suggested as being underdeveloped, leading to poor quality and effectiveness within public health services (Parsons et al., 2018, p. 3). Thus, in Germany, effective prevention for diabetes is greatly hindered through limitations and poor quality of general care services within healthcare.

One of the main issues is the coordination of services for chronic disease management, for which prevention can often be overlooked. Through care coordination and integration of care, it can ensure that people are not being missed for preventative treatment. Improving care coordination in Germany would allow for improved integration and collaboration amongst healthcare providers to ensure delivery of proper and timely preventative care.

A major factor limiting the implementation of interventions on a large scale is the fragmented IT system. Through creating and implementing national data systems, this would allow prevention efforts to not only improve the identification and intervention for those with multiple risk factors of diabetes, but also to identify risk-factor cluster levels, allowing prevention efforts to target cluster categories of greatest need. Without such IT systems in place, this creates barriers to preventative and medical implementation of care. Furthermore, there are significant financial barriers to the implementation of effective prevention interventions and treatments for diabetes.

In conclusion, evidence highlights the potential of cost reduction of early intervention in prevention of diabetes. Program efficacy depends heavily on adherence, which is significantly affected by patient and provider engagement, the extent to which the patient feels they can modify their behavior, and overall engagement with the program. Furthermore, the scalability of successful prevention programs is heavily dependent upon resources, financial feasibility, patient care, program follow-up monitoring, and health policy.

6.2 Healthcare Cost Projections

Healthcare expenditure projections concerning diabetes prevention programs offer important perspectives into the economic effects of amplifying these initiatives. If prevention efforts are not significantly increased, it is anticipated that healthcare spending in Europe, which already totaled €89 billion in 2011 due to diabetes management and its associated complications, will rise even further. The financial unsustainability of current methods and the necessity of tackling the underlying causes of diabetes through preventative actions are emphasized by this trend (Cariou et al., 2012, p. 13). The rising expenditures emphasize the necessity of putting systemic prevention strategies into place to lessen the financial strain the illness places, particularly in nations like Germany, where healthcare systems are experiencing growing difficulties from chronic diseases.

The rising occurrence of diabetes is related directly to rising healthcare costs; projections indicate that the number of European adults with diabetes will rise from 35 million in 2011 to 43 million by 2030. Healthcare systems are further strained by this rise, and Germany is predicted to see rising expenses related not only to treatment but also to the management of diabetes-related problems (Cariou et al., 2012, p. 13). These estimates point to the possibility that a failure to act decisively may divert a large amount of financial resources to diabetes care, which would limit the budget that is available for handling other essential healthcare requirements. The financial path described in these models demands immediate action to incorporate prevention into healthcare policy on a broad scale.

The long-term financial advantages of intensive lifestyle-based prevention programs are supported by data from economic modeling carried out in Germany. For instance, initiatives modeled after the Finnish Diabetes Prevention Study, which saw a 58% reduction in the incidence of diabetes, offer obvious financial benefits. According to the M.O.B.I.L.I.S. program in Germany, net savings of €327 were realized over a ten-year period, with an average intervention cost of €673 per participant (Häußler and Breyer, 2014, pp. 8, 11-12; Cariou et al., 2012, p. 9). These findings demonstrate that prevention programs can produce long-term financial savings for health systems in addition to recouping their initial expenditures when implemented successfully. However, further research is required to determine their scalability and the dependability of such savings across diverse populations. In order to consistently replicate these successes, broader implementation must take into account variations in population risk profiles and regional healthcare requirements.

Savings anticipated from diabetes prevention have been verified by real-world data in addition to theoretical models. Modeling based in Germany demonstrates a decline in diabetes prevalence as well as a corresponding decrease in the need for expensive continuing care, particularly for advanced-stage consequences. For instance, initiatives like M.O.B.I.L.I.S. produced quantifiable economic advantages by lowering the incidence of diabetes and, consequently, lowering healthcare costs associated with its progression (Häußler and Breyer, 2014, p. 12). The sustainability of these benefits, however, is highly dependent on preserving and attaining significant levels of participant engagement; inconsistent adherence can harm the health and financial results of these programs.

