Cost of Obesity in Switzerland in 2012

FINAL REPORT

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EXECUTIVE SUMMARY

There is worldwide agreement that obesity represents and remains a serious and still growing public health problem and many studies are available that address the fact that obesity-linked comorbidities such as hypertension, coronary heart disease, diabetes type 2 and depression represent the true medical as well as financial burden related to overweight and obesity for our society.
Thus, the aims of the present study were to a) assess the cost burden of adult obesity in Switzerland based on the prevalence data from the fifth Health Survey carried out in 2012, b) compare it to the cost of illness data evaluated on the basis of the previous Health Surveys from 2002 and 2007 and, c) investigate statistical interactions of possible risk factors with obesity and with respect to the most important obesity-related comorbidities using general linear regression and logistic regression model statistics.

Epidemiology of BMI

This report presents key information about overweight and obesity among the adult population (age 15 or older) in Switzerland, based on data from the five cross sectional national surveys carried out so far.
The development of overweight (BMI ≥ 25) over the period between 1992 and 2012 clearly demonstrates that the part of the Swiss population suffering from overweight and obesity increased considerably over the last 20 years from 30.3% to 41.2%.This increase in excess body weight was caused by a predominant increase in the proportion of overweight individuals with BMI 25 - 29.9 by 6% (from 24.9% to 30.9%) and a concomitant increase of the obese (BMI ≥ 30) population by 4.9% (from 5.4% to 10.3%). In 2012 the number of overweight men was with 1.7 Mio considerably higher than the corresponding number of overweight women (1.1 Mio). Looking at the segment of the actually obese adult Swiss (BMI ≥ 30), the difference between male and female inhabitants has narrowed as approximately 327'000 obese women compare to approximately 376'000 obese men.

Health problems associated with overweight and obesity

In our first report on the burden of overweight and obesity in Switzerland in 2004, 26 diseases were identified as overweight- and obesity-related comorbidities. In the previous study in 2009 this number was slightly increased to 32 diseases indicating that additional information on the relationship between obesity and the manifestation of other diseases was reported by that year. In the present study the number of obesity-related comorbidities was reduced by one - to 31 - since kidney disease was demonstrated in the mean time to not being linked to an increased BMI.
In 2004 we were able to assign costs to 18 diseases considered as comorbidities clearly associated with obesity. In the previous study in 2009 we evaluated a smaller

number of comorbidities, i.e. 12, as cost-relevant diseases for Switzerland. In our present assessment in 2014, the number of cost-relevant comorbidities was reduced further by one (elimination of kidney disease, see above) to a total of 11 comorbidities.

Economic burden of overweight and obesity in 2012

In contrast to our first study where cost estimates of only three of the comorbidities were based on actual Swiss data, the 2009 cost evaluation did rely on seven Swiss based cost estimates, three of them (diabetes type 2, coronary heart disease and asthma) belonging to the top four with regard to cost relevance. In the present study, cost estimates of seven of the total 11 cost-relevant comorbidities were based on Swiss cost data with three of them – depression, diabetes mellitus type 2 and coronary heart disease – being part of the four most cost-generating comorbidities.

The attributable fraction of the direct overweight- and obesity-linked disease costs of CHF 3'830 Mio in the year 2007 represented about 7.3% of the total healthcare expenses in Switzerland of CHF 52.7 billions in 2006 (Federal office of statistics (BFS) 2007). In 2012, the attributable fraction of the direct overweight- and obesity-linked disease costs of CHF 4'658 Mio represent 7.2% of the total Swiss healthcare expenses of 64.6 billions (Federal office of statistics (BFS) 2013) in 2011 remaining practically unchanged with respect to our previous assessment.
From the societal point of view, the estimate of the total economic burden for overweight and obesity and associated diseases (comorbidities) has exactly tripled over the past ten years from CHF 2´648 Mio (cost basis 2001) in 2002 to CHF 5´755 Mio (cost basis 2006) in 2007, to CHF 7'990 Mio (cost basis 2011) in 2012. The contribution of overweight and obesity to these costs are approximately equal.
The exclusively obesity-linked costs (direct comorbidity costs only) of CHF 2'204 Mio represent about 0.38% of the national gross domestic product (GDP) of CHF 585.1 billions in 2011 (Federal office of statistics (BFS) 2013), a basically identical percentage when compared to the situation in 2006, i.e. exclusively obesity-linked costs (direct comorbidity costs only) of CHF 1'866 Mio representing about 0.37% of the national gross domestic product (GDP) of CHF 508 billions in 2006. According to a study published in 2008 on the health-economic burden of obesity in Europe, the estimated obesity related costs range from 0.09 to 0.61% of the total annual gross domestic income in Western European countries indicating that the economic costs of obesity in Switzerland are comparable to such estimates from other European countries.

Statistical Evaluation

Using a general linear regression analysis model on the Swiss population interviewed for the fifth Health Survey carried out in 2012, it was possible to confirm that six of the 11 obesity-linked comorbidities are indeed statistically significantly correlated to body weight. Five of them, asthma, diabetes type 2, osteoarthritis, high blood pressure and depression, representing the five most costly of these chronic comorbidities (covering 80% of all direct costs of comorbidities) were actually significantly correlated to

increased body weight. Stroke, often with fatal outcome, was negatively correlated with body weight, possibly indicating that the chances to survive a stroke decrease as body weight, respectively BMI increases.

Again using a general linear regression analysis model the interaction between physical complaints - representing general stress symptoms - and body weight were evaluated. A typical general stress symptom such as back pain/lower back pain was statistically significantly correlated with increasing body weight.

Using a logistic regression model, various factors were tested for their influence on the manifestation of diabetes type 2. BMI was most impressively linked to the occurrence of diabetes type 2 in the entire segment of the Swiss population investigated. Furthermore, participating in a dietary program for medical reasons was also an important factor in the context of diabetes type 2. On the other hand, physical activity had a moderate negative effect on diabetes, whereas consumption of a moderate-to-large amount of fish was negatively linked to diabetes in the female subsegment.

Also regarding depression, BMI was significantly linked to the occurrence of depression in the entire segment of the Swiss population investigated, i.e. as body weight increases the chances of becoming depressive clearly increases. In addition, participating in a dietary program for medical reasons was also an important factor in the context of manifestation of depression. This effect was still clearly seen after exclusion of all diabetic patients from the investigated population.

As shown by multiple linear regression, BMI was also most impressively linked to the occurrence of hypertension in the entire segment of the Swiss population investigated, i.e. as body weight increases, the chances of suffering from hypertension increases drastically. Furthermore, participating in a dietary program for medical reasons also was an important factor in the context of the manifestation of hypertension.

KURZFASSUNG

Es herrscht weltweite Übereinstimmung darüber, dass massiv erhöhtes Körpergewicht (Adipositas) nach wie vor ein ernstzunehmendes Gesundheitsproblem darstellt, dessen Prävalenz weiterhin ansteigt. Zudem zeigt eine grosse Anzahl Studien auf, dass Adipositas-bedingte Begleiterkrankungen wie Bluthochdruck, koronare Herzerkrankungen, Diabetes Typ 2 und Depressionen die hauptsächlichen medizinischen sowie finanziellen Belastungen von Adipositas für unsere Gesellschaft darstellen.

Die Ziele der vorliegenden Studie sind: a) Die Abschätzung der Kosten von Adipositas bei Erwachsenen in der Schweiz anhand der Prävalenzdaten der fünften Gesundheitsbefragung, die 2012 durchgeführt wurde, b) Der Vergleich mit Kosten, die gestützt auf die Gesundheitsbefragungen von 2002 und 2007 berechnet wurden und c) Die Untersuchung statistischer Interaktion von Adipositas mit möglichen Risikofaktoren im Hinblick auf die wichtigsten Adipositas-bedingten Begleiterkrankungen unter Verwendung von mehrfach linearen und logistischen Regressionsmodellen.

Epidemiologie

In diesem Bericht werden die wichtigsten Informationen zu Übergewicht und Adipositas bei Erwachsenen (ab dem Alter von 15 Jahren) in der Schweiz anhand von Daten aus den fünf bisher durchgeführten nationalen Erhebungen präsentiert.

Im Zeitraum von 1992 bis 2012 hat sich der Bevölkerungsanteil, der an Übergewicht (BMI ≥ 25) leidet, in den letzten 20 Jahren erheblich erhöht: Er stieg von 30.3% auf 41.2% der Gesamtbevölkerung der Schweiz an. Diese Zunahme ist hauptsächlich auf einen Anstieg des Anteils der Übergewichtigen mit einem BMI von 25 - 29.9 um 6% (von 24.9% auf 30.9%) aber auch auf eine gleichzeitige Zunahme des Anteils der adipösen Personen (BMI ≥ 30) um 4.9% (von 5.4% auf 10.3%) zurückzuführen.

Im Jahr 2012 lag die Zahl der übergewichtigen Männer mit 1.7 Mio substantiell über der entsprechenden Zahl an übergewichtigen Frauen von 1.1 Mio. Im Segment der adipösen Einwohner der Schweiz ergab sich einen Annäherung zwischen den Geschlechtern mit schätzungsweise 327’000 adipösen Frauen gegenüber 376’000 adipösen Männern.

