



AALBORG UNIVERSITY
STUDENT REPORT

Cost-effectiveness analysis of the Pressure Ulcer Bundle in the municipality of Sønderborg

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Abstract:

Aim: The aim of this study was to determine the health economic cost-effectiveness of implementing the pressure ulcer bundle (PUB) as a preventive measure against pressure ulcers in the elderly care of the municipality of Sønderborg.

Methods: The health economic consequences were estimated by compiling a cost-effectiveness analysis. In this analysis, the costs and effects of the PUB and the standard care approach were compared over a one-year period. This enabled the incremental-cost-effectiveness-ratio of one prevented pressure ulcer, using the PUB, to be determined. The cost-effectiveness threshold was set at the average cost of treating one pressure ulcer using the standard care approach. The analysis was done with the perspective being limited to the municipality of Sønderborg. When data was available from the municipality, it was prioritized, and, when not, estimates from literature with as close similarity as possible was used. The effect was estimated by comparing the incidence rate of pressure ulcers in the municipality before (2013) and after (2017) the implementation of the PUB. Costs of the two alternatives were estimated using a bottom-up costing approach over a one-year period.

Results: The analysis showed that using the PUB caused a 63% reduction in the incidence of pressure ulcers in the municipality of Sønderborg. Furthermore, the overall costs associated with pressure ulcers in the municipality decreased, despite the implementation of preventive measures. This was also evident in the calculated ICER which amounted to 8153 DKK, indicating that for each pressure ulcer prevented using the PUB, the municipality has effectively gained 8153 DKK that can be used elsewhere. The sensitivity analysis showed that the model was sensitive to changes to the 2013 incidence rate, however.

Conclusion: The results suggest that the PUB is favorable to the standard care alternative as its implementation has resulted in both a decrease in expenditures as well as an improved effect. The ICER easily abided by the set cost-effectiveness threshold as well, and even estimated that resources have been freed up. Thus, the ICER suggests that the implementation of PUB in the municipality has been a lucrative, both in terms of cost and effect. However, a definitive conclusion of cost-effectiveness of the PUB is hindered by uncertainty surrounding the 2013 incidence rate, as this parameter was estimated from literature.

Preface

The analysis “Cost-effectiveness analysis of the Pressure Ulcer Bundle in the municipality of Sønderborg” was conducted by group 7015 on the 1st semester at the Master’s degree Medical Market Access, at the School of Medicine and Health at Aalborg University.

The report was based on making a health-economic analysis to assess whether the implementation of the pressure ulcer bundle in the municipality of Sønderborg has been cost-effective. The pressure ulcer bundle was compared with previous standard care for treatment of pressure ulcers in the municipality.

The analysis had focus on the relevant costs and effects seen from an elderly care perspective in the municipality. The effect in this report is the changes in the incidence rate of pressure ulcers over a one-year period. This effect measure was chosen because the PUB was introduced as a preventive initiative specifically aimed at reducing the occurrence of pressure ulcers.

The report is specifically aimed at individuals with an interest in prevention initiatives of pressure ulcers at a municipal level, to persons with a knowledge and interest in health economics, and as well to individuals dealing with, and interested in, quality development and patient safety including Danish Society for Patient Safety.

Our acknowledgements go to the municipality of Sønderborg for collaboration and assistance in obtaining the data on which the report has been rebuilt.

Additionally, we would like to thank our supervisor, Sabrina Storgaard Sørensen, for the good guidance and help she contributed with, through the project period.

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List of abbreviations

CBA	Cost-benefit-analysis
CEA	Cost-effectiveness-analysis
CER	Cost-effectiveness ratio
CUA	Cost-utility-analysis
DKK	Danish Krone
DRG	Diagnosis-related-groups
DSHP	Danish Safer Hospital Programme
HUSK	Skin-surface-mobilization-diet
ICER	Incremental cost-effectiveness ratio
ISH	In Safe Hands
PU	Pressure Ulcer
PUB	Pressure Ulcer Bundle
QALY	Quality-adjusted life years
SHA	Social and healthcare assistant
SHH	Social and healthcare helper

1 – Introduction

Pressure ulcers are a common phenomenon in both the primary and secondary sectors of the Danish Healthcare System. These pressure ulcers represent a significant problem for affected individuals on a personal level as well as for society in general.

From a patient's perspective, pressure ulcers are associated with a decreased quality of life in various ways. The decrease in quality of life is underlined by the fact that patients with pressure ulcers may experience severe pain and that they are at an increased risk of developing medical complications such as prolonged infections of the skin, bone and other tissues (1,2). Also, one study reported a 180-day mortality rate of 69% for patients with a grade 3 or 4 pressure ulcer (3). Additionally, hospitalised patients who develop pressure ulcers may require extended lengths of hospital care, further decreasing the quality of life for these patients (1). In Denmark, hospital stays are estimated to be prolonged by 37% if patients develop pressure ulcers (2). Furthermore, a qualitative study from 2007 by Spilsbury, K et al. investigated the impact of pressure ulcers on quality of life (4). This study reported a significant impact of pressure ulcers on patients' lives both emotionally, mentally, physically, and socially, thus underlining how pressure ulcers decrease quality of life (4).

However, pressure ulcers are not merely an individual problem for affected patients. Indeed, they also constitute a societal problem, which is, in part, highlighted by relatively high prevalence rates. Between 2002 and 2008, six studies investigated the prevalence of pressure ulcers among hospitalised patients in Denmark (5). These studies demonstrated pressure ulcer prevalence rates of 13-43% among hospitalised patients in Denmark (5). An additional prevalence study conducted at Odense University Hospital, Denmark in 2010 demonstrated pressure ulcers among 17,3% of all hospitalised patients (6). These studies, however, are exclusively concerned with the prevalence of pressure ulcers in the secondary healthcare sector of the Danish Healthcare System, and evidence on the prevalence in the primary healthcare sector is sparse. One study, conducted in a Copenhagen nursing home from 1999 to 2002, discovered how 60% of new residents had pressure ulcers upon admission to the nursing home (7). Furthermore, a study conducted in 2003 across 16 municipalities in the Copenhagen area discovered an ulcer prevalence of 2% among all people aged 70 or above, whether an elderly care resident or not (8). Of these ulcers, 16,3% were pressure ulcers (8).

Thus, pressure ulcers are a widespread phenomenon in both the primary and secondary sectors of the Danish Healthcare System, and the impact of pressure ulcers on the societal level is further underlined by annual treatment costs. Based on annual costs in Britain, the total annual cost of pressure ulcers for the Danish Healthcare System have previously been estimated at 1.3 billion Danish Kroners (DKK), with the average cost per case ranging from 12.240 to 168.300 DKK, depending on ulcer severity (6,9). However, these numbers were based on a 2004 study and are likely outdated (9). Additionally, a 2009 estimate placed the average cost per pressure ulcer at 200.000 DKK, with 90% of these costs caused by nursing time (2). To the best of our knowledge, a more recent analysis of the cost of pressure ulcers in Denmark does not exist.

Due to the impact of pressure ulcers on individual patients and society as whole, the prevention of pressure ulcers has been an important topic in the Danish Healthcare System in recent years. As a result, quality improvement programmes featuring initiatives for pressure ulcer prevention have been established (10,11). The In Safe Hands programme (ISH) is one such programme, implemented in the primary sector of the Danish Healthcare System in 2013 in order to, among other things, reduce the prevalence of pressure ulcers in elderly care (10). However, due to limited resources in the Danish Healthcare System, it is important to inform decision makers of the cost-effectiveness of such new initiatives in order to ensure optimal resource utilisation in the healthcare system. To the best of our knowledge, no such economic evaluation of the prevention of pressure ulcers through the ISH exists.

2 - Background

In the following section of this report, the pathophysiology and treatment of pressure ulcers is detailed, followed by an overview of the origin and structure of the pressure ulcer bundle in the ISH initiative, as well as a description of the application of this pressure ulcer bundle in the municipality of Sønderborg.

2.1 - Pathophysiology of pressure ulcers

Pressure ulcers are skin damages that may arise from persistent pressure, friction or moisture on the skin. Most commonly seen in elderly or immobile patients, the main cause of pressure ulcers in this particular group of patients is persistent pressure on the skin which obstructs the arterial and venous blood flow in the area (12). Therefore, pressure ulcers are often found over bone prominences like the occiput, scapula, elbows, sacrum, ischial tuberosities, and heels (13). This is due to the inflexible nature of the bone, as the tissue between the pressure source and the bone is compressed when pressure is applied (14). When the applied pressure on the skin increases sufficiently for the interstitial pressure to exceed the capillary pressure, the capillaries collapse. This results in deprivation of the supplied tissue from essential nutrition, causing ischemia. The oxygen deprivation causes hypoxia and, over time, anoxia which results in cell death and tissue necrosis (14). The time in which damage can be reversed varies with each individual's tolerance to hypoxia. A study of the reaction of skeletal muscles to different durations of ischemia indicates that the window for damage reversal is between 30-240 minutes (15). Whether the same principles apply for softer tissues like those located in the skin has not been investigated. Depending on the severity, pressure ulcers can be divided into four categories, see table 1.

Table 1. Classifications of pressure ulcer grades.

Table 1 – Overview of pressure ulcer classification (16).	
Grade	Definition
Grade 1	Redness of the skin which does not disappear when pressed with a finger.
Grade 2	Damage to the outermost skin layer with blister forming which may progress to an ulcer.
Grade 3	Ulcer which involves all skin layers.
Grade 4	Ulcer which exposes the underlying bone with loss of all skin layers.

Grade 1 pressure ulcers can be observed as a red discoloration of intact skin where applied pressure will not cause the skin to blanch, although the skin is intact (16,17). The persistent redness in pressure ulcers is a sign of ongoing inflammation caused by cytokine release from dead cells, promoting vasodilation and thereby oedema (18). Therefore, redness, pain and oedema can be observed as the first signs of pressure ulcers (19). If pressure relieving measures are not taken the injury will continue to progress forming an ulcer that will progress by expanding laterally and profoundly, thus involving both the epidermis and the dermis, advancing to a grade 2 pressure ulcer (16). Further cellular death will occur and, over time, progress profoundly toward the basal membrane (17). On the skin surface, the most common sign of a grade 2 pressure ulcer is vesicles and/or areas with loss of the outermost skin layer (16). With obstruction

of the intact skin, the patient is at risk of attracting infections (20). Once cellular death happens in the basal membrane, detachment of these cells will allow the tissue necrosis to progress to the fatty subcutaneous layer, thus involving all three skin layers as a grade 3 pressure ulcer (17). Further progression will cause grade 4 pressure ulcers in which there is a loss of all skin layers and involvement of the underlying tissues such as muscle, bone or tendon (16). At this stage it is possible that infection of the bone may develop and cause complications to the condition (17).

2.2 - Treatment of pressure ulcers

The treatment of pressure ulcers is highly individualised since every ulcer is different. The course of treatment depends on the location, grade, and cause of the pressure ulcer, thereby making it impossible to find procedures that state a generalised treatment applicable to all scenarios. To simplify the treatment procedure, experts' opinions and relevant literature have been used to enlighten the average wound types occurring in elderly care. Then, the average treatment courses for these wound types were elaborated by expert opinions and is described in the following subsections of this report.

In grade 1 pressure ulcers, it is important to relieve the pressure on the exposed area to avoid exacerbation of the ulcer. The actions that relieve pressure depend on how mobile the patient is. In mobile patients, it is mainly guidance on how they can relieve the pressure from the exposed area, whereas in immobile patients, caregivers help the patient by moving them in the bed. To help relieving the pressure, many patients are given pressure relieving aids, such as alternating pressure air mattresses and pillows. Skincare is also important and includes actions that reduce moisture on the skin. The most commonly used is barrier crème, which is applied to the moisture exposed area to help it dry. The most common area exposed to moisture is the diaper area.

In grade 2-4 pressure ulcers, it is still important to relieve the pressure on the skin, and the pressure relieving actions are the same as in grade 1 pressure ulcers. The difference from grade 1 to grade 2-4 is the treatment of the developed ulcer. The treatment of the ulcer aims to prevent infection and the formation of scar tissue. The exact treatment of the ulcer depends on the grade and the location, but normally includes cleaning of the ulcer and the changing of bandages to ensure optimal healing conditions and reduce the risk of complications. Large ulcers may need assistance to heal properly by either vacuum-assisted closure treatment or even plastic surgery to transplant tissue to cover the wound (21). Ulcers that demand such extensive treatment, or if systemic complications have developed, are cared for in hospitals (22).

2.3 - Pressure ulcer prevention

Pressure ulcers has been a central subject in prevention initiatives in Denmark through several improvement projects in recent years. First in the Danish Safer Hospital Programme (DSHP) in the secondary sector of the Danish Healthcare System, and secondly in the In Safe Hands (ISH) in the primary healthcare sector.

In the DSHP, five hospitals participated from 2010 to 2013. In the project, 12 focus areas were included, one of which being the prevention of pressure ulcers. A health economic study from 2013 demonstrated that if the DSHP could reduce the prevalence of pressure ulcers in the secondary healthcare sector by 50%, the improvement initiative would be cost-effective (23). A study from Odense University Hospital showed a reduction of 60% in the prevalence of pressure ulcers when implementing the methods from the DSHP (24).

Experiences from pressure ulcer prevention in the DSHP were passed on to a second improvement project, the ISH (25). Five municipalities participated in the ISH from 2013 to 2016. The ISH consisted of six focus areas, four of which were clinical areas and two of which were organizational areas. The four clinical focus areas were pressure ulcers, medicine errors, falls, and infections. The two organizational focus areas were management of improvement work and collaboration with residents and their relatives. The municipalities participating in the ISH were Frederiksberg, Lolland, Sønderborg, Viborg and Thisted from 2013 to present date, all of which were focusing on the six areas. The results showed complete elimination of pressure ulcers and medicine errors, as well as an improvement on the two organizational focus areas when guidelines were followed. After an evaluation of the programme, 13 additional municipalities were included in the project in 2016, and the focus areas were changed to only include the two organizational focus areas, as well as two clinical ones; pressure ulcers and medicine errors. The 13 municipalities were Allerød, Billund, Brøndby, Greve, Helsingør, Hillerød, Kerteminde, Mariagerfjord, Silkeborg, Syddjurs, Varde, Aabenraa and Aarhus. Different methodology bundles for improvement are included in the work with the different focus areas (10). In the following subsection of this report, the pressure ulcer bundle (PUB) used in the ISH is described.

2.3.1 - The Pressure Ulcer Bundle

The prevention of pressure ulcers in the ISH is carried out by complying with a set of actions described in the PUB (see appendix 1). The PUB aims to prevent pressure ulcers among residents in elderly care by standardising and systematising prevention efforts among employees. The PUB consists of four main actions:

1. Conducting risk assessments
2. Conducting risk-reassessments
3. Devising a plan
4. Performing preventive measures

The risk-assessments are conducted at the first contact the resident has with the care unit. In nursing homes, all residents are evaluated, while in home nursing, residents are assessed for risk if they either use wheelchairs, are immobilised, or receive personalised care. The risk-assessments are conducted in accordance with the Braden Scale. The Braden Scale is a tool which evaluates the resident on six criteria, thereby analysing if the resident is at risk of developing pressure ulcers (26).