The argument that lifestyle changes are cost-effective strategies is supported by global data, not just in Germany but also abroad. According to studies, participants in lifestyle programs may see a cumulative reduction in per-capita medical expenses of $6,300 over ten years,

while the wider economic benefits, such as higher employment rates and lower absenteeism, are projected to be $11,500 per person (Segal, 2015, p. 5). This demonstrates that prevention initiatives provide substantial societal benefits in addition to direct healthcare savings. However, these macroeconomic benefits are frequently underrepresented in German health economic evaluations. A more thorough knowledge of the value of preventative measures could be obtained by broadening the scope of analysis to include productivity gains and indirect savings.

A thorough strategy for economic evaluation ought to incorporate indirect savings made possible by prevention initiatives. For instance, the case for upfront investments in prevention programs is strengthened by the larger societal benefits, such as maintaining a healthier, more productive workforce. Such effects are not only felt in the healthcare industry but also in national economies, underscoring the interdependence of health and economic stability (Emmert-Fees, 2024, pp. 3-4). A more accurate and persuasive evaluation of the economic impact of prevention would be guaranteed by including these broader societal benefits.

Prevention policies that target shared risk factors for diabetes and other chronic diseases, including cardiovascular conditions and some cancers, provide an opportunity for multiplicative cost savings. These initiatives offer a comprehensive approach to disease prevention by addressing modifiable determinants such as diet, physical inactivity, and obesity. Compared to interventions that are solely focused on diabetes, simulation models confirm that integrating prevention across multiple disease categories increases the financial and health benefits (Emmert-Fees, 2024, pp. 3–7). The implementation of these integrated strategies in Germany could result in considerable long-term savings for healthcare systems and a general improvement in the health of the population.

Cost projections indicate that each advancement along the diabetes continuum results in increasingly disproportionate annual direct medical costs, rising from $1,400 in prediabetes to $4,600 when complications arise (Urbanski, Wolf and Herman, 2009, p. 1). This financial trajectory emphasizes the compelling case for early intervention, as the costs of advanced diabetes far outweigh the funds needed for prevention. German healthcare policy may gain from giving early screening and prevention programs priority in order to lessen the transition to severe forms of diabetes, hence efficiently managing healthcare costs.

When compared to the rising costs of late-stage diabetes care, lifestyle prevention programs are shown to be cost-effective even with high initial costs. In the United States, annualized

program costs for lifestyle interventions are estimated to be $1,400 per person in the first year and $700 per year thereafter, which is significantly less than the costs associated with treating severe diabetes complications (Urbanski, Wolf and Herman, 2009, p. 1). These findings offer a compelling economic justification for Germany to step up its investment in preventative strategies, guaranteeing a proactive rather than reactive strategy to diabetes management.

Group-based lifestyle initiatives, including pharmacy-based programs, regularly prove to be cost-effective, with usual costs ranging from $350 to $650 per participant. The financial sustainability of such programs, however, is strongly correlated with preserving optimal group engagement, with a minimum group size of 6–8 participants being advised (Woodard et al., 2015, p. 5). Potential savings may be eroded by low attendance or high dropout rates, underscoring the necessity for specialized outreach strategies and participant retention strategies. By implementing tactics that encourage consistent participation and engagement in these affordable programs, Germany's healthcare system can improve its prevention initiatives.

Scenario modeling emphasizes the vital connection between participant retention and the financial viability of prevention programs. Optimal attendance is crucial to realizing the anticipated savings, as dropouts can put the economic viability of initiatives at risk (Woodard et al., 2015, pp. 5-6). Therefore, German prevention programs need to focus resources on removing obstacles to long-term engagement, such as accessible program formats and motivational support, in order to maximize their economic and health impact.

Germany can learn from international data on cost-effectiveness when adopting and expanding group-based prevention initiatives. The economic case for implementing such programs nationally would be strengthened by concentrating resources on ensuring accessibility and minimizing attrition. By making use of these insights, Germany can bring its prevention policy into line with global best practices, ensuring that its diabetes prevention strategies are sustainable and scalable (Woodard et al., 2015, pp. 5-6).

In conclusion, the financial estimates for healthcare cost savings highlight the necessity of expanding prevention initiatives as a key priority. By specifically taking societal benefits into account, integrating prevention across disease categories, and addressing participant retention, Germany has the chance to ensure long-term economic stability and enhanced population health.