Mit Übergewicht und Adipositas verbundene Gesundheitsprobleme

In unserem ersten Bericht zum volkswirtschaftlichen Schaden von Übergewicht und Adipositas in der Schweiz haben wir 26 verschiedene Krankheiten als Begleiterkrankungen (Komorbiditäten) von Übergewicht und Adipositas eruiert. In der zweiten

Studie (2009) erhöhte sich diese Zahl auf insgesamt 32 Krankheiten, da jedes Jahr neue Informationen verfügbar wurden, die einen Zusammenhang zwischen Adipositas und weiteren Krankheiten aufzeigen. In der vorliegenden Studie reduzierte sich die Zahl der Begleiterkrankungen allerdings auf 31, da Nierenerkrankungen seit dem letzten Bericht in der Literatur nicht mehr mit erhöhtem BMI in Verbindung gebracht werden.

2004 konnten wir 18 Begleiterkrankungen, bei denen ein klarer Zusammenhang mit Adipositas besteht, entsprechende Kosten zuweisen. In der zweiten Studie (2009) beurteilten wir eine geringere Zahl von Komorbiditäten, d.h. zwölf, als kostenrelevante Begleiter-krankungen für die Schweiz. Im vorliegenden Bericht reduzierte sich die Anzahl kostenrelevanter Komorbiditäten auf total 11 aufgrund des Ausscheidens der Nierenkrankheiten aus der Gruppe der Adipositas-bedingten Begleiterkrankungen.

Volkswirtschaftlicher Schaden von Übergewicht und Adipositas 2012

In unserer ersten Studie in 2004 beruhten die Kostenschätzungen von nur drei Komorbiditäten von Adipositas auf effektiven Kostendaten aus der Schweiz. Die zweite Kostenstudie von 2009 stützte sich auf Kostenschätzungen anhand von sieben Komorbiditäten, die auf Schweizer Kostendaten beruhten; drei davon (Diabetes Typ 2, koronare Herzkrankheiten und Asthma) gehören bezüglich der Kostenrelevanz zu den vier wichtigsten Begleiterkrankungen der Adipositas. In der vorliegenden Studie basierten die Kostenschätzungen von 7 der insgesamt 11 kostenrelevanten Begleiterkrankungen auf Schweizer Daten, drei davon – Depression, Diabetes Typ 2 und koronare Herzerkrankungen – gehören zu den vier kostenträchtigsten Begleiterkrankungen.

Der Anteil der direkten Kosten der Übergewichts- und Adipositas- bedingten Begleit-erkrankungen von CHF 3´830 Mio in 2007 stellen 7.3% der gesamten Gesund-heitskosten der Schweiz von CHF 52.7 Mia in 2006 dar (Bundesamt für Statistik (BFS) 2007). In 2012 stellt der Anteil der direkten Kosten der Übergewicht- und Adipositas-bedingten Begleiterkrankungen von CHF 4´658 Mio in 2011 ca. 7.2% der gesamten Gesundheitskosten der Schweiz von CHF 64.6 Mia dar (Bundesamt für Statistik (BFS) 2013), was einen praktisch unveränderten prozentualen Anteil im Vergleich zur vorangehenden Analyse bedeutet.

Aus dem Blickwinkel der Gesellschaft stiegen die gesamten Kosten der Begleit-erkrankungen von Übergewicht und Adipositas in der Schweiz von CHF 2‘648 Mio (Kostenbasis 2001) in 2002, auf CHF 5‘755 Mio (Kostenbasis 2006) in 2007 und auf CHF 7‘990 Mio (Kostenbasis 2011) in 2012 an, was einer Verdreifachung dieser Kosten entspricht. Der Beitrag von Übergewicht respektive Adipositas an diese Kosten sind vergleichbar.

Die ausschliesslich Adipositas-bedingten Kosten (nur die direkten Kosten der Begleiterkrankungen) von CHF 2’204 Mio entsprechen 0.38% des Bruttoinlandprodukts (BIP) von 2011, das CHF 585.1 Mia betrug (Bundesamt für

Statistik (BFS) 2013). Dies ist ein praktisch identischer prozentualer Anteil zur Situation in 2007, wo die ausschliesslich Adipositas-bedingten Kosten (nur die direkten Kosten der Begleiterkrankungen) von CHF 1'866 Mio 0.37% des Bruttoinlandprodukts (BIP) in 2006 von CHF 508 Mia entsprechen.

Gemäss einer im Jahre 2008 publizierten Untersuchung zur volkswirtschaftlichen Bedeutung der Adipositas liegt der Adipositas-bedingte Anteil der Gesundheitsausgaben in westeuropäischen Ländern innerhalb einer Spannbreite von 0.09% bis 0.61% des jährlichen Bruttoinlandprodukts (BIP). Die oben beschriebenen Kostenschätzungen der Begleiterkrankungen von Übergewicht und Adipositas in der Schweiz von 0.38% des Bruttoinlandprodukts liegen somit klar innerhalb dieser Werte.

Statistische Auswertung

Unter Anwendung eines mehrfach-linearen Regressionsmodells auf die befragte Bevölkerungsgruppe der fünften Gesundheitsbefragung von 2012, hingen 6 der insgesamt 11 Begleiterkrankungen von Übergewicht und Adipositas signifikant mit dem Körpergewicht zusammen.Fünf dieser Begleiterkrankungen - Asthma, Diabetes Typ 2, Osteoarthritis, Bluthochdruck und Depression – stellen die 5 chronischen Komorbiditäten mit den höchsten Kosten dar (d.h. entsprechen 80% der gesamten direkten Kosten der Begleiterkrankungen) und korrelierten signifikant und positiv mit erhöhtem Körpergewicht. Der Schlaganfall, oft verbunden mit fatalem Ausgang, zeigte eine signifikante, aber negative Korrelation mit erhöhtem Körpergewicht, was möglicherweise darauf hinweist, dass die Chance einen Schlaganfall zu überleben mit zunehmendem Körpergewicht sinkt.

Ebenfalls unter Anwendung eines mehrfach-linearen Regressionsmodells wurde die Interaktion zwischen solchen physischen Beschwerden, welche allgemeine Stress-Symptome verkörpern, und dem Körpergewicht untersucht. Rückenschmerzen, respektive Kreuzschmerzen - ein typisches allgemeines Stress-Symptom – korrelierte statistisch signifikant mit einer Körpergewichtszunahme.

Unter Anwendung eines logistischen Regressionsmodells wurde der Einfluss verschiedener Faktoren auf das Auftreten von Diabetes Typ 2 untersucht. Der BMI zeigte einen stark positiven, statistisch signifikanten Effekt auf das Auftreten von Diabetes Typ 2. Wie erwartet war die Einnahme einer medizinisch verordneten Diät ebenfalls ein wichtiger Faktor hinsichtlich des Auftretens von Diabetes Typ 2. Körperliche Aktivität, hingegen, zeigte einen statistisch signifikanten negativen Effekt im Hinblick auf das Diabetes-Risiko Typ 2. Ebenso war die regelmässige Konsumation einer mittleren bis grossen Menge an Fisch negativ mit dem Auftreten von Diabetes Typ 2 verbunden, jedoch nur im weiblichen Segment der untersuchten Schweizer Bevölkerung.

Das Körpergewicht zeigte ebenfalls einen statistisch signifikanten positiven Einfluss auf das Auftreten von Depressionen im gesamten Segment der untersuchten Schweizer Bevölkerung, d.h. mit einer Zunahme des Körpergewichts erhöht sich das

Risiko eine Depression zu erleiden. Die Einnahme einer medizinisch verordneten Diät war ebenfalls ein wichtiger Faktor in Bezug auf das Auftreten einer Depression. Dieser Effekt zeigte sich selbst nach dem Ausschluss aller diabetischen Patienten von der untersuchten Bevölkerungsgruppe.

Mittels mehrfacher linearer Regression konnte ebenfalls gezeigt werden, dass das Auftreten von Bluthochdruck signifikant mit dem Körpergewicht verknüpft ist, d.h. zunehmendes Körpergewicht führt zu einer drastischen Erhöhung des Risikos für Bluthochdruck. Ebenso zeigte sich, dass eine medizinisch verordnete Diät ebenfalls ein wichtiger Faktor im Zusammenhang mit dem Blutdruck ist.

SYNTHÈSE

Il est incontesté à travers le monde que l'obésité demeure un problème de santé publique sérieux, qui continue de s'aggraver. En outre, nombre d'études traitent du fait que les comorbidités liées à l'obésité comme l'hypertension, les maladies coronariennes, le diabète de type 2 et la dépression représentent, pour notre société, les principales charges médicales et financières découlant de l'obésité et du surpoids. La présente étude a donc pour objectifs a) d'estimer les coûts liés à l'obésité chez l'adulte en Suisse en se fondant sur les données relatives à la prévalence tirées de la cinquième Enquête suisse sur la santé menée en 2012, b) de les comparer aux données sur les dépenses de santé évaluées d'après les Enquêtes suisses sur la santé réalisées en 2002 et 2007 et, c) de déterminer, sur le plan statistique, les interactions de l'obésité et des principales comorbidités liées à celle-ci avec d'éventuels facteurs de risque et ce, au moyen de modèles de régression linéaires multiples et logistiques.

Epidémiologie

Le présent rapport fournit des informations-clés sur le surpoids et l'obésité parmi la population adulte (à partir de 15 ans) en Suisse en s'appuyant sur des données provenant des cinq enquêtes transversales nationales menées à ce jour.
L'évolution du surpoids (IMC ≥25) entre 1992 et 2012 indique clairement que la part de la population souffrant de surcharge pondérale et d'obésité a considérablement augmenté durant les 20 dernières années, passant de 30,3 % à 41,2 %. Cette hausse est due à la forte augmentation (de 24,9 % à 30,9 %) de la proportion de personnes en surpoids (IMC de 25 à 29,9) et à l'augmentation concomitante (de 5,4 % à 10,3 %) de la population obèse (IMC supérieur ou égal à 30). En 2012, la Suisse comptait bien plus d'hommes en surpoids (1,7 million) que de femmes (1,1 million). S'agissant du segment d'adultes suisses obèses (IMC ≥ 30), l'écart entre les femmes et les hommes s'est réduit (près de 327 000 femmes obèses contre 376 000 hommes obèses environ).