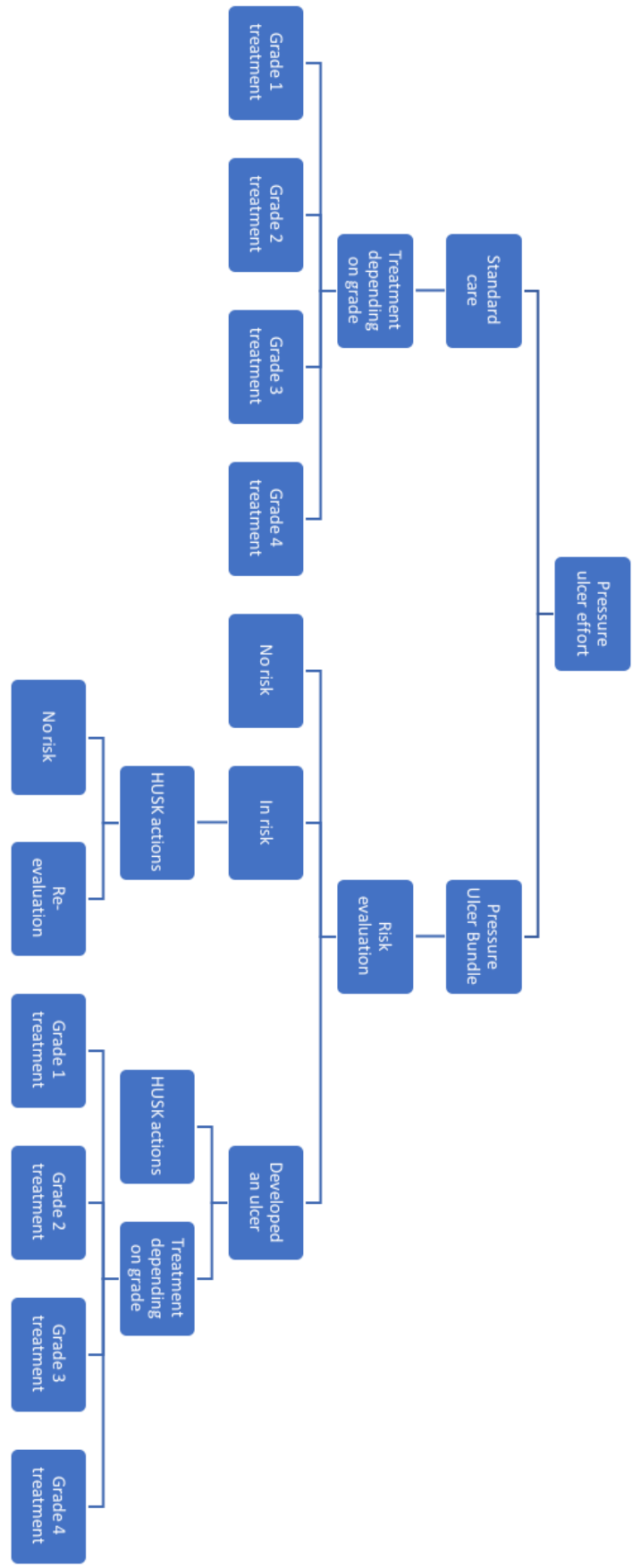
The risk reassessments are conducted when the health status of a resident changes to ensure that the resident still receives relevant preventive actions if needed. Reassessments are conducted when a resident

is either discharged from hospital, after acute disease, or if they change nutrition or mobility status. Furthermore, in nursing homes, all residents are reassessed every third month.

Following the assessment of a resident's risk of developing pressure ulcers, a plan of preventive actions is devised in order for every party involved in the care to be familiar with the mode of action. The actions are individualised but may typically include assigning specific aids, such as pressure relieving pillows and mattresses, or making a diet change to improve the nutritional status of the resident. The preventive actions have four focus areas that need attention from the Social and Healthcare Helper (SHH) or Social and Healthcare Assistant (SHA) taking care of the resident. These actions are known as HUSK, which describes the need to assess the skin, the aids, mobilisation and diet. The overall condition of the skin is assessed by looking for dryness or excess moisture along with checking for pressure ulcers or signs of precursor states. Then the surface of beds and aids are checked to ensure they are correctly adjusted and the aids used correctly. The surface of the bed is particularly important since any small bump may cause a pressure ulcer and, therefore, linen is flattened and any food crumbs or similar removed. Then, the resident is systematically mobilised or positioned to relieve and distribute skin pressure. The last step of HUSK is the diet which is to ensure that the resident is sufficiently hydrated and nourished in order to maintain a good health status. The HUSK actions itself are not new to the nursing staff, however, the systematic approach in the PUB to assess risk and conduct HUSK actions stepwise was implemented with the PUB in order to prevent pressure ulcers (27).

In the standard care approach, pressure relieving was a part of the treatment of pressure ulcers in any grade. Therefore, the systematic approach, which the PUB provides, was not used and pressure ulcers were discovered later in the further developments of the case. When using the PUB approach, pressure ulcers are discovered earlier and even prevented because of the preventive actions for the resident at risk. Therefore, two distinguishable alternatives in relation to pressure ulcers are identifiable. The first alternative, referred to as the standard care approach, where pressure ulcers are treated as they are discovered, and the new alternative, referred to as the PUB alternative, which is focused mainly on preventing pressure ulcers along with early discovery. The alternatives are shown schematically in figure 1 on the next page.

Figure 1. Flowchart depicting steps and actions of the two alternatives.



2.4 - Application of the PUB in the municipality of Sønderborg

The health economic evaluation conducted in this study is based on the elderly care of the municipality of Sønderborg. The municipality of Sønderborg has been working with the ISH from the very beginning when the pressure ulcer bundle was implemented. Thus, the municipality has worked systematically with the initiative and collected data since the beginning of the preventive alternative and are still collecting. This collection of data should represent the complete implementation of the initiative on a large population which could potentially be enough to make an economic evaluation that represents the preventive initiative as a whole.

The elderly care of the municipality of Sønderborg is divided into 13 home nursing units and 11 nursing home units, with a total of 2.808 residents distributed across these care units. The home nursing division is further divided into four districts, Nordals, Sydals, Alssund, and Fjord, respectively, and these are further subdivided into individual units within the four districts. In addition to the home nursing units, the Sønderborg elderly care also consists of 11 nursing homes. The nursing homes are Tangshave, Hørup, Gråsten, Broager, Guderup, Amaliehaven, Mølleparken, Center for kortidspladser, Tandsbjerg, Dalsmark, and Dybbøl.

2.5 The municipal activity-based co-financing

Although the purpose of the PUB is to prevent pressure ulcers, some pressure ulcers may still develop, in some cases resulting in hospital admission. In relation to this, it is necessary to detail the principle of municipal co-financing of hospital treatment costs. Danish municipalities have a financial responsibility regarding healthcare, and, thus, a partial payment liability, referred to as the municipal activity-based co-financing, exists (22). The amount of costs used on co-financing is based on the DRG-rate for the pressure ulcers diagnosis, as well as the amount of pressure ulcers treated. The municipality pays 34% of the DRG-rate for the treated pressure ulcers, however, there is a maximum amount per treatment which is set at a price of 13.750 DDK (22).

3 - Research question

As described in the introduction section of this report, pressure ulcer treatment represents a significant burden on the Danish Healthcare System in terms of resource expenditure. Furthermore, the presence of pressure ulcers is associated with varying degrees of discomfort that can lead to a decline in quality of life. Pressure ulcers are prevalent primarily among immobilised or bedridden elderly, a cohort that may very well already experience a poor quality of life. Because of the burden both to healthcare system and the individual patients suffering from pressure ulcers, the Danish Society for Patient Safety implemented the ISH to increase preventive actions aimed towards pressure ulcers in 2013. The increased preventive pressure ulcer care is aimed at reducing the amount of preventable hospital admissions due to pressure ulcers, increase patient quality of life, as well as reduce resource consumption associated with pressure ulcer treatment in municipalities. However, the costs associated with the implementation of the increased preventive care has not been established. Nor has it been estimated whether or not the increased costs of the preventive actions are outweighed by the potential effect they have on the incidence of pressure ulcers in the municipalities, as well as the subsequent reduction in treatment costs. This leads to the following research question:

What are the health economic implications of implementing the preventive pressure ulcer bundle in the municipality of Sønderborg, specifically, has it been cost-effective compared to the standard care approach?

In order to answer this question, a cost-effectiveness analysis was undertaken. Firstly, the total cost associated with the treatment of pressure ulcers in the municipality of Sønderborg over a one-year period, prior to the implementation of the PUB, was estimated. Secondly, the initial start-up costs associated with the implementation of the PUB in the municipality of Sønderborg were estimated. This was followed by an estimation of the continued costs, in order to calculate the total cost of implementing the preventive PUB in the municipality of Sønderborg over a one-year period. The costs of the PUB were then compared to the costs of standard care. Thus, a cost-effectiveness analysis will be made. The effectiveness will be estimated by comparing the incidence rate of pressure ulcers in the municipality over a one-year period, prior to and after the implementation of the PUB in the municipality of Sønderborg, thus extrapolating the number of pressure ulcers prevented by the PUB. The number of prevented pressure ulcers, as well as the costs, will be used to generate a cost-effectiveness ratio that estimates the price of each prevented pressure ulcer, using the PUB alternative in favour of the standard care approach.

4 – Methods

In order to answer the presented research question and conduct a cost-effectiveness analysis, some knowledge into the methodology of economic evaluation is necessary. In the following section of this report, the methodology used in this study is accounted for. Firstly, a short rationalization for the data used in the analysis is presented, and, secondly, the health economic method is explained. Lastly, the two care alternatives are described, first with an overview of the alternatives and then with an estimation of costs and effects in each alternative.

4.1 - Data and literature priority

This health economic evaluation was based on data collected from the elderly care of the municipality of Sønderborg. Where data was insufficient, it was supplied by data or literature from relevant organizations and databases i.e. Danish Society for Patient Safety and Medline. The supplementary literature and data used was that with the highest similarity to the municipality of Sønderborg based on the following priority list:

1. Other Danish municipalities.
2. Western countries that share similarities with Denmark regarding healthcare system.
3. Other countries.

Furthermore, literature frequently quoted and deemed reliable in other publications relating to pressure ulcers were prioritised higher.

4.2 - Health economic evaluation

Health economic evaluations are an increasingly important tool employed when decision makers must decide whether or not to implement new health technologies in a society with a finite amount of available resources. Health technologies include not only new treatments and medical devices but also preventive measures, and health economic evaluations are even used when determining reimbursement levels for medicine (28,29). A health economic evaluation aims to identify and determine the resource costs associated with the implementation of a new health technology as well as what is to be gained from said implementation. This is important because resources in a society are scarce. Any resource deployed in a given place or on a specific health technology is “lost” to other alternatives. Therefore, it is of utmost importance that the resources consumed and their effects are systematically analysed. This is in order to maximize what value can be gained from the expenditure of these resources (30). This is what the health economic evaluation aims to do at its core, while simultaneously making said systematic analysis as transparent as possible. A systematic analysis of costs and value gained, coupled with transparency regarding where and how estimated costs and values gained are derived from, is exactly what decision makers need in order to make an educated decision. The starting point of any health economic evaluation is the introduction of a new health care technology, which is compared to one or more alternatives, often the existing practice of the given treatment area (28). In order to determine the health economic

consequences of the implementation of the PUB in the municipality of Sønderborg multiple health economic analysis could be undertaken:

4.2.1 - Types of health economic analyses

Two main types of health economic analyses exist: cost-benefit-analysis (CBA) and cost-effectiveness-analysis (CEA), where the CEA also includes a further development of said analysis called a cost-utility-analysis (CUA). As is implied by the name, all three types of analyses aim to determine the monetary costs of an intervention, and the main difference between the different analyses is how they measure the outcome (28,29).

The CBA is used to determine the costs and benefits associated with a new healthcare technology and whether this cost is worth the benefit (29). In the CBA, the effect of the new technology on the health of the patient is only of secondary interest. Instead the outcome is measured purely in monetary terms and whatever positive effect there may be on health should be captured by the monetary benefits (28).

As opposed to the CBA, in a CEA the health gain obtained through the new technology is never determined in monetary terms and the primary focus of the analysis is the effect the technology has on health, in relation to its cost. The outcome is measured in natural terms relating to the treatment area of the disease which the new health technology is aimed at (28). This, for example, could be body-mass-index (BMI) related to obesity, cholesterol levels for coronary disease, functional capacity for arthritis and so forth. A limitation of the CEA is that it cannot be used to compare a new intervention across diseases that use different outcome measures. However, in an attempt to rectify this, the cost-utility-analysis can be used (28).

In a CUA, like the CEA, the primary focus is on the health benefits of the technology in relation to its associated cost, i.e. maximizing the gain in health for money. This is taken a step further in regard to the CEA as the effect is measured in a generic health value, for instance quality-adjusted life years (QALY), a combined measure of life years and quality of life, i.e. functional health. This outcome can be compared across different disease treatments and preventive actions. Thus, the CUA can be used by decision makers more broadly than is possible with a CEA, although at their core both analyses aim to clarify which of the alternatives to choose in order to maximize the health benefits gained in direct relation to the costs (28,29).

In the health economic evaluation performed in this study, a CEA will be compiled. This CEA will aim to determine whether or not the implementation of the PUB in the municipality of Sønderborg has been cost-effective over a one-year period. A CUA will not be compiled, as the broader generic outcome measure of a CUA was not deemed applicable based on the data received from the municipality and other available literature.

4.2.2 - Incremental cost-effectiveness ratio and cost-effectiveness thresholds.

When comparing two interventions with the same output measure, as done in this evaluation, it is possible to calculate the incremental cost-effectiveness ratio (ICER). The ICER expresses the cost per additional output unit of the new technology, compared to the existing one, i.e. the effectiveness. For this study, the ICER was the cost per additional prevented pressure ulcer. The effectiveness was estimated by comparing the incidence rates of pressure ulcers in the municipality of Sønderborg over a one-year period, prior and post implementation of the PUB. The difference in costs between the PUB and standard care alternative were then divided across the number of prevented pressure ulcers in order to determine the cost-effectiveness ratio between the PUB and prevented pressure ulcers, i.e. the cost per prevented pressure ulcer using the PUB.

If the cost for one additional output unit is below the decision makers willingness-to-pay threshold, a new intervention is deemed cost-effective and favourable to the old intervention. The cost-effectiveness threshold for the CEA performed in this study was set at the average cost of treating a pressure ulcer in the standard care approach. This threshold was chosen because the PUB is a preventive initiative with the purpose of reducing the number of pressure ulcers occurring in the municipality. Thus, in order for the PUB to be deemed cost-effective, the ICER for one prevented pressure ulcer cannot exceed the average cost of treating one pressure ulcer. The ICER is calculated as illustrated in the equations below, with equation 1 illustrating the theoretical calculation of an ICER and equation 2 illustrating the ICER calculated in this study.

$$ICER = \frac{Cost_{New} - Cost_{Old}}{Effectiveness_{New} - Effectiveness_{Old}}$$

Equation (1): The general ICER equation template.

$$ICER = \frac{Cost_{PUB} - Cost_{Old}}{Incidence\ of\ pressure\ ulcers_{PUB} - Incidence\ of\ pressure\ ulcers_{Old}}$$

Equation (2): The ICER equation as calculated in this study.

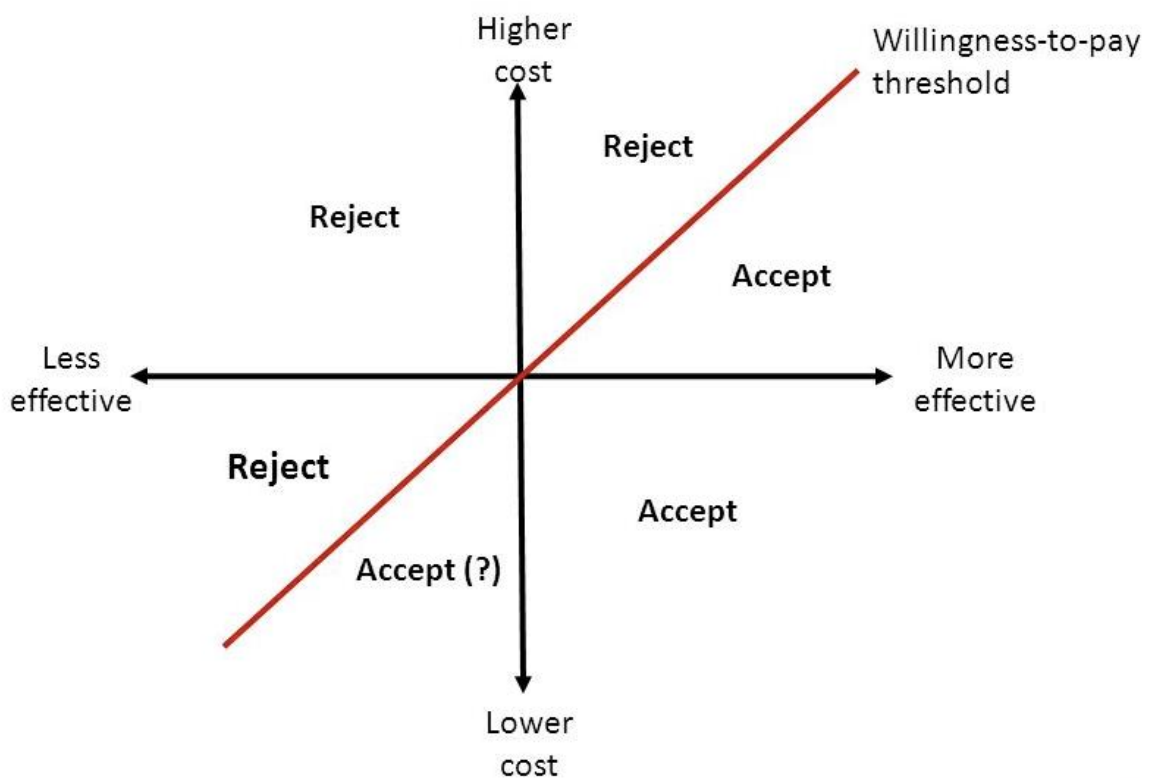
4.2.3 - The cost-effectiveness plane

A useful way to visually depict the cost-effectiveness of a technology for the decision makers is the cost-effectiveness plane, as seen in figure 2. The planes' axes represent the effectiveness (X-axis) and costs (Y-axis). Thus, when an ICER point estimate is inserted in the plane, it falls into one of the four quadrants that divides all possible cost and effect outcomes, as listed below (29).