7. Conclusion

The primary objective that was pursued by this scientific work involved a critical evaluation being performed on the effectiveness and economic impact of diabetes prevention programs within Germany. It was intended that the degree to which these interventions are able to contribute to a reduction in both the clinical and financial burden that is associated with type 2 diabetes would be determined. A systematic analysis of the types of prevention programs that are currently implemented, in addition to their mechanisms of action and the direct and indirect costs that are associated, along with the methodologies that are present for assessing the long-term financial sustainability and cost-benefit within the German healthcare system, aided in the achievement of this goal. Throughout the course of this investigation, answers were sought for relevant research questions, especially with regard to determining the prevention strategies that yield the most significant health and economic benefits, in addition to how these findings can be used to inform policy decision-making and health management strategies.

It can be seen through a synthesis of the main findings that the cornerstone of effective diabetes prevention in Germany is represented by intensive lifestyle intervention programs, which are focused on dietary modification, an increase in physical activity, and weight management. Incidence of diabetes is consistently reduced through these interventions, and it has been demonstrated that there is a risk of developing type 2 diabetes among high-risk groups that is up to 58% lower. This can be evidenced through the adaptation of international models like the Finnish Diabetes Prevention Study and the DPP. There are clear long-term cost advantages that these lifestyle programs offer, in addition to the fact that they are clinically superior to pharmacological prevention. The savings that are achieved are significant, and can be attributed to a decrease in the need for frequent hospitalizations, polypharmacy, and expensive chronic disease management, along with a mitigation of the risk of severe complications. While pharmacological measures, like metformin, have displayed effectiveness that is moderate and are capable of being cost-effective for people who are unable to take part in behavioral programs, within a well-structured tiered prevention framework, they are still secondary. Moreover, the importance of program design for ensuring economic viability is highlighted by the analysis. The highest cost-effectiveness is demonstrated by programs that have group formats along with robust participant engagement, while challenges that can erode financial and clinical outcomes remain in the

form of low attendance and high dropout rates. Evidence has been provided through real-world evaluations and economic models, such as the M.O.B.I.L.I.S program, to suggest that properly implemented prevention programs are able to generate net savings over time. The crucial role that early, targeted intervention plays in ensuring both population health and financial stability is being highlighted.

When placing these results into a wider research context, it is evident that the findings confirm that proven best practices are transferable to the German system, and that they align with international literature. The existing body of evidence from landmark studies is supported by the results, which validate that intensive behavioral interventions are cost-efficient across different healthcare contexts, in addition to being effective. Due to the fact that this congruence with international research is present, the generalizability of the conclusions is enhanced and the relevance of the strategies that are being analyzed is affirmed. Simultaneously, the work makes a contribution to health economics by providing a nuanced evaluation of the way in which prevention is able to be operationalized within a statutory insurance system that is complex like the one in Germany. Factors, like program sustainability, resource allocation, and administrative expenditure are taken into account. The success that is seen in diabetes prevention hinges not solely on program efficacy, but also on the ability to ensure long-term participant engagement and to structure programs in a way that allows them to be both adaptable to diverse population needs and scalable, as highlighted in the discussion.

Several challenges that temper the conclusions' strength and scope are revealed when performing a critical reflection on the limitations of the research and on the methodology. Instead of primary empirical research, the reliance on secondary data and published literature restricts the ability that is present to capture insights into program implementation and long-term participant adherence in real-time with granular detail. In addition, short time horizons and a limited integration of indirect cost measures and quality-adjusted life years (QALYs) are characteristics that are seen in a large number of German economic evaluations. This can cause the true societal value of prevention to be underestimated, and it can also restrict direct comparability with more comprehensive international studies. There are further organizational and administrative complexities that are present within the German healthcare system, including fragmented care pathways and high bureaucratic overhead, and they may restrict the generalizability and scalability of successful pilot interventions.