Problèmes de santé associés à la surcharge pondérale et à l'obésité

Dans notre premier rapport de 2004 sur le fardeau économique découlant de la surcharge pondérale et de l'obésité en Suisse, nous avions identifié 26 maladies comme des comorbidités liées au surpoids et à l'obésité. Dans l'étude réalisée en 2009, leur nombre a légèrement augmenté, passant à 32 maladies, ce qui indique qu'un plus grand nombre d'informations ont été rassemblées cette année-là sur le lien entre l'obésité et d'autres maladies. Dans la présente étude, leur nombre a été réduit à 31 étant donné qu'il a été démontré entre-temps que les maladies rénales n'avaient aucun lien avec un IMC élevé.
En 2004, nous avons pu déterminer les coûts de 18 maladies considérées comme des comorbidités clairement associées à l'obésité. Dans l'étude menée en 2009, nous

avons examiné un nombre restreint de comorbidités, 12 en tout, en tant que maladies ayant un impact sur les coûts en Suisse. Dans l'évaluation de 2014, ce nombre a été réduit à 11 (exclusion des maladies rénales, voir ci-dessus).

Fardeau économique découlant de la surcharge pondérale et de l'obésité en 2012

Dans notre première étude, les coûts de trois comorbidités liées à l'obésité seulement avaient été estimés d'après des données actuelles sur les coûts en Suisse. L'évaluation économique de 2009 s'est fondée sur sept estimations de coûts en Suisse, trois d'entre elles (diabète de type 2, maladie coronarienne et asthme) appartenant aux quatre principales maladies en termes de coûts. Dans la présente étude, les coûts de sept des onze comorbidités déterminantes ont été évalués à partir des données sur les coûts en Suisse ; trois d'entre elles – dépression, diabète sucré de type 2 et maladie coronarienne – font partie des quatre maladies occasionnant le plus de coûts.

D'un montant de 3830 millions de francs en 2007, les coûts de santé directement liés au surpoids et à l'obésité représentaient environ 7,3 % du total des dépenses de santé en Suisse, qui s'élevaient à 52,7 milliards de francs en 2006 (Office fédéral de la statistique OFS, 2007). En 2012, ils s'élevaient à 4658 millions de francs, soit 7,2 % du total des dépenses de santé en Suisse, qui étaient de 64,6 milliards de francs en 2011 (OFS, 2013). Ils demeurent presque inchangés par rapport à notre précédente évaluation.
Du point de vue de la société, les coûts totaux estimés du surpoids, de l'obésité et des maladies associées (comorbidités) ont exactement triplé ces dix dernières années, passant de 2648 millions de francs en 2002 (base 2001) à 5755 millions de francs en 2007 (base 2006) pour atteindre 7990 millions de francs en 2012 (base 2011). L'obésité et le surpoids y contribuent approximativement à part égale.
Les coûts exclusivement liés à l'obésité (coûts de comorbidité directs uniquement), d'un montant de 2204 millions de francs, représentent environ 0,38 % du produit intérieur brut (PIB), qui s'élevait à 585,1 milliards de francs en 2011 (OFS, 2013). Ce pourcentage est pratiquement identique à celui enregistré en 2006 : les coûts exclusivement liés à l'obésité (coûts de comorbidité directs uniquement), d'un montant de 1866 millions de francs, représentaient 0,37 % du PIB, qui s'élevait à 508 milliards de francs en 2006. Selon une étude parue en 2008 sur les coûts sanitaires et économiques de l'obésité en Europe, les coûts liés à l'obésité sont estimés entre 0,09 et 0,61 % du revenu intérieur brut annuel dans les pays européens occidentaux. Ainsi, les résultats de la Suisse sont comparables aux estimations provenant d'autres pays européens.

Evaluation statistique

Le modèle de régression linéaire généralisé utilisé auprès de la population suisse ayant participé à la cinquième Enquête sur la santé réalisée en 2012 a permis de confirmer que six des onze comorbidités associées à l'obésité sont, sur le plan

statistique, liées dans une très large mesure au poids corporel. Cinq d'entre elles, à savoir l'asthme, le diabète de type 2, l'arthrose, l'hypertension et la dépression, représentent les comorbidités chroniques occasionnant le plus de coûts (elles couvrent 80 % de tous les coûts de comorbidité directs). De plus, elles sont associées dans une très large mesure à un poids corporel élevé. S'agissant des attaques – à l'issue souvent fatale –, une corrélation négative avec le poids corporel a été mise en évidence, indiquant que les chances d'y survivre se réduisaient lorsque le poids corporel/l'IMC augmentait.

L'interaction entre les douleurs physiques – constituant des symptômes de stress généraux – et le poids corporel a été évaluée au moyen du même type de modèle. Les résultats ont mis en lumière le fait que, d'un point de vue statistique, les maux de dos/douleurs lombaires étaient, de manière significative, associés à une prise de poids.

Un modèle de régression logistique a été utilisé pour déterminer l'influence de différents facteurs sur l'apparition du diabète de type 2. L'IMC était lié, de manière saisissante, au développement de cette maladie dans tout le segment de la population suisse interrogée. Par ailleurs, le suivi d'un régime pour raisons médicales s'est avéré déterminant dans l'apparition du diabète de type 2. S'agissant de l'activité physique, elle a un effet modérément négatif sur cette maladie. Quant à la consommation de poisson en quantités modérées à importantes, elle n'a aucun lien avec l'apparition du diabète dans le segment de la population féminine.

S'agissant de la dépression, l'IMC a été associé, dans une très large mesure, à son développement dans tout le segment de la population suisse sondée. En d'autres termes, lorsque le poids corporel augmente, le risque de souffrir d'une dépression s'accentue clairement. De plus, le suivi d'un régime pour raisons médicales s'est avéré déterminant dans l'apparition de la dépression. Cet effet a perduré nettement après l'exclusion de tous les patients diabétiques de la population interrogée.

Comme le modèle de régression linéaire multiple l'a mis en évidence, l'IMC était, de manière saisissante, lié à l'apparition de l'hypertension dans l'ensemble du segment de la population suisse interrogée. En d'autres termes, lorsque le poids corporel augmente, le risque de souffrir d'hypertension s'accroît considérablement. Par ailleurs, le suivi d'un régime pour raisons médicales s'est avéré déterminant dans l'apparition de l'hypertension.

COMPENDIO

A livello mondiale vi è consenso unanime nel sostenere che l'obesità è e rimane un problema di salute pubblica serio e tuttora in crescita. Inoltre, molti studi affermano che le comorbilità legate all'obesità come l'ipertensione, le patologie coronariche, il diabete di tipo 2 e la depressione rappresentano il vero onere clinico e finanziario connesso al sovrappeso e all'obesità per la nostra società.
Perciò, gli obiettivi del presente studio sono: a) stimare i costi dell'obesità degli adulti in Svizzera sulla base dei dati di prevalenza della quinta Indagine sulla salute in Svizzera effettuata nel 2012, b) confrontarli con i dati sui costi delle malattie valutati sulla base delle precedenti indagini sulla salute del 2002 e del 2007 e c) analizzare le interazioni statistiche dei possibili fattori di rischio rispetto all'obesità e alle principali comorbilità legate all'obesità utilizzando i modelli statistici della regressione lineare generalizzata e della regressione logistica.

Epidemiologia dell'IMC

Questo rapporto contiene informazioni chiave sul sovrappeso e sull'obesità tra la popolazione adulta (a partire dai 15 anni) in Svizzera e si fonda su dati rilevati nell'ambito di cinque indagini nazionali effettuate sino ad oggi su un campionamento trasversale (cross-section).
L'evoluzione del sovrappeso (IMC ≥ 25) nel periodo compreso tra il 1992 e il 2012 mostra chiaramente che la percentuale di popolazione svizzera affetta da sovrappeso e obesità è aumentata notevolmente negli ultimi 20 anni, passando dal 30,3 al 41,2 per cento. Tale incremento in questo ambito è stato causato dall'aumento predominante di 6 punti percentuali degli individui sovrappeso con un IMC di 25 – 29,9 (da 24,9 % a 30,9 %) e da una crescita concomitante di 4,9 punti percentuali della popolazione obesa (da 5,4 % a 10,3 %). Nel 2012, il numero di uomini sovrappeso (1,7 milioni) superava nettamente quello delle donne (1,1 milioni). Considerando il segmento degli adulti svizzeri obesi (IMC ≥ 30), la differenza tra i due sessi si riduce, con circa 327 000 donne obese contro circa 376 000 uomini.

Problemi di salute legati a sovrappeso e obesità

Nel nostro primo rapporto del 2004 sugli oneri connessi al sovrappeso e all'obesità in Svizzera, 26 patologie sono state identificate come comorbilità legate al sovrappeso e all'obesità. Nello studio del 2009, precedente a quello attuale, tale numero era leggermente aumentato (32), provando che in quel lasso di tempo era stato possibile acquisire nuove informazioni sul rapporto tra l'obesità e la manifestazione di altre malattie. Nel presente studio il numero di comorbilità legato all'obesità è stato ridotto di un'unità e portato a 31: nel frattempo infatti è stato dimostrato che non sussiste un legame tra un IMC elevato e l'insufficienza renale.
Nel 2004 abbiamo determinato i costi di 18 patologie considerate come comorbilità chiaramente associate all'obesità. Nello studio del 2009, precedente a quello attuale, abbiamo valutato un numero inferiore di comorbilità (12) come patologie che generano costi per la Svizzera. Nella presente valutazione del 2014, il numero di

comorbilità che generano costi è stato ulteriormente ridotto di un'unità e portato a undici (eliminazione dell'insufficienza renale, cfr. sopra).