- Southeast quadrant: The new intervention is both more effective and less costly than the old. In this case the new technology would be fully dominant and should be accepted.

- Northwest quadrant: The new intervention is both less effective and costlier than the old, which in this case means it would be dominated by the old one; the new intervention should be rejected.
- Northeast quadrant: The new technology has a greater effectiveness but also a higher cost; potential acceptance.
- Southwest quadrant: The new technology has a diminished effect but also at a reduced cost; potential acceptance.

Figure 2: The cost-effectiveness plane. A tool for visually displaying cost-effectiveness and improving transparency for decision makers



It is expected that the PUB will be both costlier and have greater effect than standard care and as such be placed in the northeast quadrant. Whether or not the PUB should be accepted as superior, based on efficiency grounds, when placed in this quadrant, depends on the trade-off between cost and effect, as well as its ability to comply with the willingness-to-pay threshold, i.e. stay below the red line in the illustration.

4.3 - Estimating effect

The effectiveness of the PUB was estimated as the change in the incidence rate of pressure ulcers in the municipality of Sønderborg over a one-year period following its implementation. This effect measure was chosen because the PUB was introduced as a preventive initiative specifically aimed at reducing the occurrence of pressure ulcers.

4.3.1 - Incidence of pressure ulcers prior to PUB implementation

The incidence rate of pressure ulcers in the municipality of Sønderborg prior to the implementation of the PUB was estimated through the best available literature. This was done as a consequence of the lack of data available on the incidence of pressure ulcers in home nursing units and nursing homes prior to the start of the PUB. The best available literature was a 2004 study of the costs of pressure ulcers in the United Kingdom and it suggests that:

“On a conservative estimate, the incidence of new pressure damage in long-term care probably lies in the range 12–13% annually” (9).

The incidence range estimated in the UK study was made based on comparison of a number of recorded incidence rates across different western countries, such as the UK, Canada and USA. Thus, with the purpose of estimating the effect of the PUB, it was assumed that the incidence rate of pressure ulcers in the municipality of Sønderborg was at 12,5% prior to its implementation. With the municipality of Sønderborg having 2808 residents in elderly care, this amounts to 351 new pressure ulcers per year prior to the implementation of the PUB, as seen in table 2 below.

4.3.2 - Incidence of pressure ulcers post PUB implementation

The incidence rate of pressure ulcers in the municipality of Sønderborg post PUB implementation was determined from the number of recorded new occurrences of pressure ulcers in home nursing units and nursing homes over a one-year period. This data was available from the municipality of Sønderborg, although only for the first ten months of 2017. The total number of new pressure ulcers was 112, which was then extrapolated across the remaining two months of 2017. Thus, the findings for the first ten months were multiplied by $1 + 2/10$, in order to correct for the lacking two months.

- Estimated number of new pressure ulcers of 2017:
 $112 * (1 + 2/10) \approx 134$ new pressure ulcers total, see table 2.

Table 2. Incidence rates and number of new pressure ulcers per year prior and post implementation of the PUB. (9)

	Incidence rate of pressure ulcers	Citizens in long term care	New pressure ulcers pr. year
Prior to PUB	12,5%	2808	351
PUB	4,7%	2808	134
Δ Prior/Post PUB	7,8%	0	217

As seen in table 2, the implementation of the PUB in the municipality of Sønderborg resulted in a reduced annual number of pressure ulcers from 351 to 134. Thus, the efforts of the PUB effectively prevented 217 pressure ulcers annually or, in other words, reduced pressure ulcer occurrence by 61,82%.

4.4 - Estimating costs

To calculate the ICER, an estimation of costs in the two alternatives was necessary. The standard care approach is composed of the treatment of pressure ulcers, whereas the PUB consists of PUB-related actions and the treatment of those pressure ulcers which occur in spite of the preventive actions. In the following the two alternatives and their costs are described in further detail.

Before the PUB, the pressure ulcer prevention was not as systematic as it is with the PUB. The main component of the standard care approach was treatment of occurring pressure ulcers, and, therefore, the resources associated with standard care were those spent on the treatment of the pressure ulcers. For the PUB, the costs consist of both the resources spent on preventive aids as well as treatment costs. Note that in the standard care approach, pressure relieving aids were associated with treatment as long as the residents had a pressure ulcer, whereas in the PUB, they are associated with prevention.

Furthermore, additional resources have been spent on labour costs in the PUB during risk assessments, staff training, etc. In addition, costs associated with the mandatory municipal co-financing of hospital admissions related to pressure ulcers were identified. The specific resources, amounts, and costs identified in this study are presented in the remaining parts of this methods section. An overview of these is given in table 3 below.

Table 3. Identified resources associated with standard care and the PUB

Category	Costs associated with standard care	Costs associated with the PUB
Treatment of occurred pressure ulcers	Labour costs of treating ulcers	Labour costs of treating ulcers
	Remedies used to treat ulcers	Remedies used to treat ulcers
	Pressure relieving aids used for treatment	
Prevention of pressure ulcers		Pressure relieving aids used for prevention
		Risk-assessments and re-assessments
Expenses to the region	The municipal activity based co-financing	The municipal activity based co-financing
Additional labour costs		Management training courses
		Peer-to-peer training
		Staff training in PUB-related actions
		Improvement team meetings

In table 3 it is seen that some were identified for both alternatives, such as the municipal co-financing, treatment of pressure ulcers and pressure relieving aids, whereas additional labour costs were specific to the PUB. In the following subsections, all of these costs are described.

4.4.1 – Note on labour costs

A multitude of costs incurred by the PUB were identified as labour costs, i.e. the cost of staff members on a salary spending time at work. Labour costs were incurred by pressure ulcer treatment, initial risk-assessments, continuous risk-reassessments, management training courses, peer-to-peer training, staff training in PUB-related actions, and improvement team meetings.

In order to estimate the total labour cost of each of these activities, it was necessary to know the full composition of staff members participating in each activity. However, full data on staff composition was only available for the management training courses, and assumptions and estimations had to be made for all remaining activities. These assumptions and estimations are detailed in appendix 2.

Additionally, in order to calculate total labour costs, the salary of each participating staff member was needed. In some cases, these were handed over by the municipality of Sønderborg, with all remaining salaries estimated by consulting collective bargaining agreements (31,32). These estimations are thoroughly detailed in appendix 2.

4.4.2 - Costs incurred by pressure ulcer treatment

In this subsection of the report, the costs incurred by the physical treatment of pressure ulcers are detailed, whereas the costs incurred by pressure relieving aids are addressed in subsection 4.4.3, although pressure relieving aids are considered part of the treatment in the standard care approach.

As previously stated, the treatment of pressure ulcers is highly individualised and, therefore, difficult to estimate. Therefore, expert opinions of a nurse and an ulcer nurse, both with experience from elderly care, were used to identify and estimate the relevant resources used in the treatment of pressure ulcers.

The resources consumed on pressure ulcer treatment are mainly the time consumption on mobilisation and treatment of the ulcer. Mobilisation is always done by SHHs while the type of health professional treating the ulcer depends on ulcer severity. Grade 1 pressure ulcers are treated by SHHs, grade 2 by SHAs, while both grade 3 and 4 are treated by nurses. Furthermore, ulcer treatment requires remedies that are specific for each grade of pressure ulcer, as seen in table 5. Grade 1 ulcers require a barrier cream called Conveen Citric Barrier Cream, grade 2 ulcers require Allevyn adhesive wound dressing, while both grade 3 and 4 ulcers require a so-called blue pillow (an absorbent dressing), Mefix fixation which is a self-adhesive tape, and Aquacel, a type of wound dressing used to treat moderate to severe ulcers.

The time consumption of resident mobilisation is 15 minutes three times daily for all ulcer grades, while time used on treatment varies with the grade. For a grade 1 pressure ulcer, an SHH spends 1 minute three times daily, whereas at grade 2, an SHA spends 15 minutes two-three times weekly, in average 2,5 times weekly. At both grade 3 and 4, a nurse spends 20-25 minutes once a day, in average 22,5 minutes, as seen

in table 5. The unit costs, i.e. the average functional hourly wages, of SHHs, SHAs, and nurses were calculated in accordance with appendix 2. Note that staff seniority impacts the average functional hourly wages, the unit cost, seen in table 4.

Table 4. Overview of unit costs (DKK/h) for SHHs, SHAs and nurses employed in home care and at nursing homes in the municipality of Sønderborg.

Type of resource	Item	Price per unit
Labour	SHH	229,88 DKK/h
	SHA	226,76 DKK/h
	Nurse	211,62 DKK/h

The estimated amount of remedies used for one treatment can be seen in table 5. How many treatments one unit covers, as well as the unit cost, was estimated based on the expert opinion of a wound nurse with experience from elderly care. The identified unit prices are seen in table 6.

The barrier cream has a unit price of 57 DKK with one unit covering 28 treatments. The Allevyn, or other analogues used to treat grade 2 pressure ulcers, has a unit price of either 7 DDK or 10,7 DKK, depending on the size of the tube and which brand it is. As data on the distribution of these brands and tube sizes was not available, the average cost of 8,85 DKK per unit was used. One unit covers one treatment. The three items used for treatment of grade 3 and 4 ulcers is the blue pillow, Mefix fixation, and Aquacel. The blue pillow comes in two different sizes, 10x10 cm and 10x20 cm respectively, with a unit price of 0,25 and 0,35 DKK respectively. Which one is used depends on the size of the wound and, since no data on the size of pressure ulcers was available, the average cost of the two sizes was used, thereby resulting in a unit price of 0,30 DKK. The Mefix has a unit price of 17 DKK which is enough to cover 10-20 treatments, in average 15, and the Aquacel has a unit price of 15 DKK which covers one treatment.

The annual treatment cost in both alternatives was calculated individually for each pressure ulcer grade. The daily cost of treatment was then calculated and multiplied by the average number of healing days for each pressure ulcer grade and the number of pressure ulcers in that grade. Data regarding average healing days and distribution of pressure ulcers on each grade was unavailable and, therefore, these were estimated based on the previously mentioned UK study by Bennet et. al 2004 (9), as seen in table 5.

Table 5. Identified resources and amount consumed for the different grades of pressure ulcers

Resources		Grade 1	Grade 2	Grade 3	Grade 4
Time spent	Mobilisation	15 min 3 times a day	15 min 3 times a day	15 min 3 times a day	15 min 3 times a day
	Ulcer treatment	1 min 3 times a day	15 min 2-3 times a week	20-25 min per day	20-25 min per day
	Average healing time (days) (9)	28,4	93,8	127,4	154,7
	% distribution (9)	34,9 %	41,2%	12,9%	11,0%
Remedies	Barrier crème	1/28 of a unit			
	Allevyn		One unit		
	Blue pillow			One unit	One unit
	Mefix fixation			1/15 of a unit	1/15 of a unit
	Aqualcel			One unit	One unit

Table 6. Identified unit prices for the remedies used in treating pressure ulcer category 1-4.

Remedies	Barrier crème	57 DKK/unit
	Allevyn	8,85 DKK/unit
	Blue pillow	0,30 DKK/unit
	Mefix fixation	17 DKK/unit
	Aquacel	15 DKK/unit

4.4.3 - Costs incurred by pressure relieving aids

Pressure relieving aids, as previously mentioned, were a part of the pressure ulcer treatment for the standard care, while also associated with prevention for the PUB alternative. The only data available on the usage of pressure relieving aids was a list of 11 current residents with pressure relieving aids, with details of which aids they have been given. Therefore, in order to estimate the costs incurred by pressure relieving aids, the following assumptions were made.

1. The sample of 11 aids users is representable for the entire distribution of aids in the municipality of Sønderborg.
2. The pressure relieving aids used for prevention in the PUB alternative represents the composition of aids used for treatment in the standard care approach.

The costs of pressure relieving aids for the two alternatives was, thus, estimated by calculating an average daily price of pressure relieving aids, in accordance with the sample, and multiplying by the number of residents ascribed aids. For the PUB, it was assumed that a constant 283 residents are in the risk group at all times of the year, and thus 283 residents ascribed pressure relieving aids at all times (365 days/year). This was estimated by the municipality of Sønderborg.

For the standard care approach, it was assumed that patients are ascribed pressure relieving aids only during pressure ulcer healing. Thus, it was calculated as the occurrence of the different pressure ulcer

grades, multiplied by the average healing days for each grade. The average daily cost of pressure relieving aids was then calculated by dividing the purchase price with expected durability.

The list of pressure relieving aids, as handed over by the municipality of Sønderborg, is found in table 7 below. The table depicts the 11 residents as a number from 1-11 with their respective aids and, therefore, some aids appear more than once.

The HMI-number is an identification number used to look up the specific aid on www.hmi-basen.dk. Purchase prices for the various aids were obtained from retailers and may, therefore, differ from any online price listings. The durability of the pressure relieving aids were estimated based either on information handed over from retailers or on expert opinion from a wound nurse.

Table 7. List of pressure relieving aids and their purchase price ascribed to the 11 citizens at risk that make up the sample provided by the municipality of Sønderborg

Resident	HMI-number	Item – Brand	Price incl. taxes (DKK)	Durability (years)
1	79886	Foam mattress – Alpha	1.243,75	5
	85055	Foot support – MaxxCare Pro Evo.	705	2
	85055	Foot support - MaxxCare Pro Evo	705	2
	48165	Air mattress dynamic - Cirrus	43.625	8,5
2	85055	Foot support - MaxxCare Pro Evo.	705	2
	87289	Toilet seat padding	1.056,25	6
	33537	Air mattress dynamic – Sentech Thera Turn Millennium	25.000	10
3	85055	Foot support - MaxxCare Pro Evo.	705	2
	85055	Foot support - MaxxCare Pro Evo.	705	2
	87289	Toilet seat padding	1.065,25	6
4	87289	Toilet seat padding	1.065,25	6
	48165	Air mattress dynamic - Cirrus	43.625	8,5
	71719	Pull sheet – Vendlet	1.150	2
	71719	Pull sheet – Vendlet	1.150	2
	71719	Pull sheet – Vendlet	1.150	2
	71864	Positioning support pillows – Vendlet	688,75	4
	71865	Positioning support pillows – Vendlet	817,5	4
	88282	Motorised turning machine – Vendlet	4.1868,75	10
	71723	Sliding sheet – Vendlet	838,75	4
	71723	Sliding sheet – Vendlet	838,75	4
5	42932	Coating for guard rail	1.785	5
	44447	Foam mattress synthetic – PRIMA 6	1.118,75	8,5
	101082	Air mattress – AD ProCare 3 Auto	16.243,75	4
6	31235	Air mattress – Roho Quadtro Select	2.621,875	3
7	31235	Air mattress – Roho Quadtro Select	2.621,875	3
8	71719	Pull sheet – Vendlet	1.150	2
	71719	Pull sheet – Vendlet	1.150	2
	71723	Sliding sheet – Vendlet	838,75	2
	84575	Positioning support pillows – Vendlet	1.783,75	4
	88282	Motorised turning machine – Vendlet	41.868,75	10
9	16539	Foam pillows – Decu-dan seat pillow	107,5	4
10	32008	Foam mattress – Decudan pillow	2.440	5
	30257	Positioning pillows – Repons air	2.253,75	2
11	85055	Foot support - MaxxCare Pro Evo.	705	2
	85055	Foot support - MaxxCare Pro Evo.	705	2
	33256	Mater turner mattress	1.573,44	4
	49368	Master turner slide	1.573,44	4
	49368	Master turner slide	1.573,44	4
	87289	Toilet seat padding	1.056,25	6
	24960	Air mattress – Vicair Academy Adjuster 10	5.552,5	5

4.4.4 - Costs incurred by the municipal activity-based-co-financing

Another relevant cost identified is the municipal activity-based co-financing. The fact that the municipality has a co-financing responsibility applies to both the standard care approach and the PUB alternative, and, for this reason, the co-financing costs were estimated for both alternatives based on data handed over by the municipality of Sønderborg. The only difference between the two alternatives with regards to the co-financing, was deemed to be the total cost of these. However, the co-financing costs incurred in the PUB alternative was only listed for the first nine months of 2017, and, thus, the average monthly cost was extrapolated across the last three months in order to arrive at the annual total for 2017.

In this analysis, the municipal activity-based co-financing considered was limited to patients with a pressure ulcer diagnosis who received EOJ services, i.e. the ones in contact with Sønderborg home nursing units and nursing homes. Patients who did not receive EOJ services were excluded as the PUB has no influence on whether these develop pressure ulcers or not.

In order to compare the standard care approach with the PUB alternative, the value of the 2013 municipal co-financing cost was converted to present value, thus adjusting for inflation, as seen in table 8. This was done using the Danish Consumer Price Index (33). The annual index for 2017 had not yet been made fully available at the time of writing, since the year had not yet passed. Thus, the best approximation was made by averaging across the months for which data was available.