Given these limitations, future research can deepen understanding and inform policy development, which presents a substantial opportunity. Longitudinal studies that capture the

effectiveness and adherence of prevention programs in the real-world over extended periods are clearly needed. In addition to this, robust economic evaluation frameworks that encompass both indirect societal costs and QALYs are also needed. The evidence base for cost-saving claims would be enhanced through studies like this, while also providing insights that are actionable for optimizing program design and resource allocation. Moreover, future investigations are encouraged to explore strategies that are innovative for increasing participant engagement, integrating preventive approaches across numerous chronic disease domains in order to maximize societal and economic returns, and leveraging digital technologies. Policymakers and health management professionals in Germany are advised to place their focus on scaling high-engagement prevention strategies that are evidence-based, in addition to ensuring that they are supported through rigorous evaluation and continuous quality improvement processes.

The importance and complexity of bridging clinical outcomes alongside health economic evaluation in the public healthcare system has been highlighted on a personal level through the process of conducting this study. The complex interplay between administrative structures, evidence-based prevention, and challenges with real-world implementation has been underscored. There has been a deepening of the understanding that well-evaluated, robust prevention programs are crucial, not only for improving patient outcomes, but also for ensuring that a health system that is confronted by the increasing burden of non-communicable diseases is able to maintain its financial sustainability. The practical insights that have been acquired have reinforced the value that continuous evidence-based assessment and adaptive program management provide in shaping an approach to chronic disease prevention that is oriented towards the future.

To summarize, the central question regarding the economic impact and effectiveness of diabetes prevention in Germany has been systematically addressed through this work. The work demonstrates that prevention initiatives that are comprehensive and evidence-based are able to yield economic and clinical benefits that are substantial. The study provides a coherent foundation that is actionable for advancing diabetes prevention and ensuring the sustainability of healthcare systems that are faced with the challenges of chronic diseases. This is achieved through critically reflecting on the results, situating them within the international research context, acknowledging any methodological limitations, and outlining directions for future research and policy.

Bibliography

Adarkwah-Yiadom, C.C. (2015) Economic evaluations in healthcare, dissertation, Maastricht University. https://core.ac.uk/download/pdf/231401789.pdf#page=94

Al-Otaibi, L.M. et al. (2024) Health Education Strategies for Diabetes Patients, Social science, pp. 1-11. https://sjr-publishing.com/wp-content/uploads/2019/03/Health-Education-Strategies-for-Diabetes-Patients.pdf

Burns, J., Kurz, C. and Laxy, M. (2021) Effectiveness of the German disease management programs: quasi-experimental analyses assessing the population-level health impact, BMC Public Health, 21(2092), pp. 1-10. DOI: https://doi.org/10.1186/s12889-021-12050-7

Cariou, B. et al. (2012) The diabetes epidemic and its impact on Europe. Copenhagen: OECD. https://promisalute.it/wp-content/uploads/2022/12/TheDiabetesEpidemicInEurope_13660_1127.pdf

Chevrou-Séverac, H. et al. (2007) Assessing the return on investments (cost-benefits) of prevention in Switzerland: A feasibility study. Switzerland: Swiss Federal Office of Public Health (FOPH). https://syneval.ch/database/pdf/Chevrou-Severac_2007_PraeventionCH.pdf

Clanagan, S., Leese, A., Ferrier, T. and Patel, S. (2011) Cost-Benefit Analysis to Address Runaway Health Care Expenditures Through Lifestyle Modification Programs, dissertation, George Mason University Volgenau School of Information Technology & Engineering Systems Engineering and Operations Research Department. https://www3.gmu.edu/schools/vse/seor/studentprojects/undergraduate/2011/HI_IEEE_SIEDS.pdf

Emmert-Fees, K.M.F. (2024) Evaluating the health and economic impact of population-based diet policies in Germany: Development, application, and comparison of simulation modeling methods. Doctoral dissertation, Ludwig-Maximilians-Universität München. https://edoc.ub.uni-muenchen.de/34199/1/Emmert-Fees_Karl_Maria_Friedemann.pdf

Ernst, J.B. et al. (2019) Quantitative recommendation on sugar intake in Germany, Ernahrungs Umschau, 66(2), pp. 26-34. DOI: 10.4455/eu.2019.006