Impatto economico del sovrappeso e dell'obesità nel 2012

Al contrario del nostro primo studio, in cui le stime dei costi basate su dati effettivi della popolazione svizzera erano limitate a tre comorbilità, la stima dei costi del 2009 riguardava sette comorbilità valutate utilizzando dati della popolazione svizzera, tre delle quali (diabete di tipo 2, patologie coronariche e asma) rientrano tra le prime quattro per quanto concerne la rilevanza in termini di costi. Nel presente studio, le stime dei costi di sette delle undici comorbilità totali che generano costi erano basate su dati della popolazione svizzera e tre di esse (depressione, diabete mellito di tipo 2 e patologie coronariche) rientrano tra le quattro comorbilità che generano i costi più elevati.

La parte di costi imputabile ai costi diretti delle patologie legate a sovrappeso e obesità, pari a 3830 milioni di franchi nel 2007, rappresentava il 7,3 per cento delle spese complessive della sanità in Svizzera, pari a 52,7 miliardi di franchi nel 2006 (Ufficio federale di statistica UST, 2007). Nel 2012, la parte di costi imputabile ai costi diretti delle patologie legate a sovrappeso e obesità, pari a 4 658 milioni di franchi, rappresenta il 7,2 per cento delle spese complessive della sanità in Svizzera, pari a 64,6 miliardi di franchi nel 2011 (Ufficio federale di statistica UST, 2013), e resta dunque quasi invariata rispetto alla precedente rilevazione.

Dal punto di vista sociale, la stima degli oneri finanziari complessivi per sovrappeso, obesità e patologie correlate (comorbilità) è esattamente triplicata nell'ultimo decennio, passando da 2648 milioni di franchi (base di costo 2001) nel 2002 a 5755 milioni di franchi (base di costo 2006) nel 2007, sino ad arrivare a 7990 milioni di franchi (base di costo 2011) nel 2012. Il contributo di sovrappeso e obesità a tali costi è praticamente immutato.
I costi legati esclusivamente all'obesità (solo costi diretti di comorbilità) ammontano a 2 204 milioni di franchi, pari allo 0,38 per cento circa del prodotto interno lordo nazionale (PIL), che nel 2011 era di 585,1 miliardi di franchi (Ufficio federale di statistica UST, 2013). Tale percentuale è sostanzialmente identica a quella rilevata nel 2006, in cui i costi legati esclusivamente all'obesità (solo costi diretti di comorbilità) ammontavano a 1886 milioni di franchi, pari allo 0,37 per cento circa del prodotto interno lordo nazionale (PIL), che nel 2006 era di 508 miliardi di franchi. Secondo uno studio pubblicato nel 2008 concernente gli oneri finanziari connessi all'obesità in Europa, la stima dei costi legati all'obesità varia tra lo 0,09 e lo 0,61 per cento del reddito nazionale lordo complessivo su base annua nei Paesi dell'Europa occidentale. Ciò indica che i costi finanziari dell'obesità in Svizzera sono comparabili a quelli stimati per altri Paesi di quest'area geografica.

Valutazione statistica

Usando il modello di analisi della regressione lineare generalizzata sulla popolazione svizzera intervistata per l'Indagine sulla salute in Svizzera effettuata nel 2012, è stato possibile confermare che sei delle undici comorbilità legate all'obesità hanno

effettivamente una correlazione significativa con il peso corporeo in termini statistici. Cinque di esse (asma, diabete di tipo 2, osteoartrite, ipertensione e depressione), che rappresentano le cinque malattie più costose tra queste comorbilità croniche (80 % dei costi diretti complessivi delle comorbilità), erano infatti correlate in modo significativo al peso corporeo eccessivo. L'infarto, spesso con esiti letali, ha una correlazione negativa con il peso corporeo, indicando probabilmente che le possibilità di sopravvivere a un infarto diminuiscono all'aumentare del peso corporeo o dell'IMC.

Applicando nuovamente il modello di analisi della regressione lineare generalizzata abbiamo analizzato l'interazione tra disturbi fisici, rappresentati da sintomi di stress generali, e peso corporeo. Un tipico sintomo da stress generale come il dolore alla schiena/dolore lombare è stato statisticamente correlato in modo significativo all'aumento del peso corporeo.

Usando un modello di regressione logistica, è stata analizzata l'influenza di vari fattori sulla manifestazione del diabete di tipo 2. Il legame tra l'IMC e l'incidenza del diabete di tipo 2 è impressionante nell'intero segmento della popolazione svizzera oggetto dell'indagine. Inoltre, partecipare a un programma nutrizionale per ragioni mediche rappresentava un fattore importante nel contesto del diabete di tipo 2. D'altro canto, l'attività fisica ha mostrato un moderato effetto negativo sul diabete, mentre il consumo di una quantità da moderata ad abbondante di pesce era negativamente legato al diabete nel sottosegmento delle donne.

Anche per quanto concerne la depressione, l'IMC ha mostrato un legame significativo con l'incidenza della depressione sull'intero segmento della popolazione svizzera oggetto dell'indagine, vale a dire che all'aumentare del peso corporeo crescono nettamente anche le possibilità di ammalarsi di depressione. Inoltre, partecipare a un programma nutrizionale per ragioni mediche rappresentava un fattore importante nel contesto della manifestazione della depressione. Questo effetto era ancora chiaramente rilevabile anche dopo aver escluso tutti i pazienti diabetici dalla popolazione oggetto dell'indagine.

Come dimostrato dalla regressione lineare multipla, il legame tra l'IMC e l'incidenza dell'ipertensione è impressionante nell'intero segmento della popolazione svizzera oggetto dell'indagine, vale a dire che all'aumentare del peso crescono in modo drastico anche le possibilità di soffrire di ipertensione. Inoltre, partecipare a un programma nutrizionale per ragioni mediche rappresentava un fattore importante nel contesto della manifestazione dell'ipertensione.

PART 1: HEALTH CARE COSTS OF OVERWEIGHT AND OBESITY IN SWITZERLAND IN 2012: AN UPDATED COST-OF-ILLNESS STUDY

1. Introduction

Since the 1970s the worldwide increase in obesity prevalence has been dramatically approaching epidemic proportions (1). Switzerland is no exception, although – according to recent data (2010) – the prevalence of obesity was lowest in Switzerland with 8% compared to an average of 17% among EU member states (2). Thus, it is no wonder that overweight and obesity have become a major concern on the Swiss public health agenda and, as the present study shows, will remain an important topic with respect to future developments regarding excess body weight in the Swiss population and its accompanying medical expenditures.

The major health risks associated with overweight and obesity are non-communicable diseases such as type 2 diabetes, hypertension, coronary heart disease and stroke, osteoarthritis (knee and hip), cancer and depression (3, 4). One important aspect related to the obesity-comorbidities interactions has so far never been investigated: which of these comorbidities is most intimately associated with an increased body mass index (BMI), i.e. are there statistical correlations and to what extend between the occurrence of the above mentioned comorbidities in the Swiss population with the actual body weight and BMI, respectively.

Aims of the present study are

- to assess the cost burden of adult obesity based on the prevalence data from the fifth Health Survey carried out in 2012 and to compare it to the cost of illness data evaluated on the basis of the previous Health Survey from 2007 (5), and,
- to investigate statistical interactions of possible risk factors with obesity and with respect to the most important obesity-related comorbidities, based on the data from the fifth Swiss Health Survey carried out in 2012, using general linear regression models and multivariate statistics.

The present report will provide us with an answer, whether the increase in prevalence in overweight and obesity in the Swiss adult population continues at the previously observed rate. Furthermore, the economic burden related to overweight and obesity will be updated from our last estimate done in 2008. New scientific findings regarding the causal association of overweight and obesity with the above mentioned chronic, non-communicable diseases linked to excess body weight will be evaluated to obtain a more accurate picture regarding the expected increase in health care costs within this context.

Whatever these results may elucidate, it already has become widely accepted that excess body weight threatens health and well-being of a large number of individuals

to a considerable degree and places an increasing burden on the Swiss society in terms of health care costs, on employers through a rise in lost productivity and on families because of the increasing burden of long-term chronic disability.

2. Methods

2.1 Definition of overweight and obesity

Overweight and obesity are defined via the body mass index (BMI), which represents a measure of weight relative to height, defined as weight (kg) divided by height in square meters (m^2). The BMI range for Normal Weight is 18.5 - 24.9 kg/m^2; Overweight is 25 - 29.9 kg/m^2, Obese is ≥ 30 kg/m^2. In the present study the above definitions of Overweight and Obesity were being applied.

2.2 Epidemiology

The Health Surveys for Switzerland (Schweizerische Gesundheitsbefragung) is a series of surveys, first instituted in 1992/3 and carried out in 5 year intervals, is part of an overall program of surveys commissioned by the Federal office of public health (Bundesamt für Gesundheit (BAG)) designed to provide regular information on various aspects of the nation's health. The data from the four Health Surveys conducted in 1992/3, 1997, 2002, 2007 and 2012 were used to estimate the prevalence of overweight and obesity of the adult Swiss population. The data from the recent survey conducted in 2012 was used to calculate the actual numbers of the Swiss population grouped by age, gender and BMI in the year 2012.