Listed below are the estimated the costs incurred by the municipal co-financing for each alternative, as seen in table 8 below, see appendix 3.

Table 8. Costs of municipal co-financing for hospital treated pressure ulcers.

	Standard care (2013)	PUB (2017)
Costs spent on co-financing	96.410 DDK	87.393 DDK for 9 months

4.4.5 - Costs specific to the PUB alternative

As previously stated, some identified costs are specific to the PUB-alternative and, thus, not incurred in the standard care approach. These costs are related to the implementation and operation of the PUB.

When a new technology is implemented, certain costs are associated with the implementation processes. Implementation costs associated with the prevention of pressure ulcers via the PUB were incurred by management training courses, peer-to-peer training, staff training in PUB-related actions, and initial risk-assessments. In this report the implementation costs associated with the implementation of the PUB are depreciated over a four-year period. Annuitization is a method to allocate the costs over an assets' expected lifetime. The implementation of PUB, in all the units of the municipality, extends over a number of years and thus these costs are associated with the implementation, the implementation costs should be depreciated over the entire implementation period, which is a four-year period. The annuitization of the implementation costs are detailed in section 5.4.5.

In addition to the implementation costs, some annual costs associated with operating the PUB were identified, consisting of continuous risk-reassessments and improvement team meetings. All of these costs were identified as labour costs and are detailed in the following subsections of this report.

4.4.5.1 - Costs incurred by management training courses

In order to implement the prevention of pressure ulcers via the PUB in the ISH, a series of management training courses were conducted. The courses concerned the ISH as a whole, thereby making the PUB one of six topics. Therefore, it was assumed that the cost associated with the PUB consists of one 6th of the total labour cost of the management training courses. These courses were organised by the Danish Society for Patient Safety and, therefore, the only municipal costs associated with these courses were deemed to be the labour cost of each participant spending work time at the courses.

In order to estimate the total labour cost of the management training courses, the total time spent, as well as the salary of each participant, was needed. All 34 participants attended the training courses for 104 hours, spread across two days in 2013, four days in 2014, four days in 2015, and three days in 2016, with each day consisting of 8 working hours, as seen in table 9.

The participants varied in staff position and, therefore, salary as well. Some annual salaries were handed over by the municipality of Sønderborg, whereas the remaining annual salaries were estimated in accordance with appendix 2. All annual salaries were then converted to functional hourly wages, and the unit cost, i.e. the average functional hourly wage across all participants, was calculated as detailed in appendix 2 and seen in table 9 below.

Table 9. Overview of management training courses, the hours spent and unit price of a functioning work hour.

	Days spent per participant	Hours spent per participant	Wage hour range
2013	2	16	297,34 DKK/hour
2014	4	32	297,34 DKK/hour
2015	4	32	297,34 DKK/hour
2016	3	24	297,34 DKK/hour

4.4.5.2 - Costs incurred by peer-to-peer training and staff training in PUB-related actions

In addition to the management training courses, peer-to-peer training and staff training in PUB-related actions was conducted in order for staff members to get familiar with the new methodology. The staff training in PUB-related actions was a theoretical walkthrough of the PUB-related actions, lasting two hours and 30 minutes per staff member in each care unit, while peer-to-peer training lasted four hours per staff member in the pilot units and two hours per staff member in all remaining care units. The resources used on these activities were the time spent by the attending staff, thus resulting in labour costs.

Unit costs is given as the functional wage hour range for the participants see table 10. For the exact wage for each attendee see appendix 2.

Table 10. Overview of duration and unit price of staff training and peer-to-peer training.

	Hours spent per participant	Wage hour range
Staff training	2 ½	216,84-242,92 DKK/hour
Peer-to-peer training (pilot unit)	4	216,84-242,92 DKK/hour
Peer-to-peer training	2	216,84-242,92 DKK/hour

4.4.5.3 - Costs incurred by risk-assessments

Both implementation costs and operating costs were identified to be incurred by risk-assessments. At the point of implementation, risk-assessments were performed on all nursing home residents and on those home nursing residents who use wheelchairs, are immobilised, or receive personal hygiene care. In addition to the initial risk-assessments, continuous risk-reassessments are performed on those residents previously deemed in risk. Data on the on how many risk-assessments are performed both in nursing homes and in the home nursing units is found in appendix 4.

It was estimated by the municipality that a risk-assessment lasts 2-3 minutes and is conducted by either an SHH or an SHA. The only resource consumed during risk-assessment is the time spent by the respective staff member and, thus, the only incurred cost is the associated labour cost.

The exact number of risk-assessments conducted at implementation was not available. In order to make the best estimate, the data shown in appendix 4 has been used. In the appendix 4, the total number of residents in each care unit, as well as those in risk, among other things, is shown. This data is from November 2017 and this is assumed to be a representative measure for the number of residents in risk across the entire year of 2017, as the number of residents in risk is considered by the municipality of

Sønderborg to have been stable since the PUB was implemented. Therefore, this data is used to estimate how many risk evaluations were conducted at implementation of the PUB with the assumption that:

1. The resident number and distribution from November 2017 is representative of the resident composition at implementation in 2013.

The key number is shown in table 11, which highlights how many residents were assessed for risk in both nursing homes and the home nursing units along with the annual number of risk reassessments.

Since the resources used on risk-assessments is the time spent by either an SHH or an SHA, the unit cost was estimated as the average functional hourly wage across these staff members, in accordance with appendix 2.

Table 11. Overview of the number of risk-assessments and the unit cost.

Unit		Number of risk-assessments	Unit price
Nursing homes	Initial	580	227,98 DKK/hour
	Continuous (annual)	2968	227,98 DKK/hour
Home nursing units	Initial	821	227,98 DKK/hour
	Continuous (annual)	1092	227,98 DKK/hour

4.4.5.4 - Costs incurred by improvement team meetings

As part of the operation of the PUB, improvement team meetings are held for 30 minutes on a weekly basis in the pilot units and 30 minutes on a biweekly basis in all remaining units. The purpose of these meetings is continuous evaluation of the daily work with the PUB.

In order to estimate the total annual labour cost of these improvement team meetings, the staff composition of all improvement teams across Sønderborg elderly care was estimated in accordance with appendix 4, based on the following assumption.

1. The composition of employees attending the team improvement meetings in Egernsundeved is representable for the composition of the team improvement meetings in the entire care unit in the municipality of Sønderborg.

Thus, it was estimated that all improvement teams consist of three SHAs and one SHH, all with less than 10 years of experience, along with one operational manager. In order to calculate the total labour cost, the unit cost, i.e. the average functional hourly wage across all participants, was calculated in accordance with appendix 2. This, along with the resource consumption, is shown in table 12.

Table 12. Overview of units consumed and unit price, related to improvement team meetings.

	Units (Total Hours attended/year)	Unit price (wage/hour)
Improvement team meetings	1820	239,21

4.5 - Sensitivity analysis

Seeing as health economic evaluations are often based on a substantial number of estimates with regards to costs and effects, a fair amount of uncertainty is often associated with the results. Estimates are an inherent part of health economic evaluations, and while it is nearly impossible to be free of them, the uncertainty they create can be dealt with by using a sensitivity analysis (29). This uncertainty arises when there is uncertainty in regard to the true numerical value of the parameters included in the health economic evaluation, i.e. the inputs. A sensitivity analysis is a set of tools that, when applied correctly, should make transparent how sensitive the results are to uncertainty, or in other words, what impact changes in numerical value of the inputs has on the result (34).

The one-way sensitivity analysis aims to identify how sensitive the results are to changes in one input parameter at a time. By adjusting the numerical value of one input parameter at a time and observing the effects on the result, it is possible to identify what parameters of the evaluation are the key drivers. If a small change in the input value has a big impact on the results, it is a parameter with great amount of uncertainty associated with it. When changing the value of the input parameter during a sensitivity analysis it is often done within what is referred to as a plausible range (29). This range is defined as the plausible upper and lower boundaries for the numerical value of the input parameter. This plausible range can be informed by expert opinions, statistical procedures, or popularly by raising or lowering the base value of the parameter X%. It is also possible to vary more than one input parameter at the same time. This is done using the two-way sensitivity analysis that includes two or more parameters at a time. The strength of the two-way analysis is that it is able to identify interactions between parameters and their combined effect on the results, something that may be overlooked when using the one-way sensitivity analysis (34). The weakness of the two-way sensitivity analysis is the complexity, especially when altering more than two input parameters at a time.

Whenever a sensitivity analysis is applied to a health economic evaluation it is important to report the outputs extensively. These outputs will enable the decision maker to consider a wider range of scenarios for the health economic evaluation and ultimately improve their confidence in the model (34).

5 – Results

In the following section of this report, the results of the health economic evaluation are presented. Firstly, the identified resources and their associated cost are presented for both alternatives. These are then used to estimate the total annual costs related to the two alternatives. This is then followed by the CEA, including the ICER of the PUB. Finally, variables with high impact on the results of the analysis are presented using a sensitivity analysis.

5.1 - Treatment of pressure ulcers

In order to calculate the total cost spent on treating pressure ulcers over a one-year period for both the standard care approach and the PUB alternative, the costs of the time spent treating the ulcers and the costs of remedies were calculated. Results are seen in table 13.

Table 13. Identified resources and their associated costs for treatment of pressure ulcers across the different categories. Total cost at the bottom of the table. The calculation of pressure relief aids is described in section 5.2.

Type of resource	Item	Unit cost	Grade 1	Grade 2	Grade 3	Grade 4
Labour	SHH	229,88 DKK/h	183,90 DKK	183,90 DKK	183,90 DKK	183,90 DKK
	SHA	226,76 DKK/h		20,25 DKK		
	Nurse	211,62 DKK/h			79,36 DKK	79,36 DKK
Remedies	Barrier crème	57 DKK/unit	6,11 DKK			
	Allevyn	8,85 DKK/unit		0,79 DKK		
	Blue pillow	0,28 DKK/unit			0,28 DKK	0,28 DKK
	Mefix fixation	17 DKK/unit			1,13 DKK	1,13 DKK
	Aquacel	15 DKK/unit			15 DKK	15 DKK
Aids cost/day			9,37 DKK	9,37 DKK	9,37 DKK	9,37 DKK
Total cost/day DKK			199,38 DKK	214,31 DKK	289,04 DKK	289,04 DKK
Average healing time (days)(9)			28,4 days	93,8 days	127,4 days	154,7 days
Price per PU (DKK)			5.622,42 DKK	20.102,33 DKK	36.823,67 DKK	44.714,46 DKK

5.2 Pressure relief aids

Table 14. Price/day of pressure relief aids, as estimated from the sample of 11 citizens at risk, provided by the municipality of Sønderborg.

Resident	Item – Brand	Price incl. taxes	Durability (years)	Price per day (DKK)
1	Foam mattress – Alpha	1243,75	5	0,68
	Foot support – MaxxCare Pro Evo.	705	2	0,98
	Foot support - MaxxCare Pro Evo	705	2	0,98
	Air mattress dynamic - Cirrus	43625	8,5	14,05
2	Foot support - MaxxCare Pro Evo.	705	2	0,98
	Toilet seat padding	1056,25	6	0,48
	Air mattress dynamic – Sentech Thera Turn Mil.	25000	10	6,85
3	Foot support - MaxxCare Pro Evo.	705	2	0,98
	Foot support - MaxxCare Pro Evo.	705	2	0,98
	Toilet seat padding	1065,25	6	0,48
4	Toilet seat padding	1065,25	6	0,48
	Air mattress dynamic - Cirrus	43625	8,5	14,05
	Pull sheet – Vendlet	1150	2	1,57
	Pull sheet – Vendlet	1150	2	1,57
	Pull sheet – Vendlet	1150	2	1,57
	Positioning support pillows – Vendlet	688,75	4	0,47
	Positioning support pillows – Vendlet	817,5	4	0,56
	Motorised turning machine – Vendlet	41868,75	10	11,46
	Sliding sheet – Vendlet	838,75	4	1,15
	Sliding sheet – Vendlet	838,75	4	1,15
5	Coating for guard rail	1785	5	0,98
	Foam mattress synthetic – PRIMA 6	1118,75	8,5	0,36
	Air mattress – AD ProCare 3 Auto	16243,75	4	11,12
6	Air mattress – Roho Quadtro Select	2621,875	3	2,39
7	Air mattress – Roho Quadtro Select	2621,875	3	2,39
8	Pull sheet – Vendlet	1150	2	1,56
	Pull sheet – Vendlet	1150	2	1,56
	Sliding sheet – Vendlet	838,75	2	1,15
	Positioning support pillows – Vendlet	1783,75	4	1,22
	Motorised turning machine – Vendlet	41868,75	10	11,46
9	Foam pillows – Decu-dan seat pillow	107,5	4	0,07
10	Foam mattress – Decudan pillow	2440	5	1,34
	Positioning pillows – Repons air	2253,75	2	3,09
11	Foot support - MaxxCare Pro Evo.	705	2	0,98
	Foot support - MaxxCare Pro Evo.	705	2	0,98
	Mater turner mattress	1573,44	4	1,08
	Master turner slide sheet	1573,44	4	1,08
	Master turner slide sheet	1573,44	4	1,08
	Toilet seat padding	1056,25	6	0,48
	Air mattress – Vicair Academy Adjuster 10	5552,5	5	3,04
	Total daily price of relevant aids			103,1
	Average cost of pressure relief aids/day			9,37

The daily price of each individual aid was calculated by dividing the item price with expected durability (days). In order to estimate the average daily price across all 11 citizens at risk, the relevant aids were summed up and divided by the number of aids users, which amounted to 9,37 DKK/day.

For the standard care approach, pressure relief aids were used as part of the treatment, as seen in table 13. Thus, when calculating the expenditures of aids, the average daily price of pressure relieving aids was multiplied by the average healing time. This was then multiplied by the number of pressure ulcers in each grade for the end result, as seen in table 16.

For the PUB, pressure relieving aids were not part of the treatment but instead used preventively. Pressure relieving aids were calculated as being given to each resident placed in the risk group of developing a pressure ulcer. According to data from the municipality of Sønderborg, roughly 283 citizens are in this risk group at any time across a one-year period. Thus, preventive pressure relieving aids are associated with the following yearly cost:

$$PUB \text{ aids } \frac{\text{cost}}{\text{year}} = \text{aids } \frac{\text{cost}}{\text{day}} * \text{number of citizens in risk group} * \text{annual risk days}$$

Thus:

$$9,37 * 283 * 365 = 967.874,15 \text{ DKK}$$

5.3 - Municipal co-financing

Municipal co-financing of hospital treatment costs associated with the treatment of pressure ulcers were included for both alternatives, and the value of these costs was extracted directly from their database by the municipality for the years 2013 and 2017, see appendix 3.

5.3.1 - Standard care

The directly extracted costs of the municipal co-financing in 2013 amounted to 96.410 DKK. Due to inflation, this value had to be corrected to a present-day value, in order to make comparison with the value of the PUB possible. This was done according to the following equation:

$$\text{Present value} = \frac{\text{2013 co financing value} * \text{average index value for 2017}}{\text{index value for 2013}}$$

$$\text{Present value} = \frac{(96.410 * 101,4)}{99} = 98.747,21 \text{ DKK}$$

5.3.2 - PUB

Costs of the municipal co-financing were only available for the first nine months of 2017 at the time of writing. This was corrected for by estimating the last three months from an average of the first nine of the year.

$$\frac{87.393}{9} = 9.710,33 \text{ DDK per month on average.}$$

Based on this monthly average, the last three months of the year were estimated. It is assumed that the average rate is the same for all the months, and this average monthly cost can thus be used to estimate a total annual price of the co-financing.

$$9.710,33 \text{ DDK/month} * 12 = 116.523,96 \text{ DDK/year.}$$

Table 15. Municipal co-financing of pressure ulcers treated in hospital 2013 and 2017.

	Standard care (2013)	The PUB (2017)
Cost of co-financing	98.747,21 DKK	116.523,95 DKK

Table 16. Overview of number of pressure ulcers on grade as well as the total cost associated with the treatment of pressure ulcers on grade per year, for both alternatives. Note that the pressure relief aids costs, are included in the total cost of PU

	Standard care				The PUB			
Total PU	351				134			
Grade	Grade 1	Grade 2	Grade 3	Grade 4	Grade 1	Grade 2	Grade 3	Grade 4
Distribution of PU (9)	34,9%	41,2%	12,9%	11,0%	34,9%	41,2%	12,9%	11,0%
Number of PU	122,5	144,6	45,3	38,6	45,37	53,56	16,77	14,3
Total cost per PU (DKK)	5.622,42	20.102,33	36.823,67	44.714,46	5.622,42	20.102,33	36.823,67	44.714,46
Total cost PU on grade (DKK)	693.6741,3	2.907.038,86	1.667.339,17	1.726.425,39	252.364,1	1.061.287,0	615.899,0	637.724,9
Total cost municipal co-financing (DDK)	98.747,2 DKK				116.524 DKK			
Total cost of treatment	7.093.192 DKK				2.683.799 DKK			

5.4 – PUB-specific costs

In the following subsections, the results of the estimated costs for the PUB-specific resource consumptions are detailed. These consist of the management training courses, peer-to-peer training, staff training in PUB-related actions, initial and continuous risk-assessments, and improvement team meetings, all of which are detailed below.