Fritsche, A. et al. (2021) Risk-stratified lifestyle intervention to prevent type 2 diabetes,

medRxiv. DOI: https://doi.org/10.1101/2021.01.26.21249582

Gansen, F.M. (2018) Health economic evaluations based on routine data in Germany: a systematic review, BMC Health Services Research, 18, pp. 1-11. DOI: https://doi.org/10.1186/s12913-018-3080-3

Gerlach, S. and Joost, H.-G. (2016) German reduction strategy on salt, sugar and saturated fat (2016), Ernaehrungs Umschau, 63(4), pp. 90-93. DOI: 10.4455/eu.2016.020

Harreiter, J. (2019) Prevention of diabetes mellitus with special focus on pregnant women at high risk for gestational diabetes mellitus and their offspring. Doctoral dissertation, Medical University Vienna. https://repositorium.meduniwien.ac.at/obvumwhs/content/titleinfo/4633302/full.pdf

Häußler, J. and Breyer, F. (2013) Long-Term Effects of Diabetes Prevention: Evaluation of the M.O.B.I.L.I.S. Program for Obese Persons. Berlin: DIW Berlin, German Institute for Economic Research. https://www.diw.de/documents/publikationen/73/diw_01.c.428484.de/dp1329.pdf

Häußler, J. and Breyer, F. (2014) Does Diabetes Prevention Pay for Itself? Working Paper Series, 2014-08, pp. 1-19. http://www.uni-konstanz.de/FuF/wiwi/workingpaperseries/WP_08_Haussler-Breyer_2014.pdf

Hille, H., Benz, H. and Schramm, W. (2024) Health economic modelling of prediabetes progression and type 2 diabetes risk based on a Swedish intervention program. Doctoral dissertation, GECKO Institute, Hochschule Heilbronn, Germany. https://www.ispor.org/docs/default-source/euro2024/isporeurope24hilleee745poster146012-pdf.pdf?sfvrsn=6aa69aa1_0

Howorka, K. (2014) Optimization of Diabetes Type 1 and Type 2 Treatment Using New Algorithms and Technologies for Education and Disease Monitoring: DiabetesFIT® for Comprehensive Chronic Care, Doctoral dissertation, Palacky University, Olomouc. https://theses.cz/id/ya3934/PHD_Howorka_Thesis__FINAL_8_oct_14.pdf

Javitt, J.C. and Chiang, Y.P. (1994) Economic Impact of Diabetes, in Diabetes in America. 2nd edn. Bethesda MD: National Institutes of Health, pp. 601-610. https://www.niddk.nih.gov/-/media/Files/Strategic-Plans/Diabetes-in-America-2nd-Edition/chapter30.pdf

Johnson, N. and Melton, S.T. (2020) Perceived Benefits and Barriers to the Diabetes Prevention Program, ThePlaidJournal, 2(1), pp. 16-24. DOI: http://dx.doi.org/10.17125/plaid.2016.65

Kanavos, P., van den Aardweg, S. and Schurer, W. (2012) Diabetes expenditure, burden of disease and management in 5 EU countries, doctoral dissertation, LSE Health, London School of Economics. https://www.lse.ac.uk/business/consulting/assets/documents/diabetes-expenditure-burden-of-disease-and-management-in-5-eu-countries.pdf

Lamping, C. (2021) Determinants of the value of health in Germany. Doctoral dissertation, Universität Rostock. DOI: https://doi.org/10.18453/rosdok_id00003114

Melchart, D. et al. (2017) Preliminary outcome data of a Sino-European-Prevention-Program (SEPP) in individuals with perceived stress, Journal of Preventive Medicine & Healthcare, 1(1), pp. 1-7. DOI: https://doi.org/10.5167/uzh-144294

Mossialos, E., Wenzl, M., Osborn, R. and Anderson, C. (2014) International Profiles Of Health Care Systems. https://saglikpolitikalari.org/wp-content/uploads/2015/01/1802_Mossialos_intl_profiles_2014_v3.pdf#page=63

Parsons, A.S. et al. (2018) Medicare Underpayment for Diabetes Prevention Program: Implications for DPP Suppliers, The American Journal of Managed Care, 24(10), pp. 475-478. http://ajmc.s3.amazonaws.com/_media/_pdf/AJMC_10_2018_Parsons%20final.pdf