2.3 Costs

Cost estimates are separated from those covering actual treatment costs of overweight and obesity per se and from estimates of costs related to comorbidities attributable to obesity including both direct and indirect costs. Direct costs comprise all the costs that incur directly by treatment of overweight and obesity and by preventive measures to avoid obesity, e.g. medication, dietician and physician visits, surgical procedures, hospital stays and others. Indirect costs are represented by productivity losses (lost wages) caused by obesity-related work absenteeism, early retirement, and premature death before retirement age. However, work absenteeism, invalidity, or premature deaths related to obesity are predominantly linked to the occurrence of comorbidities. Therefore, all indirect costs were handled in the context of estimating the costs of these comorbidities whereas for overweight and obesity only direct treatment costs were estimated.

2.3.1 Direct costs

Direct costs comprise all the costs that incur directly by treatment, prevention, etc. of overweight and obesity, e.g. medication, physician visits, hospital stays etc. Indirect costs are productivity losses (lost wages) caused by the disease through work absenteeism, early retirement, and premature death. However, work absenteeism, invalidity, or (premature) deaths that occur in the context of obesity are essentially linked to the obesity-associated comorbidities. Therefore, all indirect costs were handled under cost estimates for comorbidities (see point 2.3.2 below) whereas for obesity and overweight only direct treatment costs were estimated. Obesity related direct costs were assessed by a top-down approach as it was not possible to exactly assign a certain resource use to an overweight person. The usual approach for treating overweight - diet modification and increased physical activity - cannot be linked to a certain monetary value and was therefore omitted. Visits to a physician occur mostly in the context of a comorbidity and are therefore included in this evaluation via costs of overweight/obesity-linked comorbidities. For this reason, direct obesity related costs are restricted to prescribed medication, to consultations with nutritionists, and to bariatric surgical interventions. To estimate the total costs of the only (in Switzerland) registered drug used in the treatment of obesity (Xenical®) published information on the total volume sold in the year 2012 (or nearest) in Switzerland was searched on the internet. To calculate the annual costs for nutritional consultations associated to overweight, the number of these consultations (physician prescribed and reimbursed by health insurance) in the year 2012 (provided by Santésuisse) was multiplied with the monetary value according to the tariff contract between SVDE and Santésuisse dated 01.01.2002. This value is CHF 99.00 for a first consultation and CHF 77.00 for follow-up consultations. The costs of bariatric surgical interventions were estimated by multiplying the number of bariatric surgical procedures carried out in 2012 (provided by the Swiss Federal Statistical Office (SFSO), Neuenburg) with the costs estimates for surgery derived via DRG calculation (ADRG K04: grosse Eingriffe bei Adipositas; cost basis 2012) for the following CHOP-codes 44.31, 44.38, 44.39, 44.68, 44.69, 44.93, 44.95 and 44.96. For total direct costs of obesity in Switzerland, the costs of medication, dietary consultations, and surgery were aggregated.

2.3.2 Indirect costs

Several non-communicable disease conditions are associated with overweight and obesity and are therefore called comorbidities. They include, concentrating on the most important ones, type 2 diabetes, hypertension, coronary heart disease and stroke, osteoarthritis (knee and hip), cancer (3) and recently depression (4).

All data used for cost estimates related to comorbidities attributable to obesity, were extracted from current literature and/or official national statistics. The following 11 comorbidities of obesity were included in the cost estimate: hypertension, Type II (non-insulin-dependent) diabetes mellitus (NIDDM), stroke, coronary heart disease (CHD), breast cancer, colorectal cancer, gallstones, osteoarthritis, depression, and road traffic accidents due to sleep apnea and asthma. Additional comorbidities partly

attributable to obesity such as hypercholesterolemia, various cancers (colon, oesophagus, pancreas, stomach, liver, prostate, uterus), gout, oedemas or gastric reflux were not included because of low population attributable risks and/or missing cost data. To estimate the extent to which a disease and its management costs can be attributed to overweight and obesity the population attributable risks (PAR) was employed. We calculated the PAR based on odds ratios (OR) or the relative risk ratios (RR) for selected obesity related chronic diseases using the following equations:

$$PAR = \frac{p\,(OR - 1)}{p\,(OR - 1) + 1}$$

or

$$PAR = \frac{p\,(RR - 1)}{p\,(RR - 1) + 1}$$

PAR = population attributable risk, p = probability of being obese in a given population; OR = odds ratio for the specific chronic disease of an obese subject developing a disease and RR = relative risk ratio for the specific chronic disease of an obese subject developing a disease.

OR and RR for the various diseases were taken from recently published literature concentrating on specific, new, and evidence-based findings and generally favouring a conservative approach. It was assumed that the relationship between obesity and a given disease (obesity-linked comorbidity) is comparable among Western countries. The calculated PAR was then applied to annual total costs (direct and indirect costs) of the selected obesity-related diseases mentioned. Data about disease costs were also extracted from the most recently published literature using Swiss-specific cost data whenever available. Cost data were adjusted to the price level of 2011. This cost adaptation was made based on the consumer price (inflation) index (see Table 1) in the health care sector (Bundesamt für Statistik 2013).

Table 1 Development of health care costs in Switzerland – changes on a yearly basis in % (Bundesamt für Statistik 2013)

2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
4.0	4.0	3.5	2.0	1.4	4.6	5.4	4.4	2.5	3.3

http://www.bfs.admin.ch/bfs/portal/de/index/infothek/lexikon/lex/0.topic.1.html accessed 27.10.2013.

Where no Swiss cost data were available, data from industrial countries with comparable health care levels (predominantly from Germany) were substituted. Such cost data were adapted to Swiss conditions by using OECD purchasing power parities (PPPs) and by converting costs according to actual population numbers. PPPs are currency conversion rates that both convert to a common currency and equalise the

purchasing power of different currencies, i.e. the differences in price levels between countries in the process of conversion are being eliminated. Finally, costs were adjusted to price levels of 2011. Included in these total cost estimates of the various diseases were always direct as well as indirect costs. Estimates for both overweight and obesity were calculated separately.

3. Results

3.1 Prevalence of overweight and obesity in adults in Switzerland: evolution from 1992/93 to 2012

All estimates in this study are based upon prevalence data from the five surveys "Schweizerische Gesundheitsbefragung" carried out by the Federal office of statistics (Bundesamt für Statistik (BFS)) between 1992 and 2012. Overweight was defined as BMI (body mass index) 25 - 29.9 kg/m^2 and obesity as BMI ≥ 30 kg/m^2. It is known, however, that public polls have limitations because they are based on self-reported weight and height. On average, body weight is underestimated and body height overestimated (6).

A first survey (Schweizerische Gesundheitsbefragung 1992/93) conducted in 1992/93 involved 15'288 people (age ≥ 15) across Switzerland (representative random sample, quota of participants 71%) (7). Observed prevalence for obesity was 5.6%, for overweight 25.9% (Table 2).

Table 2 Schweizerische Gesundheitsbefragung 1992/93 (7)

	Overweight BMI 25 - 29.9		Obesity BMI ≥ 30	
Age	**Females**	**Males**	**Females**	**Males**
	%	**%**	**%**	**%**
15-24	6.1	11.8	0.7	1.1
25-34	9.4	26.0	2.4	3.8
35-44	13.7	34.5	4.3	5.3
45-54	19.0	41.7	5.4	8.8
55-64	27.8	48.7	8.7	10.7
>64	30.3	41.6	7.9	8.5
Total		***25.9***		***5.6***

The second survey (Schweizerische Gesundheitsbefragung 1997) was conducted in 1997 and involved 13'004 people (age ≥ 15) across Switzerland (representative random sample, quota of participants 69%) (8). The observed prevalence for obesity

was 7.0%, for overweight 28.5% (Table 3).

Table 3 Schweizerische Gesundheitsbefragung 1997 (8)

	Overweight BMI 25 - 29.9		Obesity BMI ≥ 30	
Age	**Females**	**Males**	**Females**	**Males**
	%	**%**	**%**	**%**
15-34	11.0	19.7	2.7	3.7
35-49	18.9	39.5	5.5	5.7
50-64	29.1	49.0	11.4	10.7
>64	32.1	44.2	11.2	9.7
Total		***28.5***		***7.0***

Five years later, in 2002, a third survey (Schweizerische Gesundheitsbefragung 2002) (9) was carried out involving 19'471 individuals (age ≥ 15) and living in private households. The results showed a prevalence of 7.7% for obesity and 29.4% for overweight in this randomly selected cohort of the Swiss population, yielding a total of 37.1% (Table 4).

Table 4 Schweizerische Gesundheitsbefragung 2002 (9)

	Overweight BMI 25 - 29.9		Obesity BMI ≥ 30	
Age	**Females**	**Males**	**Females**	**Males**
	%	**%**	**%**	**%**
15-24	5.4	12.7	2.6	1.6
25-34	15.0	32.4	4.3	4.5
35-44	18.6	39.2	6.2	6.8
45-54	22.0	46.1	9.3	11.9
55-64	30.8	46.3	10.5	12.0
65-74	37.5	47.2	11.9	12.0
>74	31.1	46.7	9.5	9.5
Total		***29.4***		***7.7***

The next public poll (Schweizerische Gesundheitsbefragung 2007) (10) was conducted in 2007 involving 18'760 individuals (10'336 females and 8'424 males (age ≥ 15), living in private households) and yielded the following results in a randomly selected cohort of the Swiss population: a prevalence of 8.1% for obesity and 29.2% for overweight, yielding a total of 37.3% (Table 5).