5.4.1 - Management training courses

Table 17. List of identified resources and their cost (DKK), associated with training of managers. See appendix 4 for calculations of labor cost/hour.

	Participants	Hours	Unit price (DKK)	Total
2013	34	16	297,34 DKK/hour	
2014	34	32	297,34 DKK/hour	
2015	34	32	297,34 DKK/hour	
2016	34	24	297,34 DKK /hour	
Total		104		1.050.195,33 DKK

As the management training courses covered all of the six focus areas of the ISH, the total cost listed in table 17 was divided evenly across these. Thus, the following cost was incurred by the management training courses for the PUB:

$$\frac{1.050.195,33}{6} = 175.032,6 \text{ DKK}$$

5.4.2 - Peer-to-peer training and staff training in PUB-related actions

The costs of peer-to-peer training and staff training in PUB-related actions were calculated by multiplying the number of participants with the duration of the training multiplied by the average hourly wage. Results are seen in table 18.

Table 18. List of identified resources and their cost (DKK), associated with non-management staff training and peer-to-peer training. See appendix 4 for calculations of labor cost/hour.

	Participants	Duration (hours)	Wage/hour range	Total cost (DKK)
Staff training	1039	2 ½	216,84-242,92	592.184,3
Peer-to-peer training (pilot units)	280	4	216,84-242,92	548.916,2
Peer-to-peer training	759	2	216,84-242,92	
Total				1.141.100,5

5.4.3 – Risk-assessments

Risk assessments costs were calculated by multiplying the number of initial and annual risk assessments with the unit price of performing one risk assessment. The unit cost was calculated in accordance with the wages found in appendix 2 and the time consumption of an assessment.

Table 19. List of identified resources and their cost (DKK), associated with initial and yearly performed risk assessments. See appendix 4, for calculations of the unit price (functional work time) of one assessment.

		Number of Initial risk evaluations	Units (total hours spent)	Unit price (wage/hour)	Total costs DKK
Initial	Home care	821	34,21	227,98	13.307,3
	Nursing home	580	24,17	227,98	
One-year	Home care	1092	45,5	227,98	38.562,74
	Nursing home	2968	123,66	227,98	
Total					51.870 DKK

5.4.4 - Improvement team meetings

The cost of improvement team meetings was calculated by multiplying the sample (Egernsundeved) with the total number of care units in the municipality of Sønderborg.

Table 20. List of identified resources and their cost (DKK), associated with improvement team meetings. See appendix 4, for calculations of the unit price.

	Units (Total Hours attended/year)	Unit cost DKK (wage/hour)	Total (DKK)
Improvement team meetings	1820	239,21	435.354,8 DKK

5.4.5 – Annuitization of implementation costs

Relevant costs that have been consumed in relation to implementation of the PUB are depreciated using the annuitization method. The costs are annuitized over the implementation period (n), which is four years and an interest rate (r) of 3,5%.

The relevant costs are initial risk assessments and staff training in both peer to peer and PUB related actions along with management training courses.

The individual costs for all implementation activities can be seen in table 21.

Table 21. List of activities and their associated costs, related to the implementation of the PUB

Overview of individual implementation costs related to the pub pre-annuitization, DKK.	
Initial risk-assesments	13.307,3 DKK
Staff training, managers	175.032,6 DKK
Staff training, peer to peer	548.916,2 DKK
Staff training, PUB related actions	592.184,3 DKK
Total	1.329.440,4 DKK

Annuitization are done using the formula below:

$$Costs_{of\ implementation} * \frac{1}{(1 - (1 + r)^{-n})/r}$$

$$1.329.440,4 * \frac{1}{(1 - (1 + 0,035)^{-4})/0,035} = 361.941,36\ DKK$$

This gives a total cost of 361.941,36 DKK which are payed four times over the next four years giving a total cost of 1.447.765,44 DKK for the implementation when all rates are payed back. Since this economics evaluation only uses a one-year perspective, only one rate will be used in the following calculations.

5.5 - Total annual cost of both alternatives

The total cost of the standard care approach was made up of the costs related to; 1) Treating pressure ulcers in home nursing units and nursing homes in 2013. Included in this treatment cost was the expenses for pressure relieving aids. 2) Municipal co-financing of hospital treatment costs related to pressure ulcers in 2013.

$$6.994,444,75 + 98747,21 = 7.093.191,96\ DKK$$

Next, the average cost per treated pressure ulcer in 2013 was calculated as this was to serve as the cost-effectiveness threshold for the PUB:

$$\frac{7.093.191,96}{351} = 20.489,8\ DKK$$

The calculation of costs related to the PUB consisted of an increased number of parameters, mainly due to the staff training that was part of its implementation. Note that for the calculation of the PUB costs, pressure relieving aids were not part of treatment cost, but rather calculated as provided to any citizen assessed to be in risk in accordance with the Braden score. The parameters, as well as their associated cost, are summarized in table 22.

Table 22. List of identified resources and their associated cost (DKK), that combined make up the expenses of the PUB.

Overview of	
PUB resource consumption and cost 2017	Costs (DKK)
Implementation costs:	
All implementation costs annuitized	361.941,36 DKK
Operating costs (yearly):	
Risk assessments continued	38.562,7
Improvement team meetings	435.354,8
Treatment of pressure ulcers	2.490.640,2
Pressure relief aids	839.390,5
Municipal co-financing 2017	116.524
Total	4.487.532,52 DKK

Notably, the overall costs related to pressure ulcers in the municipality decreased after the implementation of the PUB, despite the initial costs to staff training and the increase in pressure relieving aids. The decrease in costs amounted to 2.605.659,44 DKK over the annuitization period the next four years. After annuitized is complete a further reduction in the costs of the PUB is expected, thereby making the PUB even cheaper.

5.6 - Cost per prevented pressure ulcer

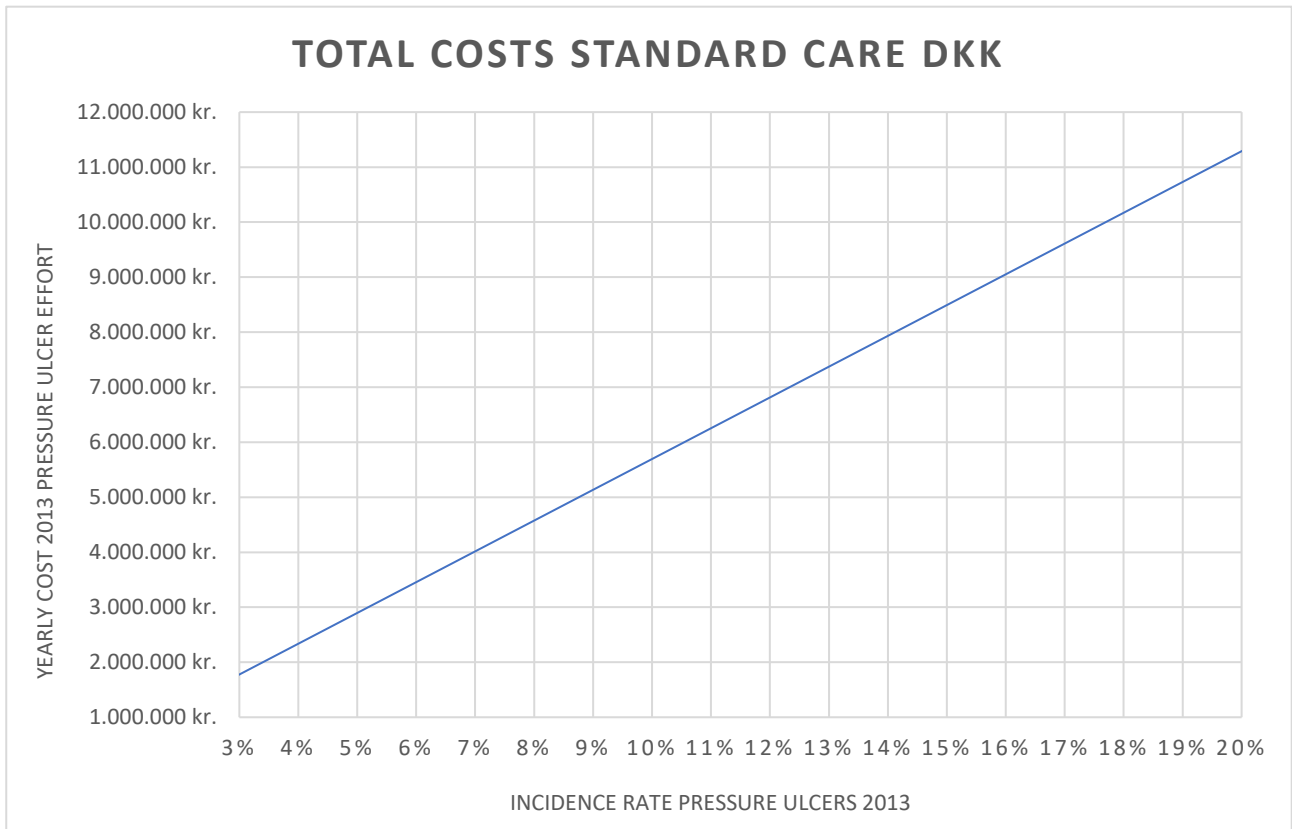
In order to assess the cost-effectiveness of the PUB, the ICER equation was used. The result of the ICER describes the price of each prevented pressure ulcer in the municipality of Sønderborg. The ICER is compiled using the total yearly costs of PUB (2017), and the pressure ulcer treatment costs of 2013 as the standard care. The effect measure is the incidence of pressure ulcers in the municipality for the given years. As stated previously, the incidence rate for 2013 was estimated from literature, while for 2017 actual data from the municipality was available.

$$ICER = \frac{4.487.532,52_{PUB2017} - 7.093.191,96_{2013}}{217_{PUB2017} - 0_{2013}} = -12.007,6 \text{ DKK per prevented pressure ulcer}$$

Thus, the ICER analysis shows that for each pressure ulcer the PUB prevented, compared to the old effort, the municipality of Sønderborg has seemingly gained 12.007,6 DKK. Based on the established threshold, the PUB was found cost-effective in the municipality of Sønderborg.

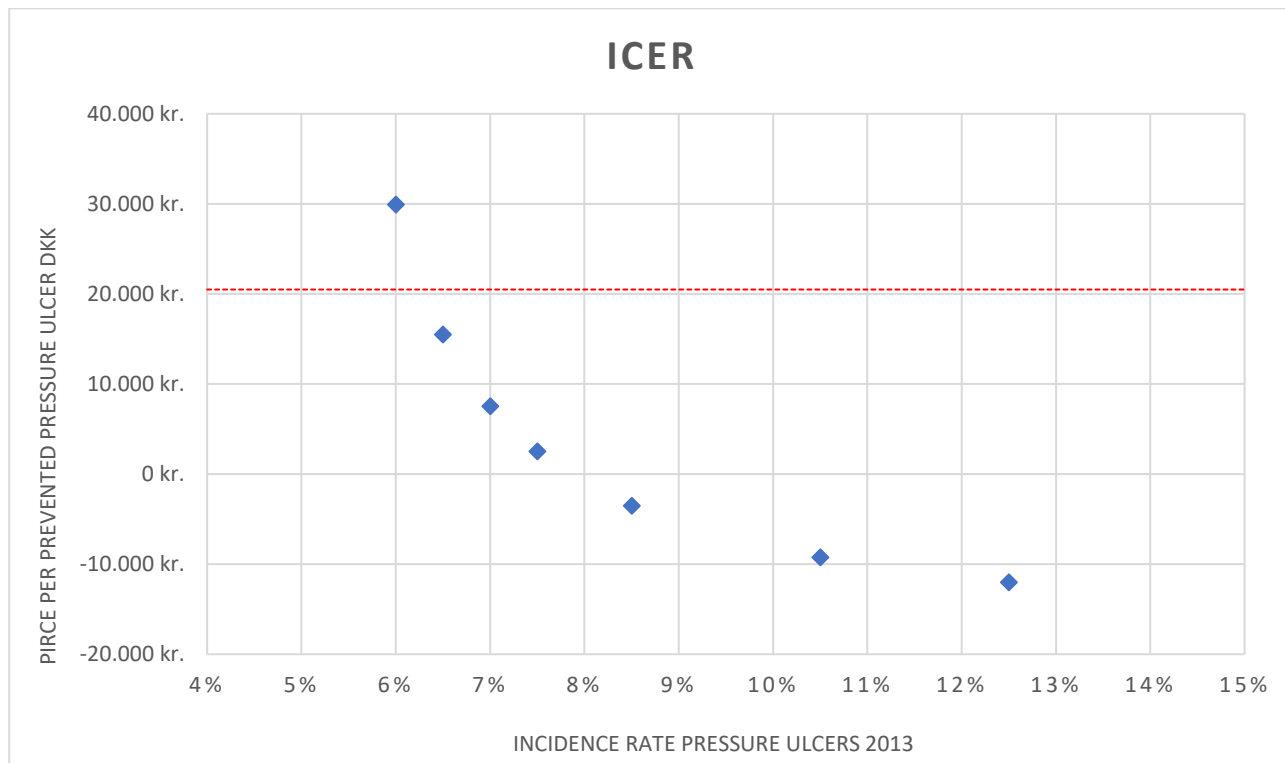
5.7 - Sensitivity analysis

When a sensitivity analysis was applied to the CEA, the parameter found to have by far the greatest impact on the results of the model was the incidence rate used for calculating costs of the 2013 pressure ulcer effort. As the incidence rate for pressure ulcers 2013 is lowered, the costs related to the standard care approach decrease proportionally in a linear manner, as seen in graph 1.



Graph 1. Relationship between the incidence rate used for 2013 calculations and the total cost of the pressure ulcer effort 2013

A similar relationship was observed when analysing the impact of the 2013 incidence rate on the final results of the ICER. When the incidence rate of the 2013 calculation was decreased, the result of the ICER decreased, i.e. the price per prevented pressure ulcer using the PUB increased. However, for the ICER, this decrease happens at an exponential rate, as seen in graph 2.



Graph 2. Relationship between incidence rate used for calculations of the 2013 alternative and the ICER. As the 2013 incidence is decreased, the ICER rises at an exponential rate.

Other parameters with some uncertainty tied to their values, such as the daily price of the pressure relief aids, number of citizens in the risk group and labour costs associated with implementation, showed robustness to at least 50% (and some as high as 300%) increases to parameter values when analysed on their own. In fact, a 200% increase to two of the three mentioned parameters did not even cause the ICER to become negative. See appendix 5.

When analysed in a two-way sensitivity analysis the model again showed robustness to significant (50%) changes, and only when any parameter was altered at the same time as the 2013 incidence rate, did they alter the cost-effectiveness of the ICER, i.e. bring it below the acceptance threshold. Thus, it can be concluded that the 2013 incidence rate was the driving force behind any changes observed in the two-way sensitivity analysis.

6 – Discussion

In this study, a health economic cost-effectiveness analysis of the PUB in the municipality of Sønderborg 2017 was performed. According to said analysis, the PUB has decreased annual costs associated with pressure ulcers by approximately 2.605.659,44 DKK from 2013 to 2017, a decrease of approximately 12.007,6 DKK per prevented pressure ulcer as demonstrated by the calculated ICER. When using the average cost of treating a pressure ulcer in 2013, 20.489,86 DKK as the cost-effectiveness threshold, the PUB is thus comfortably cost-effective. This finding is supported by a study by Mathiesen et al. 2013 (23) which found the PUB to be cost-effective in the secondary sector of the Danish Healthcare System, and Padula et al. 2011 (35) who, similarly, found standardised prevention of pressure ulcers to be cost-effective compared to standard care.

Additionally, a sensitivity analysis was performed in order to evaluate the robustness of the cost-effectiveness analysis. This sensitivity analysis indicated that the calculated ICER-value is highly dependent on the 2013 incidence rate of pressure ulcers in the municipality of Sønderborg, which was deemed the key parameter for the analysis. This is highlighted by the fact that a reduction of a mere 4.5% in the incidence rate causes the ICER to become positive, and a reduction to 6.3% causes it to rise above the cost-effectiveness threshold.

In the following sections of this report, these results, and the methods used to arrive at said results, are discussed.

6.1 – Discussion of methodology

As detailed in the methods section of this report, annual costs and effects were estimated for both the standard care in 2013 and the PUB in 2017. In the following subsections of this report, the methods used to estimate costs and effects for the standard care and the PUB, respectively, are discussed.