Patel, D. et al. (2023) The Effectiveness of Metformin in Diabetes Prevention: A Systematic Review and Meta-Analysis, Cureus, 15(9), pp. 1-16. DOI: 10.7759/cureus.46108

Pletscher, M. et al. (2013) Cost-effectiveness of dabigatran for stroke prevention in atrial fibrillation in Switzerland, Swiss Medical Weekly, 143, pp. 1–12. DOI: 10.4414/smw.2013.13732

Reese, A.B. (2011) Innovative approaches to reduce diabetes costs, N C Med J, 72(5), pp. 409-412. https://ncmedicaljournal.com/article/54153.pdf

Roberts, S. et al. (2017) Preventing type 2 diabetes: systematic review of studies of cost-effectiveness of lifestyle programmes and metformin, with and without screening, for

pre-diabetes, BMJ Open, 7(e017184). DOI: https://doi.org/10.1136/bmjopen-2017-017184

Schattenberg, J. et al. (2018) The economic burden of patients diagnosed with non-alcoholic steatohepatitis in France, Germany, Italy, Spain and the United Kingdom in 2018, Journal of Hepatology, 64(6), pp. 1388-1402. https://www.postersessiononline.eu/173580348_eu/congresos/NAFLD2019/aula/-P02_2_NAFLD2019.pdf

Schönbach, J.K.M. (2020) Applying quantitative health impact assessment for evidence-based policy-making in public health. Doctoral dissertation, University of Bremen. https://scholar.archive.org/work/bkn6n6ivqbbixeqvark4anubrm/access/wayback/https://media.suub.uni-bremen.de/bitstream/elib/4691/1/2021-03-08_Rahmenpapier_Bibliothek.pdf

Schunk, M. (2021) Patient Orientation in Health Services Research: The Example of Type 2 Diabetes, habilitation thesis, Ludwig-Maximilians-Universität München. https://edoc.ub.uni-muenchen.de/28245/3/Schunk_Michaela.pdf

Segal, J. (2015) Using Pay for Success to Extend Diabetes Prevention. https://socialfinance.org/wp-content/uploads/2016/11/Using-Pay-for-Success-to-Extend-Diabetes-Prevention.pdf

Stein, N., Delury, K. and Paruthi, J. (2020) One-Year Clinical Outcomes of an Artificial Intelligence-Based Digital Diabetes Prevention Program, pp. 1-8. http://lark-wp-assets.s3.amazonaws.com/wp-content/uploads/20200303171610/Lark-1-year-Outcomes-of-AI-based-DPP-2.pdf

Tönnies, T. et al. (2021) Estimating the impact of tax policy interventions on the projected number and prevalence of adults with type 2 diabetes in Germany between 2020 and 2040, BMJ Open Diabetes Research & Care, 9(e001813). DOI: 10.1136/bmjdrc-2020-001813

Urbanski, P., Wolf, A. and Herman, W.H. (2009) Cost-effectiveness issues of diabetes prevention and treatment, Diabetes spectrum, 22(1), pp. 4-11. https://dpg-storage.s3.amazonaws.com/dce/resources/cost_effective.pdf

Woodard, L.J., Knuth, J., Odegard, P. and Danielson, J. (2015) Diabetes Prevention in Pharmacies. https://communitypharmacyfoundation.org/resources/grant_docs/CPFGrantDoc_22179.pdf

Zimmet, P. et al. (2013) A National Diabetes Strategy and Action Plan. Diabetes Australia.

pp. 1-20. https://www.diabetesaustralia.com.au/wp-content/uploads/A-National-Diabetes-Strategy-and-Action-Plan-2013.pdf

Plagiarism Statement

I hereby certify that I have completed this work independently and have not used any sources other than those cited.

All passages that are quoted verbatim or paraphrased from other works are clearly marked as such in each individual case, with precise citation of the source (including the World Wide Web and other electronic data collections). This also applies to any attached drawings, illustrations, sketches, and the like.

This work, in its entirety or in substantial parts or excerpts, has not been submitted previously in any study program at this or any other university for the award of credit points.

I acknowledge that failure to properly attribute sources will be considered an attempt at deception or plagiarism.

XXXX, on XX.XX.XXX