Table 5 Schweizerische Gesundheitsbefragung 2007 (10)

	Overweight BMI 25 - 29.9		Obesity BMI ≥ 30	
Age	**Females**	**Males**	**Females**	**Males**
	%	**%**	**%**	**%**
15-24	6.0	13.6	1.7	1.8
25-34	14.2	33.6	5.4	5.8
35-44	18.2	41.3	6.5	8.0
45-54	19.8	43.1	10.3	12.1
55-64	30.2	47.6	10.4	12.9
65-74	34.1	45.9	12.7	12.2
>74	33.8	48.1	9.6	8.5
Total		***29.2***		***8.1***

In 2012 the fifth Swiss health survey (Schweizerische Gesundheitsbefragung 2012) (11) was carried out involving 21'602 randomly selected individuals (age ≥ 15) living in private households. The poll showed a prevalence of 10.3% for obesity and one of 30.9% for overweight, resulting in a total of 41.2% of the total Swiss population having excess bodyweight (Table 6).

Table 6 Schweizerische Gesundheitsbefragung 2012 (11)

	Overweight BMI 25 - 29.9		Obesity BMI ≥ 30	
Age	**Females**	**Males**	**Females**	**Males**
	%	**%**	**%**	**%**
15-24	10.1	20.4	3.8	3.2
25-34	13.9	33.5	5.1	7.5
35-44	19.6	41.9	7.1	9.5
45-54	23.3	44.2	9.2	14.3
55-64	27.2	46.9	15.0	16.1
65-74	33.6	49.0	14.0	16.6
>74	34.9	39.4	13.1	12.3
Total		***30.9***		***10.3***

In absolute numbers, as shown in Table 7, a total of more than 2.8 Mio adult inhabitants of Switzerland have to be considered overweight using the presently accepted definition of having a BMI ≥ 25. This part of the population represents about 40% of the total Swiss population (from 15 years on up) in 2012. The number of overweight men (1.7 Mio) is considerably higher than the corresponding number of overweight women (1.1 Mio). Looking at the segment of the actually obese adult

Swiss (BMI ≥ 30), the difference between male and female inhabitants has narrowed as approximately 327'000 obese women compare to approximately 376'000 obese men.

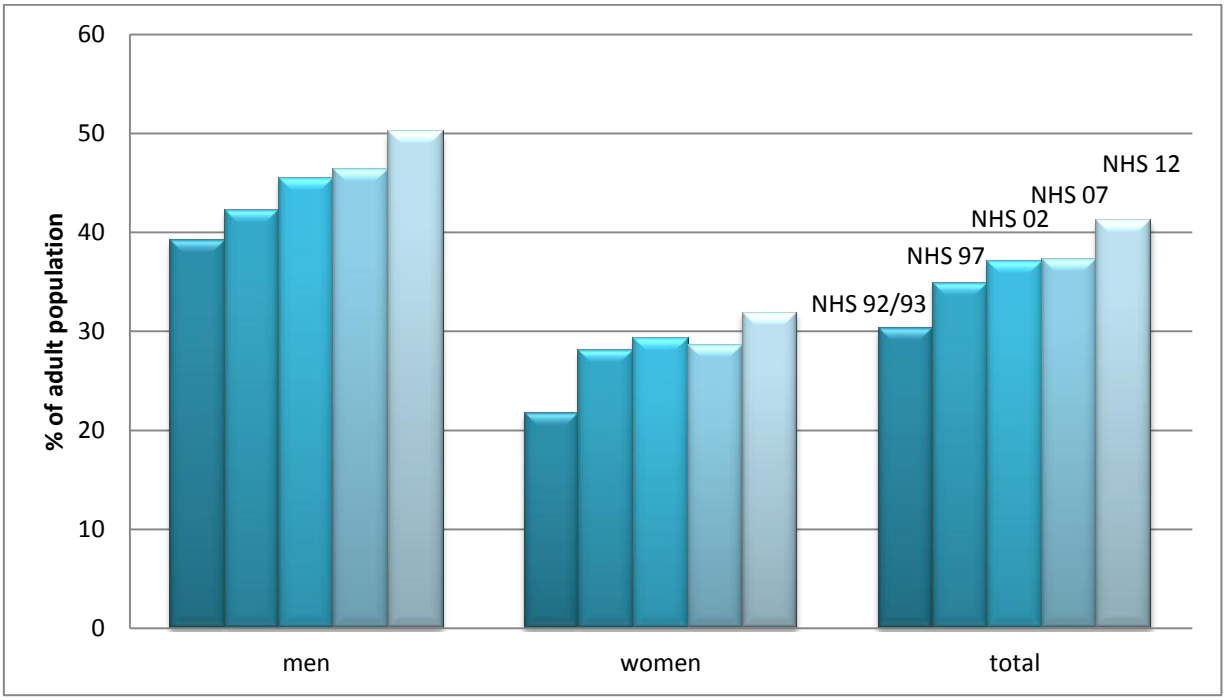
Table 7

Schweizerische Gesundheitsbefragung 2012 ***Bundesamt für Statistik, Standardtabellen (Auszug, 2013***

Age	Women						Men						Overall
	Population count	BMI 25-29.9 %	count	BMI >30 %	count	Total	Population count	BMI 25-29.9 %	count	BMI >30 %	count	Total	
15-24	442‘749	10.1	44718	3.8	16824	61542	457‘300	20.4	93289	3.2	14634	107923	169465
25-34	525‘748	13.9	73079	5.1	26813	99892	540‘999	33.5	181235	7.5	40575	221810	321702
35-44	572‘683	19.6	112246	7.1	40660	152906	574‘242	41.9	240607	9.5	54553	295160	448066
45-54	644‘890	23.3	150259	9.2	59330	209589	660‘782	44.2	292066	14.3	94492	386557	596146
55-64	483‘550	27.2	131525	15.0	72532	204058	485‘609	46.9	227751	16.1	78183	305934	509992
65-74	402‘989	33.6	135404	14.0	56418	191822	366‘197	49.0	179436	16.6	60789	240225	432057
>74	414‘908	34.9	144803	13.1	54353	199156	265‘623	39.4	104655	12.3	32672	137327	336483
Total	**3‘487‘517**		**792‘034**		**326‘930**	**1‘118‘964**	**3‘350‘751**		**1‘319‘038**		**375‘898**	**1‘694‘936**	**2'813‘911**

The development of overweight (BMI ≥ 25) over the period between 1992 and 2012 is depicted in Figure 1 and clearly shows that the part of the population suffering from overweight increased considerably (10%) over the last 20 years. This development occurred in both, the male as well as the female part of the Swiss population, although – in absolute numbers – the male portion with excess body weight is considerably larger with 1.7 Mio than the female portion with 1.1 Mio.

Figure 1: Development of overweight (BMI ≥ 25, age ≥ 15) prevalence in Switzerland from 1992 till 2012



3.2 Direct costs

Pharmacological therapy costs

Currently, there is only one drug registered on the Swiss market (Xenical®) for weight loss treatment. The costs for this compound are covered by health insurance for 6 months in the case of BMI of 35 kg/m² and above. In combination with diabetes costs for Xenical® are already covered as of a BMI of 27 kg/m².

Based on the total worldwide turnover of this compound, reported for 2011, of CHF 238 Mio (12), the Xenical® costs in Switzerland were estimated at a maximum of 10% of total turnover resulting in CHF 24 Mio.

Bariatric surgical therapy costs

In 2011 and 2012, based on the yearly Federal office of statistics (BFS) reports (13), surgical procedures used in bariatric surgery were distributed over 7 CHOP-codes as follows:

Table 8: CHOP-codes, description and number surgical procedures including bariatric surgery carried out in 2011 and 2012

		number of procedures	
CHOP-code	**Description**	**2011**	**2012**
44.31	Hoher Magen-Bypass (gastric bypass)	1240	625
44.38	Laparoskopische Gastroenterostomie (laparoscopic gastroenterostomy)	761	2121
44.39	Sonstige Gastroenterostomie (other gastroenterostomy)	101	123
44.68	Laparoskopische Gastroplastik (laparoscopic gastroplasty)	19	5
44.93	Einsetzen eines Magenballons (placement of intragastric balloon)	4	7
44.95	Laparoskopisch restriktive Magenoperation (laparoscopic restrictive stomach operation)	56	53
44.96	Laparaskopische Revision von restriktiven Magen-operationen (laparoscopic revision of a restrictive stomach operation)	50	64
Total		**2‘231**	**2‘998**

The above procedures were classified according to the Spitalplanungs-Leistungs-gruppen (SPLG) definitions of the Swiss Conference of Health Directors (Schweizer-ische Konferenz der Gesundheitsdirektorinnen und -direktoren (GDK)) into two DRGs, either into K04A (large bariatric operations with complex procedures {grosse Eingriffe bei Adipositas mit komplexem Eingriff}; procedure (Prozedur) K04-2: 44.68/ 44.93/ 44.95/ 44.96) with a costweight Cw=2.096 or K04B (large large bariatric operation without complex procedures {grosse Eingriffe bei Adipositas ohne komplexem Eingriff}; procedure (Prozedur) K04-1: 44.31/ 44.38/ 44.39) with a costweight Cw=1.910.

Calculations were based on a non-complicated patient without comorbidities and cost weight version Swiss DRG 1.0/2012. For Cw=1 a base rate of CHF 8’866 was applied.