6.1.1 – Standard care

As stated in the methods section of this report, no data on the incidence rate of pressure ulcers in the municipality of Sønderborg in 2013 was available and, consequently, the estimated incidence rate of 12,5% was based on a 2004 UK study (9). Therefore, this is obviously an estimate associated with a significant degree of uncertainty. However, in the UK study, the 12,5% incidence rate is referred to as conservative, and, as stated in the introduction section of this report, Danish literature indicates pressure ulcer incidence rates of 13-43%, although in the secondary sector (2,23). To the best of our knowledge, no studies investigating incidence rates in elderly care in the primary sector exist, although point prevalence studies suggest ranges from 3-60% among elderly care residents (7,23,36). As such uncertainty exists on the incidence rate associated with the standard care alternative, this raises concerns regarding the validity of the findings in this study which is further discussed in later sections of the discussion section.

The costs of the standard care approach were deemed to consist of the cost of treating pressure ulcers, including pressure relieving aids, and municipal co-financing of hospital treatment costs. As stated in the

results section of this report, the total costs of pressure ulcer treatment and municipal co-financing in 2013 were estimated at 6.994.444,75 DKK and 98.747 DKK, respectively. These estimates are discussed in the following paragraphs.

In order to estimate the cost of municipal pressure ulcer treatment, it was, of course, necessary to know the treatment procedure. However, as treatment procedures for pressure ulcers are highly variable and individualised, this proved difficult. In this study, the treatment procedure was estimated based on expert opinions from home nursing care personnel, an ulcer nurse, and the project manager. However, as stated by expert opinions, both the cause and location of pressure ulcers are different from individual to individual, and these factors are highly influential on the treatment procedure, seeing as, for instance, the need for pressure relieving aids varies greatly. As the cost of pressure ulcer treatment is based on the estimated treatment procedure, these uncertainties raise concerns regarding the validity of the calculated cost of pressure ulcer treatment.

Additionally, no data on the aids used in pressure ulcer treatment was available and, furthermore, putting an exact value on the cost of treatment aids proved difficult due to the highly individualised treatment procedures. For this reason, the cost of aids used in the standard care pressure ulcer treatment was based on the calculated cost of preventive pressure relieving aids in the PUB. This cost was estimated based on a sample of 11 Egersundevad residents who, during risk-assessment by nursing staff, had been deemed in risk of developing pressure ulcers and thus received pressure relieving aids. As this sample of 13 residents represents a mere 0,46% Sønderborg elderly care, the assumption that this is a reliable sample is, perhaps, unreliable. One consequence of using such a small sample to estimate the aids used across the entire elderly care is the fact that not all the different individual aids in use are discovered. Indeed, some pressure relieving aids may be rather common in the Sønderborg elderly care and yet not represented in this study, as none of the 11 residents in the sample happened to have these aids. Additionally, in order to estimate the daily cost of these pressure relieving aids, it was necessary to estimate the life expectancy of each aid, as well as price paid when purchasing the aids. Life expectancies were estimated based on expert opinions from retailers and care staff, whereas purchase prices were informed by retailers alone. Although by no means an exact estimate, basing the cost of aids used in the standard care treatment on highly individualised treatment procedures and a minute sample size was the most representative measure available in this study.

The uncertain validity of the estimated cost of municipal pressure ulcer treatment is, perhaps, underlined by comparison to the UK study (9), from which 2013 incidence rates were estimated. In that study, the daily cost of treating pressure ulcers ranged from 321,73 to 423,32 DKK (394,857 to 519,669 DKK in present value) dependent on ulcer category, whereas the equivalent estimated daily cost in this report ranges from kr. 198 to kr. 287,6 DKK (9). Thus, the estimated standard care treatment costs in this study seem significantly lower than those in the UK study. This is, however, not a completely valid comparable basis, seeing as the perspective varies between those two. The UK study has a secondary sector perspective (9), whereas this report is based on a perspective from the elderly care in the municipality of Sønderborg.

However, to the best of our knowledge, no other literature on the daily cost of treating pressure ulcers exists.

Finally, the standard care approach also had costs associated with municipal co-financing of hospital treatment costs. As stated in the results section of this report, the total cost of the municipal co-financing in 2013, amounted to approximately 98.747 DKK. This is likely the most exact estimate in this entire report as the co-financed costs were directly available from the municipality of Sønderborg.

In summary, vast assumptions and rough estimations were made in order to arrive at a value for the costs and effects of the standard care approach, especially regarding the effect measure and the cost of pressure ulcer treatment, raising serious concerns as to the validity of these costs and effects.

6.1.2 – Pressure ulcer bundle

As for the standard care alternative, costs and effects were estimated for the PUB alternative, based on the year 2017 as more data was available for this year than any other. The effect measure, the annual incidence rate of pressure ulcers, was available for the first 10 months of 2017 and merely had to be adjusted to represent the full year, resulting in an incidence rate of 4.77%. Thus, only ever so slight uncertainties regarding the effects of the PUB exist, meaning this is a rather exact estimate.

In this study, the costs of the PUB were divided into implementation costs and operating costs. These are discussed further in the following subsections of this report.

6.1.2.1 – Implementation costs

As stated in the results section of this report, implementation costs of the PUB were deemed to consist entirely of labour costs, amounting to a total of approximately 1.329.440,4 DKK. These were associated with peer-to-peer training, staff training in PUB-related actions, management training courses, and initial risk-assessments, respectively. These are discussed in the following paragraphs.

The labour costs associated with peer-to-peer training and staff training in PUB-related actions were estimated at 548.916,2 DKK and 592.184,3 DKK, respectively. However, in order to arrive at these results, a series of assumptions were made. As the exact number of staff members in each staff position was only known for the Egersundevad home nursing unit and none of the remaining 23 care units, it was assumed that the relative proportion of staff members in each position was identical across all care units. It is, however, unlikely that this is truly the case. This is further underlined by the fact that, according to information handed over by the municipality of Sønderborg, no nurses are employed in the Egersundevad home nursing unit. Thus, when extrapolating the staff composition of Egersundevad across all remaining units, seemingly no nurses are employed in Sønderborg elderly care, a highly unlikely proposition. Additionally, the exact number of total staff was only known for 19 of the total 24 care units. Thus, it was necessary to estimate the number of total staff in all remaining care units, and this was done by simply averaging the number of total staff members in the 19 units from which numbers were available. As labour costs associated with the peer-to-peer training and staff training in PUB-related actions are entirely dependent on the staff members in participation, these assumptions and estimations on total staff

numbers and staff composition raise concerns regarding the validity of the results. Thus, it would have been recommendable to investigate the exact staff number and staff composition of each care unit.

Fewer concerns exist regarding the estimated labour costs associated with the management training courses. The total labour costs of the management training courses were estimated at 175.032,6 DKK. Although, as management training courses were aimed at the entire ISH, which consists of six focus areas, the total labour costs were divided by six in order to estimate the share for which the PUB was responsible. However, it is unknown if equal amounts of time were spent on each focus area at the meetings, meaning the PUB's share of the total labour costs incurred by the management training courses could theoretically be anywhere between 0,00 DKK and 175.032,6 DKK. It is, however, unlikely that the PUB would have taken up anywhere near either 0% or 100% of the time dedicated to these management training courses, and for this reason, one 6th of the time is considered the best estimate. Additionally, even if the time spent on the PUB is hypothetically increased, the increase in the associated labour cost is insignificant in comparison to the grand total costs of the PUB. For instance, if the time spent on the PUB at the management training courses is increased to one 3rd, the associated labour costs increase from 175.032,6 DKK to 350.065,2 DKK, but even if the estimated time allocation of the management training courses is inaccurate, it is unlikely to greatly influence the end result.

Finally, implementation costs were also incurred by the initial risk-assessments. At the point of implementation, risk-assessments were performed on all nursing home residents and those home nursing residents who used wheelchairs, were immobilised, or received personalised care. In this study, the labour costs associated with these risk-assessments were estimated at 13.307,3 DKK. The validity of this estimate, however, is uncertain. First of all, the labour costs of these risk-assessments were based on the same assumptions and estimations as for the peer-to-peer training and staff training in PUB-related actions regarding staff numbers and staff composition, thus immediately raising concerns as to the validity. Furthermore, it was informed by the municipality of Sønderborg that each risk-assessment last between 2 and 3 minutes. For this study, the mean value of 2,5 minutes was used when calculating the labour costs of the risk-assessments. However, if the time spent per risk-assessment is hypothetically increased to 3 minutes, the associated increase in the labour cost of these risk-assessments is a mere 2.661,46 DKK, which is unlikely to influence the end result.

Lastly, the number of risk-assessments performed at the point of implementation was not registered by the municipality of Sønderborg and, instead, the total number of current residents – three years after the point of implementation – who have been assessed for pressure ulcer risk was used. This, however, is considered a somewhat valid estimate as the number of residents from year to year is likely to be fairly stable.

6.1.2.2 – Operating costs

In addition to the implementation costs, the PUB is associated with annual operating costs. As stated in the results section of this report, these operating costs consist of the annual cost of treating pressure ulcers, pressure relieving aids, improvement team meetings, continuous risk-reassessments and municipal co-financing. These amounted to a total annual cost of 4.487.532,52DKK. As the methods used to estimate treatment costs and the cost of pressure relieving aids have already been thoroughly discussed in the standard care subsection of this discussion, they are not detailed again. Thus, the estimated costs of improvement team meetings and continuous risk-reassessments, as well as slight differences in the estimated municipal co-financing costs, are discussed in the following paragraphs.

As part of the PUB work, meetings are held in small improvement teams at each care unit. These last for 30 minutes on a weekly basis in the Egersundeved unit and for 30 minutes on a biweekly basis in all remaining units. In this study, the total annual labour cost of these improvement team meetings was estimated at 435.354,8 DKK. However, the validity of this result is questionable, as the staff composition of these improvement teams was only known for the Egersundeved unit. Thus, it was assumed that each improvement team across all care units were composed of identical staff members on identical salaries, which is, perhaps, unlikely. As the estimated labour cost of the improvement team meetings was 435.354,8 DKK, 9,07% of the total PUB costs, the assumed composition of each improvement team may represent a source of error in this study.

Additionally, in order to prevent the development of pressure ulcers, continuous risk-reassessments are carried out on all nursing home residents and those home nursing residents who use wheelchairs, are immobilised, or receive personalised care, as was the case for the initial risk-assessments at implementation. These risk-reassessments are carried out every three months for all residents, and on a weekly basis for those residents deemed in high-risk. In this study, the total annual labour cost of these risk-reassessments was estimated at 38.562,7 DKK. It is, however, questionable whether this estimate is valid. Indeed, this result was arrived at using the same assumptions and estimations regarding staff numbers and staff composition as for the peer-to-peer training and staff training in PUB-related actions already discussed. Additionally, the time spent per risk-reassessment was estimated in the same manner as for the initial risk-assessments, although this is unlikely to influence the end result significantly.

Finally, the municipal co-financing of hospital treatment costs for the PUB alternative were estimated in the same manner as for the standard care alternative, amounting to 116.524 DKK. However, as this study was conducted in November and December of 2017, the year had not yet reached its conclusion and data was unavailable for these final months. Therefore, the full municipal co-financing costs for 2017 were estimated by extrapolating the available 2017 data across the full year. This, however, is unlikely to greatly influence the end result as the available data is considered highly exact. It is, however, curious that the total co-financing costs seemingly increase from 2013 to 2017, as one would expect the improved focus on pressure ulcer prevention to result in fewer hospital admissions and, thus, a reduction in municipal co-financing costs. One explanation for this could be that pressure ulcers were simply not discovered in the standard care approach, meaning residents were not admitted to hospital even if severe pressure ulcers had

developed. Conversely, even if the increased focus on finding pressure ulcers in the PUB alternative means a higher relative share of pressure ulcers are discovered, one would still expect these to be discovered in early stages and well before hospital admission is required. Thus, no definite answer as to why the municipal co-financing cost has increased from 2013 to 2017 exists.

In summary, although a highly valid effect measure was available for the PUB alternative, serious concerns similar to those of the standard care alternative arise when analysing the costs of the PUB. These are associated with both the implementation costs and operating costs, as both were calculated based on a series of vast assumptions and estimations. Therefore, conclusions should not be made lightly based on these.

6.2 – Validity of results

In the following subsection of this report, the validity of the final results in this study are discussed. The robustness of an analysis is almost completely dependent on the validity of the assumptions and estimates on which the analysis is based. The analysis in this study was based on a multitude of such assumptions and estimates with increasingly questionable validity, as discussed above, which immediately raises concerns as to the validity of the end results.

As stated, the calculated ICER fell within the assumed cost-effectiveness threshold and, as such, is considered cost-effective. There is, however, a possibility that this is misleading. This is due to the fact that, when calculating an ICER, it is assumed that the alternative used as the comparator, the standard care approach in this study, is cost-effective itself. Thus, if the standard care approach was never cost-effective, the apparent cost-effectiveness of the PUB, as estimated by the ICER, may be an artefact. The average rate of 23.835 DKK per treated pressure ulcer, which was used as the cost-effectiveness threshold, is difficult to judge as cost-effective or not. To the best of our knowledge, no literature describing the cost of treating pressure ulcers in elderly care exists, although a 2013 study by Mathiesen et al. suggests a cost range of 12.231 to 168.174 DKK per treated pressure ulcer in a hospital setting (23). Comparably, in this study, treatment costs per pressure ulcer were estimated at 5.621 to 44.490 DKK. However, as the costs calculated in the 2013 study include treating ulcers which have developed medical complications, these are, indeed likely to be higher than the costs estimated in this study. This is because treating ulcers with medical complications always requires hospitalisation, in which case the costs fall outside the municipal perspective assumed in this study. Thus, although some uncertainties surround the cost-effectiveness threshold, this study indicates that the PUB is, indeed, cost-effective.

Additionally, as stated previously in this report, the conducted sensitivity analysis found the standard care effect measure, the 2013 incidence rate of pressure ulcers, to be the key parameter for the results of this study. This is highlighted by the fact that a 6% reduction of the incidence rate causes the ICER to fall beneath the cost-effectiveness threshold. This significant impact of the 2013 incidence rate, as well as the exponential relationship between said rate and the ICER, is due to the fact that the rate impacts both the cost of the standard care alternative and the perceived effectiveness of the PUB. When the incidence rate of 2013 is hypothetically decreased, so too is the amount of pressure ulcers prevented by the PUB. As fewer pressure ulcers occur in 2013, their associated costs drop, while the cost of the PUB remains the

same. However, the relative cost of the PUB per prevented pressure ulcer increases, as the amount of prevented pressure ulcers decreases. This, coupled with the previously discussed lack of validity associated with basing the 2013 incidence rate of pressure ulcers on a UK study from 2004, indicates that conclusions should not be made lightly on the apparent cost-effectiveness of the PUB.

Furthermore, the results in this study may be significantly impacted by the chosen timeline over which the PUB was evaluated. The year of 2017 was chosen to analyse costs and effects of the PUB. This decision was made purely on the basis that more data was available for 2017 than for any other year in which the PUB was in action. However, the decision to analyse the PUB based purely on 2017 data may have impacted the results. This is due to the fact that as staff members become more experienced and accustomed to working with the PUB, they are likely to become more efficient in their work. Thus, associated labour costs are likely to decrease as the years go by, and so too the treatment and municipal co-financing costs if an increased relative share of pressure ulcers is prevented. On the other hand, one might argue that new initiatives are likely to over-perform in the first few years after implementation, since a high amount of focus is placed on the importance of the initiative. Then, as the years go by, performance may drop as focus is diverted elsewhere and habits evolve. Although the timeline chosen in an economic evaluation clearly impacts the analysis, it is impossible to say exactly how the decision to analyse the PUB based on 2017 data influences this study. Therefore, it would have been beneficial to analyse the PUB based on data from all years since the point of implementation. However, not enough data was available for this to be possible.

7 – Conclusion

In the above sections of this report, the results, as well as the methods used to arrive at these, were discussed. As stated, the analysis resulted in an ICER rate of 12.007 DKK for the PUB, which was deemed cost-effective when using the treatment cost per pressure ulcer in the standard care approach as the cost-effectiveness threshold. This result, however, was based on a series of vast assumptions and estimations, and, therefore, uncertainties regarding the validity of this result exist.

In conclusion, this study indicates that preventing pressure ulcers in elderly care through the PUB has been cost-effective for the municipality of Sønderborg. However, due to the uncertain validity of the assumptions and estimations upon which the results were based, conclusions as to the cost-effectiveness of the PUB should not be made lightly. This is thoroughly underlined by the sensitivity analysis conducted in this study, which indicated that a 6% hypothetical reduction of the standard care incidence rate plummets the ICER below the cost-effectiveness threshold. This, combined with the fact that the standard care incidence rate was based on UK literature from 2004, highlights the inconclusiveness of this study.

Additionally, the conclusiveness of this study is further limited by the fact a municipal perspective on the health economic evaluation was assumed. It would, conversely, be of interest to evaluate the cost-effectiveness of the PUB from a societal perspective as this would capture the full societal costs and effects of the initiative, seeing as an increased amount of prevented pressure ulcers in the municipal elderly care would, arguably, result in significantly reduced hospital treatment costs.

Lastly, this study evaluated the PUB using a cost-effectiveness analysis, which completely ignores the effect of the PUB on the quality of life of elderly care residents. It would have been of great interest to investigate how the prevention of pressure ulcers impacts quality of life, which would have been possible using a cost-utility analysis, with QALYs as the effect measure, in favour of the selected cost-effectiveness analysis. This, however, was not possible as no literature on the quality of life associated with pressure ulcers exists, to the best of our knowledge.

Thus, the authors of this report suggest caution when considering the cost-effectiveness of the PUB in municipal elderly care based on this study. Finally, the authors call for further research into the cost-effectiveness of the PUB in municipal elderly care, preferably from a societal perspective and using a cost-utility approach.

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9 - List of Appendices

Appendix 1: PUB

Appendix 2: Labour costs

Appendix 3: Co-financing data and related calculations

Appendix 4: Data from the municipality of Sønderborg regarding number of residents, risk evaluated, in risks and employees from each district

Appendix 5: Sensitivity analysis

Appendix 1 - PUB

Content in the pressure bundle

The pressure bundle contains evaluations, planning and actions which together reflects best practice on pressure ulcer prevention.

1. **Everyone is assessed pressure ulcer by risk evaluation at first contact/visitation**
2. **Re-evaluation of pressure ulcer risk when a citizen is**
 - Discharge from the hospital
 - After acute disease
 - When there are changes in nutritional state
 - When there are changes in functional level
3. **Needs at assessed in citizens in rick for developing pressure ulcers plans are made for**
 - Use of pressure reliving and pressure distribution aids
 - Positioning changes and mobilising
 - Nutrition (nutrition screening and diet plan)
4. **Actions for citizens in risk for pressure ulcers – HUSK**

Skin

- Is the skin inspected for pressure ulcers on the entire body?
- Is the skin moist possibly due to incontinence or sweat?
- Is the skin too dry?
- Does the citizen express pain or discomfort?

Surface/aids

- Are the aids adjusted correctly to the specific citizen?
- Are the aids applied correctly in bed, the chair or wheelchair?
- Is there a need for re-evaluation of the need for aids?

Position change/mobilisation

- Is the citizen mobilized the best way?
- Does the citizen get repositioned correct?

Diet

- Does the citizen receive the planned food and drink?

Appendix 2 - Labour costs

In this appendix, calculations made to estimate the labour costs of the PUB are detailed. This was done for the management training courses, peer-to-peer training, staff training in PUB-related actions, initial risk-assessments, continuous risk-reassessments, and improvement team meetings, respectively.

In order to estimate labour costs, it was necessary to know the annual salary of each participant in each activity. Data on some management training course participants' salaries was handed over by the municipality of Sønderborg, whereas all remaining salaries were estimated by consulting collective bargaining agreements. This was done for all SHAs, SHHs, nurses, and nursing assistants. As different pay scale levels exist for each staff position exist, depending on staff seniority, annual salaries were estimated by averaging across relevant scale levels for each staff position. Then, pension supplements identified in the collective bargaining agreements, as well as the standard 12.5% holiday pay and any other identifiable salary supplements in the collective bargaining agreements, were added to the salary. Exact calculations performed to estimate the annual salary of a social and healthcare assistant with unknown seniority, as an example, are shown below:

$$\text{Base salary: } \frac{278419 + 282562 + 314966}{3} = 291982,33\text{DKK}$$

$$13.83\% \text{ pension supplement: } 291982,33 * 0,1389 = 40556,35\text{DKK}$$

$$12.5\% \text{ holiday pay: } 291982,33 * 0,125 = 36497,79\text{DKK}$$

$$\text{Total annual salary: } 291982,33 + 40556,35 + 36497,79 = 369036,47\text{DKK}$$

In the following tables, estimated annual salaries for each staff position are detailed.

Social and Healthcare Assistant, seniority unknown	
Base salary	291982,33DKK
Pension supplement (13.89%)	40556,35DKK
Holiday pay (12.5%)	36497,79DKK
Total annual salary	369036,47DKK

Social and Healthcare Helper, seniority unknown	
Base salary	278977,67DKK
Pension supplement (13.89%)	38750DKK
Holiday pay (12.5%)	34872,21DKK
Total annual salary	352599,87DKK

Nurse, seniority unknown	
Base salary	261666,67DKK
Pension supplement (13.94%)	36476,33DKK
Holiday pay (12.5%)	32708,33DKK
Total annual salary	330851,33DKK

Nursing Assistant, seniority unknown	
Base salary	281707,64DKK
Pension supplement (13.89%)	39129,19DKK
Holiday pay (12.5%)	35213,45DKK
Total annual salary	356050,28DKK
Social and Healthcare Assistant, seniority less than 10 years	
Base salary	280490,5DKK
Pension supplement (13.89%)	38960,13DKK
Holiday pay (12.5%)	35061,31DKK
Total annual salary	354511,94DKK

Social and Healthcare Helper, seniority less than 10 years	
Base salary	268226,5DKK
Pension supplement (13.89%)	37256,66DKK
Holiday pay (12.5%)	33528,31DKK
Total annual salary	339011,47DKK

Social and Healthcare Helper, seniority more than 10 years	
Base salary	300480DKK
Pension supplement (13.89%)	37560DKK
Holiday pay (12.5%)	41736,67DKK
Total annual salary	379776,67DKK

Additionally, it was necessary to convert the estimated annual salary to functional hourly wages. The functional hourly wage was calculated by dividing the annual salary, including pension supplement and holiday pay, by the total number of hours spent at work in a year. The total number of working hours in a year was estimated by subtracting 25 days of holiday leave, 12 bank holidays, 104 weekend days, and 12.73 days of sick leave. The annual amount of time spent on sick leave was estimated by consulting StatBank Denmark at www.statistikbanken.dk/FRA027 and looking up the mean annual days of sick leave for municipal work places in Sønderborg in 2016, the most recent year for which data was available. Thus, using 7.4 hours as the standard length of a work day, the total amount of working hours in a year was estimated as follows:

$$(365 - 25 - 12 - 104 - 12.73) * 7.4 = 1.563,4 \text{ working hours in a year}$$

This value was then used to estimate each staff member's functional hourly wage by dividing their annual salary by the total number of working hours in a year. The total labour cost of each activity was then estimated by calculating the mean functional hourly wage, referred to as the unit cost, across all activity participants and multiplying by the accumulated number of hours spent by all participants.

Lastly, as the care staff composition for the peer-to-peer training, staff training in PUB-related actions, initial risk-assessments, continuous risk-reassessments, and improvement team meetings was only known for the Egernsundeved unit, it was necessary to extrapolate this staff composition across all other units. The composition of the 41 staff members at the Egernsundeved unit was as follows:

- 17 SHAs with less than 10 years of experience
- 13 SHHs with less than 10 years of experience

- 11 SHHs with more than 10 years of experience

These numbers were converted to relative share of the total number of staff members at the Egersundevad unit, resulting in 41,46% SHAs with less than 10 years of experience, 31,71% SHHs with less than 10 years of experience, and 26,83% SHHs with more than 10 years of experience. The relative share of each staff position was then used to estimate the staff composition at all other units. In the following two tables, each home nursing and nursing home care unit, respectively, along with their total number of staff and estimated staff composition, is listed.

Home nursing units		
Care unit	Total number of staff	Staff composition
Egernsundeved	41	17 SHAs, less than 10 years 13 SHHs, less than 10 years 11 SHHs, more than 10 years
Broager/Dybbøl*	28	12 SHAs, less than 10 years 9 SHHs, less than 10 years 7 SHHs, more than 10 years
Gråsten*	28	12 SHAs, less than 10 years 9 SHHs, less than 10 years 7 SHHs, more than 10 years
Nordals, nord	34	14 SHAs, less than 10 years 11 SHHs, less than 10 years 9 SHHs, more than 10 years
Nordals, rehabilitation	35	15 SHAs, less than 10 years 11 SHHs, less than 10 years 9 SHHs, more than 10 years
Nordals, syd	36	15 SHAs, less than 10 years 11 SHHs, less than 10 years 10 SHHs, more than 10 years
Alssund, midt	20	8 SHAs, less than 10 years 6 SHHs, less than 10 years 6 SHHs, more than 10 years
Alssund, syd	25	10 SHAs, less than 10 years 8 SHHs, less than 10 years 7 SHHs, more than 10 years
Alssund, vest	29	12 SHAs, less than 10 years 9 SHHs, less than 10 years 8 SHHs, more than 10 years
Alssund, øst	28	12 SHAs, less than 10 years 9 SHHs, less than 10 years 7 SHHs, more than 10 years
Sydals, øst	26	11 SHAs, less than 10 years 8 SHHs, less than 10 years 7 SHHs, more than 10 years
Sydals, vest	25	10 SHAs, less than 10 years 8 SHHs, less than 10 years 7 SHHs, more than 10 years
Sydals, rehabilitation	12	5 SHAs, less than 10 years 4 SHHs, less than 10 years 3 SHHs, more than 10 years
Total	367	153 SHAs, less than 10 years 116 SHHs, less than 10 years 98 SHHs, mor than 10 years

**Data on the total number of staff members at this unit was available. Thus, the mean number of staff members at all remaining home nursing units was used as an estimate.*

Nursing home units		
Care unit	Total number of staff	Staff composition
Tangshave	68	28 SHAs, less than 10 years 22 SHHs, less than 10 years 18 SHHs, more than 10 years
Hørup	55	23 SHAs, less than 10 years 17 SHHs, less than 10 years 15 SHHs, more than 10 years
Gråsten	40	17 SHAs, less than 10 years 12 SHHs, less than 10 years 11 SHHs, more than 10 years
Broager	47	19 SHAs, less than 10 years 15 SHHs, less than 10 years 13 SHHs, more than 10 years
Guderup	90	37 SHAs, less than 10 years 29 SHHs, less than 10 years 24 SHHs, more than 10 years
Tandsbjerg*	61	25 SHAs, less than 10 years 19 SHHs, less than 10 years 17 SHHs, more than 10 years
Dalsmark*	61	25 SHAs, less than 10 years 19 SHHs, less than 10 years 17 SHHs, more than 10 years
Dybbøl*	61	25 SHAs, less than 10 years 19 SHHs, less than 10 years 17 SHHs, more than 10 years
Amalienhaven	94	39 SHAs, less than 10 years 30 SHHs, less than 10 years 25 SHHs, more than 10 years
Mølleparken	60	25 SHAs, less than 10 years 19 SHHs, less than 10 years 16 SHHs, more than 10 years
Center for korttidspladser	35	15 SHAs, less than 10 years 11 SHHs, less than 10 years 9 SHHs, more than 10 years
Total	672	278 SHAs, less than 10 years 212 SHHs, less than 10 years 182 SHHs, more than 10 years

**Data on the total number of staff members at this unit was available. Thus, the mean number of staff members at all remaining home nursing units was used as an estimate.*

Thus, a grand total of 1.039 care staff members were estimated to work in Sønderborg elderly care, consisting of 431 SHAs with less than 10 years of experience, 328 SHHs with less than 10 years of experience, and 280 SHHs with more than 10 years of experience.

Management training courses

34 staff members participated in the management training courses. These are listed in the table below, along with their annual salaries and calculated functional hourly wages.

Staff position	Annual salary	Functional hourly wage
Daglig leder, hjemmeplejen	467323.00	298.91
Daglig leder, hjemmeplejen	467323.00	298.91
Social- og sundhedshjælper	352599.87	225.53
Social- og sundhedsassistent	369036.47	236.05
Social- og sundhedsassistent	369036.47	236.05
Daglig leder	467323.00	298.91
Uddannelsesansvarlig	315586.00	201.86
Distriktsleder, hjemmeplejen	702386.00	449.27
Hjemmesygeplejerske	330851.33	211.62
Social- og sundhedsassistent	369036.47	236.05
Daglig leder, hjemmeplejen	467323.00	298.91
Distriktsleder, hjemmeplejen	702386.00	449.27
Hjemmesygeplejerske	330851.33	211.62
Daglig leder, hjemmesygeplejen	467323.00	298.91
Hjemmesygeplejerske	330851.33	211.62
Hjemmesygeplejerske	330851.33	211.62
Distriktsleder, hjemmesygeplejen	702386.00	449.27
Sundhedschef	675166.00	431.86
Plejecenterchef	675166.00	431.86
Udviklingskonsulent	484000.00	309.58
Hjemmeplejeforfører	675166.00	431.86
Social- og sundhedsassistent	369036.47	236.05
Daglig leder	467323.00	298.91
Plejecenterleder	675166.00	431.86
Kompetenceudvikler	484000.00	309.58
Social- og sundhedsassistent	369036.47	236.05
Social- og sundhedshjælper	352599.87	225.53
Social- og sundhedsassistent	369036.47	236.05
Social- og sundhedsassistent	369036.47	236.05
Daglig leder	467323.00	298.91
Sygehjælper	356050.28	227.74
Plejecentersygeplejerske	330851.33	211.62
Plejecenterleder	675166.00	431.86
Daglig leder	467323.00	298.91

Annual salaries in DKK per year, functional hourly wages in DKK per hour.

Annual salaries for SHAs (“social- og sundhedsassistent”), SHHs (“social- og sundhedshjælper”), nurses (“hjemmesygeplejerske” and “plejecentersygeplejerske”), and nursing assistants (“sygehjælper”) were calculated as detailed in the first section of this appendix, with data on the remaining participants’ annual salaries handed over by the municipality of Sønderborg. Functional hourly wages were then calculated as detailed in the first section of this appendix.

The unit cost, i.e. the mean functional hourly wage across all 34 participants, was then calculated as follows:

$$\frac{298,91 + 298,91 + 225,53 + 236,05 + 236,05 + 298,91 + 201,86 + 449,27 + 211,62 + 236,05 + 298,91 + 449,27 + 211,62 + 298,91 + 211,62 + 211,62 + 449,27 + 431,86 + 432,86 + 309,58 + 431,86 + 236,05 + 298,91 + 431,86 + 309,58 + 236,05 + 225,53 + 236,05 + 236,05 + 298,91 + 227,74 + 211,62 + 431,86 + 298,91}{34} = 297,34 \text{ DKK per hour}$$

Then, the total number of units, i.e. the accumulated number of hours spent, was calculated as follows, seeing as all 34 participants spent 104 hours each:

$$34 * 104 = 3.536 \text{ hours}$$

The total labour cost of the management training courses was then calculated by multiplying the total number of units by the unit cost. This was then divided by 6, as all 6 focus areas of the ISH initiative were discussed at the training courses.

Peer-to-peer training

Peer-to-peer training was conducted at all care units. The staff composition of each unit was estimated as stated in the first section of this appendix. Thus, a total of 1.039 staff members, consisting of 431 SHAs with less than 10 years of experience, 328 SHHs with less than 10 years of experience, and 280 SHHs with more than 10 years of experience, participated in the peer-to-peer training. These are listed in the table below, along with their annual salaries and calculated functional hourly wages, both of which were calculated as stated in the first section of this appendix.

Staff position	Number of staff	Annual salary	Functional hourly wage
SHAs, less than 10 years	431	354511.94	226.76
SHHs less than 10 years	328	339011.47	216.84
SHHs more than 10 years	280	379776.67	242.92

The unit cost, i.e. the mean functional hourly wage across all 1.039 participants, was then calculated as follows:

$$\frac{431 * 226,76 + 328 * 216,84 + 280 * 242,92}{1.039} = 227,98 \text{ DKK per hour}$$

Then, the total number of units, i.e. the accumulated number of hours spent, was calculated as follows, seeing as all 280 staff members in the pilot units (Egernsundevad, Broager/Dybbøl, and Gråsten home nursing units, and Tandsbjerg, Dalsmark, and Dybbøl nursing home units) spent 4 hours each and all 759 staff members spent 2 hours each:

$$280 * 4 + 759 * 2 = 2.638 \text{ hours}$$

The unit cost and total number of units were then multiplied to achieve the total labour cost of the peer-to-peer training.

Staff training in PUB-related actions

Staff training in PUB-related actions was conducted at all care units. The staff composition of each unit was estimated as stated in the first section of this appendix. Thus, a total of 1.039 staff members, consisting of

431 SHAs with less than 10 years of experience, 328 SHHs with less than 10 years of experience, and 280 SHHs with more than 10 years of experience, participated in staff training in PUB-related actions. These are listed in the table below, along with their annual salaries and calculated functional hourly wages, both of which were calculated as stated in the first section of this appendix.