Table 9: Cost estimate (K04A, large bariatric operation with complex procedures {grosse Eingriffe bei Adipositas mit komplexem Eingriff} / K04B, large bariatric operation without complex procedures {grosse Eingriffe bei Adipositas ohne komplexem Eingriff}) of bariatric surgical procedures carried out in 2012

CHOP-code	number of procedures	DRG	Costweight (Cw)	Costs per procedure	Total costs per CHOP code
44.31	625	K04B	1.910	16'934	10'583'750
44.38	2121	K04B	1.910	16'934	35'917'014
44.39	123	K04B	1.910	16'934	2'082'882
44.68	5	K04A	2.096	18'583	92'915
44.93	7	K04A	2.096	18'583	130'081
44.95	53	K04A	2.096	18'583	984'899
44.96	64	K04A	2.096	18'583	1'189'312
Total cost	**2'998**				**50'980'853**

Based on the specific bariatric procedures in 2012 reported by the Federal office of statistics (BFS) (13) the actual number of metabolic/bariatric operative procedures reached approximately 3000. Based on this number of procedures the estimated cost of bariatric surgery amounts to about CHF 50 Mio in 2012 as shown in Table 9.

The above cost estimate for bariatric surgery in Switzerland in 2012 represents a conservative estimate. The true costs may be considerably higher since many obese patients suffer from comorbidities and the risk for postoperative complications for such patients is increased.

Dietary counselling costs

The total number of dietary consultations in 2012 obtained from Santésuisse remained practically unchanged since 2006 at about 75'000. Assuming a similar proportion of overweight and obesity related consultations of approx. 50% as in 2006, the total number of primary consultations was estimated at approx. 7'500 and at approx. 30'000 follow up consultations. To estimate the annual costs for dietary consultations associated with overweight and obesity for 2012 (Table 10), the number of these consultations was multiplied with the monetary value according to the tariff contract between SVDE and Santésuisse dated 01.01.2002. This value is CHF 99.00 for a first consultation and CHF 77.00 for follow-up consultations.

Table 10: Costs for dietary counselling in relation with overweight and obesity in 2012

	Estimated number of consultations	Tariff (per consultation)	costs
Primary consultation	7'500	99	742'500
Follow-up consultation	30'000	77	2'310'000
Total costs			**3'052'500**

In conclusion, **direct treatment costs** for obesity in Switzerland were estimated at **CHF 77 million** for the year 2012. Included in this sum are drug costs of CHF 24 Mio, counselling costs (nutritionists) of CHF 3 Mio and costs for surgical interventions at a minimum of about CHF 50 Mio.

Compared to the cost estimate for **direct treatment costs** of overweight and obesity of CHF 47 Mio in 2006, the present cost estimate of CHF 77 Mio indicates an increase by ca. 60% for 2012. This cost increase is entirely caused by increased bariatric surgical procedures (from CHF 19 Mio in 2007 to CHF 50 Mio in 2012), whereas costs for weight loss medication and for dietary counselling remained unchanged.

3.3 Diseases (comorbidities) linked to overweight and obesity

In the following section we provide an update on the relationship between overweight and obesity and various diseases, as such links have been elucidated and confirmed in recent years.

The probabilities of a person of presently being overweight respectively obese in Switzerland, i.e. the relative risk ratios (RR) or the odds ratios (OR) of the presently known diseases linked to overweight and obesity and the corresponding population attributable risk (PAR) for Switzerland are shown in Table 11.

Table 11: Probabilities (p), risk ratios (RR), odds ratios (OR) and population attributable risks (PAR) for Switzerland for the most important diseases linked to overweight (BMI 25 - 29.9 kg / m2) and obesity (BMI $\geq$ 30 kg/m^2) in females (f) and males (m).

Obesity linked disease		p	RR	OR	Total PAR in %	Reference
Hypertension	f. & m. – overweight	0.309			**69.5**	**14**
	f. & m. – obese	0.103				
Hypercholesterolemia	female – overweight	0.226	1.10		**7.0**	**15**
	female – obese	0.093	0.90			
	male – overweight	0.393	1.30			
	male – obese	0.112	1.20			
Diabetes Typ 2 (NIDDM)	f. & m. – overweight	0.309			**59.5**	**14**
	f. & m. – obese	0.103				
Stroke	female – overweight	0.226		1.4	**34.5**	**16**
	female – obese	0.093		3.0		
	male – overweight	0.393		2.0		
	male – obese	0.112		2.8		
CHD („heart disease“)	female – overweight	0.226	1.56		**21.6**	**17**
	female – obese	0.093	2.48			
	male – overweight	0.393	1.61			
	male – obese	0.112	2.13			
Breast cancer	female - overweight *	0.226	1.12		**4.9**	**18**
	female - obese *	0.093	1.25			
Colorectal cancer	f. & m. – overweight	0.309		1.21	**9.3**	**19**
	f. & m. – obese	0.103		1.32		
Colon cancer	female – overweight	0.226	1.09		**7.6**	**18**
	female – obese	0.093	1.06			
	male – overweight	0.393	1.19			
	male – obese	0.112	1.55			
Rectum cancer	male – overweight	0.393	1.09		**5.5**	**20**
	male – obese	0.112	1.19			
Oesophageal adenocarcinoma	female – overweight	0.226	1.59		**32.0**	**21**
	female – obese	0.093	2.17			
	male – overweight	0.393	2.13			
	male – obese	0.112	2.17			

Obesity linked disease		p	RR	OR	Total PAR in %	Refe-rence
Pancreatic cancer	female – overweight	0.226	1.12		**4.6**	**18**
	female – obese	0.093	1.25			
	male – overweight	0.393	1.07			
	male – obese	0.112	1.14			
Liver cancer	male – overweight	0.393	1.09		**5.5**	**18**
	male – obese	0.112	1.19			
Gall bladder cancer	female – overweight	0.226	1.59		**14.9**	**18**
	female – obese	0.093	2.53			
	male – overweight	0.393	1.09			
	male – obese	0.112	1.19			
Prostate cancer	male – overweight	0.393	1.03		**1.9**	**18**
	male – obese	0.112	1.06			
Renal cancer	female – overweight	0.226	1.34		**14.2**	**18**
	female – obese	0.093	1.8			
	male – overweight	0.393	1.24			
	male – obese	0.112	1.54			
Non-Hodgkin‘s lymphoma	female – overweight	0.226	1.07		**3.2**	**18**
	female – obese	0.093	1.14			
	male – overweight	0.393	1.06			
	male – obese	0.112	1.12			
Leukaemia	female – overweight	0.226	1.17		**6.0**	**18**
	female – obese	0.093	1.37			
	male – overweight	0.393	1.08			
	male – obese	0.112	1.17			
„Multiple myeloma“	female – overweight	0.226	1.11		**5.0**	**18**
	female – obese	0.093	1.23			
	male – overweight	0.393	1.11			
	male – obese	0.112	1.23			
Endometrial cancer	fem. – overweight *	0.226	1.59		**24.2**	**18**
	female – obese *	0.093	2.53			
Ovarian cancer	fem. – overweight *	0.226	1.03		**1.2**	**18**
	female – obese *	0.093	1.06			
Thyroid cancer	female – overweight	0.226	1.14		**12.6**	**18**
	female – obese	0.093	1.3			

Obesity linked disease		p	RR	OR	Total PAR in %	Refe-rence
	male – overweight	0.393	1.33			
	male – obese	0.112	1.77			
Thromboembolism	female – overweight	0.226		**1.9**	**23.5**	**22**
	female – obese	0.093		**2.5**		
	male – overweight	0.393		**1.3**		
	male – obese	0.112		**1.7**		
Osteoarthritis-hip	female – overweight	0.226		**1.2**	**10.0**	**23**
	female – obese	0.093		**1.4**		
	male – overweight	0.393		**1.1**		
	male – obese	0.112		**1.8**		
Osteoarthritis-knee	female – overweight	0.226		**2.09**	**50.2**	**24**
	female – obese	0.093		**4.26**		
	male – overweight	0.393		**2.21**		
	male – obese	0.112		**4.00**		
Depression	female – overweight	0.226		**0.98**	**13.2**	**4**
	female – obese	0.093		**1.67**		
	male – overweight	0.393		**1.30**		
	male – obese	0.112		**1.31**		
Sleep apnea	female – overweight	0.226		**1.87**	**42.4**	**25**
	female – obese	0.093		**4.17**		
	male – overweight	0.393		**1.74**		
	male – obese	0.112		**3.69**		
Gallstones	f. & m. – overweight	0.309		**1.86**	**40.7**	**26**
	f. & m. – obese	0.103		**3.38**		
Gout	male – overweight	0.393	1.95		**40.2**	**27**
	male – obese	0.112	2.33			
PCOS	female – overweight	0.226	1.16		**7.9**	**28**
	female – obese	0.093	1.50			
Misscarriage	female – overweight	0.226		**1.11**	**5.2**	**29**
	female – obese	0.093		**1.31**		
Asthma	f. & m. – overweight	0.309		**1.83**	**37.8**	**30**
	f. & m. – obese	0.103		**3.04**		

* only postmenopausal women (age ≥ 50 years)

Relative risks for the various diseases were taken from recently published literature concentrating specifically on new, evidence-based findings and generally favouring a conservative approach. We were particularly interested in evidence linking obesity with a given comorbidity, which was based on a meta-analysis of a substantial number of prospective observational studies. In the study of Renehan et al (25), for example, 221 datasets including 282'137 cases of cancer were analysed to investigate whether BMI is associated with cancer risk. As can be seen in Table 11 above, overweight and obesity were strongly associated with the occurrence of certain cancers types such as oesophageal adenocarcinoma or renal cancer in both genders, others such as thyroid and colon cancer were strongly linked to BMI increases in men, whereas gallbladder cancer was strongly linked to increased BMI in women.