Staff position	Number of staff	Annual salary	Functional hourly wage
SHAs, less than 10 years	431	354511.94	226.76
SHHs less than 10 years	328	339011.47	216.84
SHHs more than 10 years	280	379776.67	242.92

The unit cost, i.e. the mean functional hourly wage across all 1.039 participants, was then calculated as follows:

$$\frac{431 * 226,76 + 328 * 216,84 + 280 * 242,92}{1.039} = 227,98 \text{ DKK per hour}$$

Then, the total number of units, i.e. the accumulated number of hours spent, was calculated as follows, seeing as all 1.039 staff members spent 2,5 hours each:

$$1.039 * 2,5 = 2.597,5 \text{ hours}$$

The unit cost and total number of units were then multiplied to achieve the total labour cost of the staff training in PUB-related actions.

Initial risk-assessments

Initial risk-assessments were conducted at all care units. The staff composition of each unit was estimated as stated in the first section of this appendix. As no data was available as to which staff members conducted the risk-assessments, it was assumed that the assessments were spread evenly across all staff members. Thus, a total of 1.039 staff members, consisting of 431 SHAs with less than 10 years of experience, 328 SHHs with less than 10 years of experience, and 280 SHHs with more than 10 years of experience, participated in conducting the initial risk-assessments. These are listed in the table below, along with their annual salaries and calculated functional hourly wages, both of which were calculated as stated in the first section of this appendix.

Staff position	Number of staff	Annual salary	Functional hourly wage
SHAs, less than 10 years	431	354511.94	226.76
SHHs less than 10 years	328	339011.47	216.84
SHHs more than 10 years	280	379776.67	242.92

The unit cost, i.e. the mean functional hourly wage across all 1.039 participants, was then calculated as follows:

$$\frac{431 * 226,76 + 328 * 216,84 + 280 * 242,92}{1.039} = 227,98 \text{ DKK per hour}$$

The total number of initial risk-assessments at each care unit is listed below:

Home nursing units	
Care unit	Number of initial risk-assessments
Egernsundeved	77
Broager/Dybbøl	88
Gråsten	85
Nordals, nord	72
Nordals, rehabilitation	75
Nordals, syd	56
Alssund, midt	60
Alssund, syd	55
Alssund, vest	56
Alssund, øst	52
Sydals, øst	65
Sydals, vest	55
Sydals, rehabilitation	25
Total	821

Nursing home units	
Care unit	Number of initial risk-assessments
Tangshave	69
Hørup	76
Gråsten	37
Broager	40
Guderup	56
Tandsbjerg	48
Dalsmark	38
Dybbøl	59
Amaliehaven	60
Mølleparken	60
Center for kortidspladser	37
Total	580

Thus, a total of 1.401 initial risk assessments were performed.

Then, the total number of units, i.e. the accumulated number of hours spent, was calculated as follows, seeing as each risk-assessment was estimated to last 2,5 minutes:

$$\frac{1.401 * 2,5}{60} = 58,38 \text{ hours}$$

The unit cost and total number of units were then multiplied to achieve the total labour cost of the initial risk-assessments.

Continuous risk-reassessments

Continuous risk-reassessments are conducted at all units. The staff composition of each unit was estimated as stated in the first section of this appendix. As no data was available as to which staff members conducted the risk-assessments, it was assumed that the assessments are spread evenly across all staff members. Thus, a total of 1.039 staff members, consisting of 431 SHAs with less than 10 years of experience, 328 SHHs with less than 10 years of experience, and 280 SHHs with more than 10 years of experience, participate in conducting the continuous risk-assessments. These are listed in the table below, along with their annual salaries and calculated functional hourly wages, both of which were calculated as stated in the first section of this appendix.

Staff position	Number of staff	Annual salary	Functional hourly wage
SHAs, less than 10 years	431	354511.94	226.76
SHHs less than 10 years	328	339011.47	216.84
SHHs more than 10 years	280	379776.67	242.92

The unit cost, i.e. the mean functional hourly wage across all 1.039 participants, was then calculated as follows:

$$\frac{431 * 226,76 + 328 * 216,84 + 280 * 242,92}{1.039} = 227,98 \text{ DKK per hour}$$

In nursing homes, quarterly risk-reassessments are performed on all residents in risk, and weekly risk-reassessments are performed on those deemed in high risk. In home nursing care, continuous risk-reassessments are only performed on those residents in high-risk. The total number of continuous risk-reassessments at each care unit is listed below, calculated as weekly assessments multiplied by 52 and quarterly assessments multiplied by 4, added together:

Home nursing units			
Care unit	Number of weekly risk-reassessments	Number of quarterly risk-reassessments	Total annual risk-reassessments
Egernsundeved	2,5	0	130
Broager/Dybbøl*	3	0	156
Gråsten*	3	0	156
Nordals, nord	1	0	52
Nordals, rehabilitation	2	0	104
Nordals, syd	1	0	52
Alssund, midt	1	0	52
Alssund, syd	1	0	52
Alssund, vest	1	0	52
Alssund, øst	1	0	52
Sydals, øst	1	0	52
Sydals, vest	1	0	52
Sydals, rehabilitation	2,5	0	130
Total	21	0	1.092

Nursing home units			
Care unit	Number of weekly risk-reassessments	Number of quarterly risk-reassessments	Total annual risk-reassessments
Tangshave	2	69	380
Hørup	1	76	356
Gråsten	1	37	200
Broager	1	20	132
Guderup	2	56	328
Tandsbjerg	1	48	244
Dalsmark	1	38	204
Dybbøl	1	59	288
Amaliehaven	1	60	292
Mølleparken	1	60	292
Center for korttidspladser	2	37	252
Total	21	0	2.968

Thus, a total of 4.060 risk-reassessments were performed in 2017.

Then, the total number of units, i.e. the accumulated number of hours spent, was calculated as follows, seeing as each risk-reassessment was estimated to last 2,5 minutes:

$$\frac{4.060 * 2,5}{60} = 169,17 \text{ hours}$$

The unit cost and total number of units were then multiplied to achieve the total labour cost of the continuous risk-reassessments.

Improvement team meetings

Improvement team meetings are conducted for 30 minutes on a weekly basis in the pilot units (Egersundevad, Broager/Dybbøl, and Gråsten home nursing units, and Tandsbjerg, Dalsmark, and Dybbøl nursing home units) and on a biweekly basis in all remaining units, with the purpose of continuous evaluation. As the staff composition of these improvement teams was only known for the Egersundevad unit, an assumption was made that all improvement teams were identical to the Egersundevad one, consisting of 3 SHAs with less than 10 years of experience, 1 SHH with less than 10 years of experience, and one operational manager. Thus, in total, 72 SHAs, 24 SHHs, and 24 operational managers participate in the improvement team meetings. These are listed in the table below, along with their annual salaries and calculated functional hourly wages, both of which were calculated as stated in the first section of this appendix.

Staff position	Number of staff	Annual salary	Functional hourly wage
SHAs, less than 10 years	72	354511.94	226.76
SHHs less than 10 years	24	339011.47	216.84
Operational managers	24	467323.00	298.91

The unit cost, i.e. the mean functional hourly wage across all 120 participants, was then calculated as follows:

$$\frac{72 * 226,76 + 24 * 216,84 + 24 * 298,91}{120} = 239,21 \text{ DKK per hour}$$

Then, the total number of units, i.e. the accumulated number of hours spent, was calculated as follows, seeing as meetings in the 4 pilot units lasted for 30 minutes on a weekly basis and meetings in the remaining 20 units lasted 30 minutes on a biweekly basis, with 5 staff members participating in each unit:

$$\frac{4 * 30 * 52 + 20 * 30 * 26}{60} * 5 = 1.820 \text{ hours}$$

The unit cost and total number of units were then multiplied to achieve the total labour cost of the improvement team meetings.

Appendix 3 - Co-financing data and related calculations

This is the dataset sent from the municipality, where the costs spent on co-financing is listed:

Rækkenavne	Antal sygehusudskrivninger	Antal sengedage (Somatik)	Kommunal medfinansiering (Somatik)
2010	7	86	51.090
Ikke modtaget: EOJ ydelser	7	86	49.723
Ikke modtaget: EOJ ydelser. Bor i plejebolig.			329
Modtaget: EOJ ydelser			1.038
2011	5	70	52.242
Ikke modtaget: EOJ ydelser	< 5	19	13.324
Ikke modtaget: EOJ ydelser. Bor i plejebolig.			1.328
Modtaget: EOJ ydelser	< 5	51	37.590
2012	7	83	151.533
Ikke modtaget: EOJ ydelser	7	83	141.894
Ikke modtaget: EOJ ydelser. Bor i plejebolig.			5.175
Modtaget: EOJ ydelser			4.464
2013	7	68	131.522
Ikke modtaget: EOJ ydelser			7.812
Ikke modtaget: EOJ ydelser. Bor i plejebolig.	< 5	10	27.300
Modtaget: EOJ ydelser	5	58	96.410
2014	8	108	120.492
Ikke modtaget: EOJ ydelser			16.909
Ikke modtaget: EOJ ydelser. Bor i plejebolig.			96
Modtaget: EOJ ydelser	8	108	103.487
2015	5	65	134.955
Ikke modtaget: EOJ ydelser	< 5	30	79.702
Modtaget: EOJ ydelser	< 5	35	55.253
2016	< 5	< 5	87.076
Ikke modtaget: EOJ ydelser			12.046
Modtaget: EOJ ydelser	< 5	< 5	75.030
2017	< 5	8	108.288
Ikke modtaget: EOJ ydelser			20.895
Modtaget: EOJ ydelser	< 5	8	87.393

Based on the annual price index' primary numbers, the calculating of the value for 2013 to present time is as followed:

Firstly, the average for the full year is calculated as given in the index table from the website price index:

	Jan	Feb	Mar	Apr	Maj	Jun	Jul	Aug	Sep	Okt	Nov	Dec
2017	100,3	101,1	101,2	101,4	101,3	101,2	102,0	101,7	101,8	101,9		

Part of the index table from the website

$$\text{Average: } \frac{100,3+101,1+101,2+101,4+101,3+101,2+102,0+101,7+101,8+101,9}{10} = 101,4$$

The formula used to calculate the present value is given as follows:

$$\text{Present value} = (\text{Amount of co-financing in 2013} \times \text{index average for 2017}) / \text{index from 2013}$$

The index from 2013 is 99,0 as stated on price index.

Now inserting the numbers in the formula results in:

$$\frac{(96,410 \text{ DKK} * 101,4)}{99,0} = \underline{98,747,21 \text{ DDK per year}}$$

The distribution of the co-financing from each month is unknown, but can be estimated, based on an average amount per month. The average cost per month was calculated in the following way:

$$\frac{87.393}{9} = 9.710,33 \text{ DDK per month on average.}$$

Based on this monthly average, the last three months of the year can be assessed. It is assumed that the average rate is the same for all the months, and this average monthly price can thus be used to estimate a total annual price of the co-financing. The monthly average price is multiplied by 12, to get the total annual price for 2017 as seen below:

$$9.710,33 \text{ DDK} * 12 = \underline{116.523,96 \text{ DDK per year}}$$

Appendix 4 – Data from the municipality of Sønderborg regarding number of residents, risk evaluated, in risks and employees from each district

Data from the municipality of Sønderborg of residents in risk, has been screenet, beeing re-evaluated per week, number of residents and employees

Distrikt Nordals

Nord

- 10 borgere i tryksårsrisiko
- 72 er screenet for tryksårsrisiko
- 1 borgere bliver revurderet pr uge
- 265 borgere og 55 medarbejdere

Rehab

- 13 borgere i tryksårsrisiko
- 75 er screenet for tryksårsrisiko
- 2 borgere bliver revurderet pr uge
- 164 borgere og 35 medarbejdere

Syd

- 11 borgere i tryksårsrisiko
- 56 er screenet for tryksårsrisiko
- 1 borger bliver revurderet pr uge
- 204 borgere og 52 medarbejdere

Distrikt Alssund

Midt

- 10 borgere i tryksårsrisiko
- 60 er screenet for tryksårsrisiko
- 1 borger bliver revurderet pr uge
- 20 medarbejdere og 153 borgere

Syd

- 7 borgere i tryksårsrisiko
- 55 er screenet for tryksårsrisiko

- 1 borger bliver revurderet pr uge
- 25 medarbejdere og 95 borgere

Vest

- 8 borgere i tryksårsrisiko
- 56 er screenet for tryksårsrisiko
- 1 borger bliver revurderet pr uge
- 29 medarbejdere og 148 borgere

Øst

- 9 borgere i tryksårsrisiko
- 52 er screenet for tryksårsrisiko
- 1 borger bliver revurderet pr uge
- 28 medarbejdere og 109 borgere

Distrikt Fjord

Egernsundeved

- 11 borgere i tryksårsrisiko
- 77 er screenet for tryksårsrisiko
- 2-3 borgere bliver revurderet pr uge
- 180 borgere og 41 medarbejder

Broager/Dybbøl

- 13 borgere i tryksårsrisiko
- 88 er screenet for tryksårsrisiko
- 3 borgere bliver revurderet pr uge
- 219 borgere og ? medarbejdere

Gråsten

- 8 borgere i tryksårsrisiko
- 85 er screenet for tryksårsrisiko
- 3 borgere bliver revurderet pr uge
- 209 borgere og ? medarbejdere

Distrikt Sydals

Øst

- 12 borgere i tryksårsrisiko
- 65 er screenet for tryksårsrisiko
- 1 borgere bliver revurderet pr uge.
- 219 borgere og 26 medarbejdere.

Vest

- 10 borgere i tryksårsrisiko
- 55 er screenet for risiko
- 1 borgere bliver revurderet pr uge
- 228 borgere og 25 medarbejdere

Rehab

- 2 borgere i tryksårsrisiko
- 25 er screenet for risiko
- 2-3 borgere bliver revurderet pr uge
- 35 borgere og 12 medarbejdere

Plejecentrene

Tangshave plejecenter

69 beboere

13 borgere i tryksårsrisiko

69 er screenet for tryksårsrisiko

69 beboere bliver revurderet hv. 3 måned

2 borgere bliver revurderet pr uge.

68 Medarbejdere

Hørup plejecenter

76 beboere

16 borgere i tryksårsrisiko

76 er screenet for tryksårsrisiko

76 beboere bliver revurderet hv. 3 måned

1 borger bliver revurderet pr uge

55 Medarbejdere

Gråsten plejecenter

37 beboere

11 borgere i tryksårsrisiko

37 er screenet for tryksårsrisiko

37 beboere bliver revurderet hv. 3 måned

1 borger bliver revurderet pr uge.

40 Medarbejdere

Broager

40 beboere

20 borgere i tryksårsrisiko

40 er screenet for tryksårsrisiko

20 beboere bliver revurderet hv. 3 måned

1 borger bliver revurderet pr uge

47 Medarbejdere

Guderup

56 beboere

22 borgere i tryksårsrisiko

56 er screenet for tryksårsrisiko

56 beboere bliver revurderet hv. 3 måned

2 borgere bliver revurderet pr uge

90 Medarbejdere

Amaliehaven plejecenter

60 beboere

14 borgere i tryksårsrisiko

60 er screenet for tryksårsrisiko

60 beboere bliver revurderet hv. 3 måned

1 borger bliver revurderet pr uge.

94 Medarbejdere

Mølleparken

60 beboere

16 borgere i tryksårsrisiko

60 er screenet for tryksårsrisiko

60 beboere bliver revurderet hv. 3 måned

1 borger bliver revurderet pr uge.

60 Medarbejdere

Center for kortidspladser

37 beboere

8 borgere i tryksårsrisiko

37 er screenet for tryksårsrisiko
37 beboere bliver revurderet hv. 3 måned
2 borgere bliver revurderet pr uge.
35 Medarbejdere

Tandsbjerg plejecenter

48 beboere
11 borgere i tryksårsrisiko
48 er screenet for tryksårsrisiko
48 beboere bliver revurderet hv. 3 måned
1 borger bliver revurderet pr uge
? Medarbejdere

Dalsmark plejecenter

38 beboere
9 borgere i tryksårsrisiko
38 er screenet for tryksårsrisiko
38 beboere bliver revurderet hv. 3 måned
1 borger bliver revurderet pr uge.
? Medarbejdere

Dybbøl plejecenter

59 beboere
19 borgere i tryksårsrisiko
59 er screenet for tryksårsrisiko
59 beboere bliver revurderet hv. 3 måned
1 borger bliver revurderet pr uge.
? Medarbejdere

Appendix 5 - Sensitivity analysis

Table 23, appendix 5. Effects on the results of the ICER (DKK) when adjusting uncertain parameters. For reference the original result of the ICER is 8153 DKK.

% Increase ----- Parameter	50%	100%	150%	200%	300%
Pressure relief aids cost/day	6770,4	5387,8	4005,2	2622,5	-142,7
Number of citizens at risk	6254	4354,9	2455,9	556,8	-3241,4
Total labor cost implementation	5145,3	2137,5	-870,3	-3878,1	-9893,6