With respect to our previous report, a thorough literature search revealed the following new publications describing recent findings regarding risk of excess weight on obesity-linked comorbidities:

The association of increased BMI levels in men and women with oesophageal adenocarcinoma was confirmed by a recent meta-analysis, published in 2013, evaluating 22 studies (80). A new systematic review and meta-analysis covering 23 studies involving more than 168’000 participants corroborated the significant link of higher BMI categories with the prevalence of colorectal cancer revealing a dose response (78).

The contribution of overweight and obesity to the prevalence of the cardiovascular risk factors hypertension and type 2 diabetes were assessed in a recently published Swiss study using measured data from a population of over 6000 subjects from Lausanne (71) resulting in Swiss population-specific PARs.

As published in 2010, the risk of CHD associated with excess weight among men and women with and without comorbid conditions were assessed prospectively over a 16-year period (76) demonstrating that more than a third of the incident CHD may be attributable to increased BMI categories.

Depression, included – for the first time – in our previous report (5) as comorbidity to obesity in both, men and women, emerged in the meantime as firmly linked to a BMI increase in adults (4), suggesting a strong correlation between overweight and obesity with having major depressive symptoms.

The association of higher BMI levels with the incidence of severe knee osteoarthritis was again confirmed through a recent meta-analysis of 47 observational studies (446’219 subjects) (77). This study found a 2 to 4-fold increased risk in development of knee osteoarthritis in overweight and obese individuals, and relationship was dose dependent.

Finally, it was assumed that the relationship between overweight and obesity and a given comorbidity is comparable in European countries and therefore applicable to Switzerland. Table 12 shows the population attributable risks (PAR) for overweight and obesity-linked comorbidities separated according to BMI 25-29.9 and BMI > 25 in Switzerland.

Table 12 Population attributable risks (PAR) for Switzerland for the most important diseases according to overweight and obesity (in %)

	PAR for BMI 25-29.9	PAR for BMI >30
Hypertension	35.9	33.7
Hypercholesterolemia (Dyslipidemia)	6.4	0.6
Diabetes type 2 (NIDDM)	15.9	43.6
Stroke	18.3	16.2
CVD („heart disease“)	10.2	11.5
Breast cancer	2.6	2.3
Colorectal cancer	6.1	3.2
Colon cancer	4.5	3.2
Rectum cancer	3.4	2.1
Oesophageal adenocarcinoma	21.3	10.3
Pancratic cancer	2.7	1.9
Liver cancer	3.4	2.1
Gall bladder cancer	7.6	7.3
Prostate cancer	1.2	0.7
Renal cancer	7.9	6.3
Non-Hodgkin's lymphoma	1.9	1.3
Leukaemia	3.4	2.6
"Multiple myeloma"	3.3	2.3
Endometrial cancer	11.8	12.5
Ovarian cancer	0.7	0.8
Thyroid cancer	7.3	5.3
Thromboembolism	13.7	9.8
Osteoarthritis-hip	4.1	5.9
Osteoarthritis-knee	26.0	24.2
Depression	10.2	3.0
Sleep apnea	19.5	23.0
Gallstones	21.0	19.7
Gout	27.2	13.0
PCOS	3.5	4.4
Miscarriage	2.4	2.8
Asthma	20.4	17.4

Of the Swiss overweight and obese population about 38% are expected to suffer from sleep apnoea (AHI > 15) according to Young et al (81). This corresponds to approx. 1 Mio persons. In Switzerland 74.4% of all women above 18 years of age and 87.8% of the male population had a driver´s licence in 2010 (Federal office of statistics (BFS); Mikrozensus Mobilität und Verkehr 2010). Assuming a similar proportion of driver licences in the overweight population with sleep apnoea as in the entire Swiss population in 2012, then the number of drivers (males and females) with BMI >25 and suffering from sleep apnoea amounts to approximately 880´000 resulting in a prevalence of 0.129.

Based on a study by Teran-Santos et al (31) a strong association between sleep apnoea (as determined by AHI) and the risk of traffic accidents exists. They describe an odds ratio of 5.8 (unadjusted) for being involved in a traffic accident when suffering from sleep apnoea. Using the above prevalence of 0.129 the PAR for traffic accidents caused by drivers with BMI > 25 suffering from sleep apnoea is estimated at 38.2% as shown in Table 13.

Table 13 Probability, odds ratio and population attributable risk for traffic accidents due to sleep apnoea in drivers with BMI >25

		p	OR	Total PAR in %
Sleep apnoea related traffic accidents	male/female BMI >25	0.129	5.8	**38.2**

3.4 Cost of diseases linked to overweight and obesity

All data used for cost estimates related to comorbidities attributable to obesity, were extracted from current literature and official national statistics. The following complications of obesity were included in the analysis: hypertension; non-insulin-dependent diabetes mellitus (NIDDM); stroke; coronary heart disease (CHD, colorectal cancer; gallstones (gall bladder disease); osteoarthritis (knee and hip); depression; gout; road traffic accidents (due to sleep apnoea); and asthma. Additional comorbidities partly attributable to obesity, some of them with high relative risk or odds ratios, such as many cancer types, thromboembolism, gout, poly cystic ovary syndrome (PCOS) were not included because of missing cost data.

To estimate the extent to which a disease and its management costs can be attributed to overweight and obesity the *population attributable risk* (PAR) will be employed. PAR includes the relative risk of obese persons of developing a disease as well as the prevalence of obesity in the population and yields the percentage of patients with a given comorbidity that is attributable directly to overweight and obesity.

The calculated PAR was applied to annual total costs (direct and indirect costs) of the above mentioned obesity-related diseases.

Information about disease costs were also extracted from existing literature using Swiss-specific cost data whenever available. With respect to our previous analysis, one new Swiss cost study was identified. A recently published (2013) new cost study on depression, which was based on retrospectively evaluating the medical resource utilization of 556 patients with depression, was substituted for the previously used cost data. Where no Swiss cost data were available, data from Germany - with one exception, i.e. gall bladder disease (US cost data) –, having a comparable health care level, were employed.

Table 14a shows the total (total where available and direct) disease costs (in Mio) and their adaptation to Swiss conditions for the year 2011.

Table 14b shows the direct disease costs (in Mio) and their adaptation to Swiss conditions for the year 2011.

Table 14a: Total (direct and indirect) costs (in Mio) of diseases linked to obesity and their adaptation to Swiss conditions for 2011 (PPP = Purchasing Power Parity)

	Ref.	Country	type of cost	cost year	currency	cost in €	PPP€→CHF	cost in CHF	exchange rate**	population adjusted cost	2011 cost in CHF
Hypertension	**32**	**D**	**direct**	**2002**	**€**	**8'100**	**1.77**	**14´337**		**1345**	**1933**
Diabetes (NIDDM)	**33**	**CH**	**total**	**2000**	**CHF**			**1644**		**1815**	**2563**
Stroke	**34**	**CH**	**total**	**2004**	**€**	**304**			**1.544**	**504**	**657**
Coronary heart disease*	**35**	**CH**	**total**	**1993**	**CHF**			**2163**		**2469**	**3779**
Breast cancer	**36**	**CH**	**direct**	**2006**	**CHF**					**164**	**202**
Colorectal cancer	**37**	**D**	**direct**	**2002**	**€**	**1558**	**1.77**	**2758**		**266**	**375**
Gallstones	**38**	**US**	**direct**	**1998**	**US$**	**5´800**	**1.88**	**10´904**		**321**	**461**
Osteoarthritis (knee & hip)	**39**	**D**	**total**	**2002**	**€**	**11´828**	**1.77**	**20´935**		**2118**	**2989**
Depression	**40**	**CH**	**total**	**2007/08**	**€**	**8‘200**			**1.362**	**11535**	**13439**
Traffic accidents (sleep apnea)	**41**	**CH**	**direct**	**2011**	**CHF**			**264**		**264**	**264**
Asthma	**42**	**CH**	**total**	**1997**	**CHF**			**1252**		**1326**	**2013**

* costs given in US$, converted to CHF with 1993 exchange course of 1.478

** Source: Schweiz. Nationalbank: Devisenkurse in der Schweiz; http//www.bfs.admin

country	year	population
CH	1993	6.968.570
CH	1997	7.096.465
CH	1998	7.123.537
CH	2000	7.204.055
CH	2002	7.313.853
CH	2004	7.415.102
CH	2006	7.508.739
CH	2008	7.701.856
CH	2011	7.954.662

country	Year	population
D	2002	82.536.680
USA	1998	270.300.000

Table 14b: Direct costs (in Mio) of diseases linked to obesity and their adaptation to Swiss conditions for 2011 (PPP = Purchasing Power Parity)

	Ref.	Country	Cost type	cost year	Curr.	cost in €	PPP€→CHF	cost in CHF	exchange rate**	population adjusted cost§	2011 cost in CHF
Hypertension	**32**	**D**	**direct**	**2002**	**€**	**8'100**	**1.77**	**14´337**		**1345**	**1933**
Diabetes (NIDDM)	**33**	**CH**	**direct**	**2000**	**CHF**					**932**	**1315**
Stroke	**34**	**CH**	**total**	**2004**	**€**	**304**			**1.544**	**504**	**657**
Coronary heart disease*	**35**	**CH**	**direct**	**1993**	**CHF**			**1020**		**1164**	**1642**
Breast cancer	**36**	**CH**	**direct**	**2006**	**CHF**					**164**	**202**
Colorectal cancer	**37**	**D**	**direct**	**2002**	**€**	**1558**	**1.77**	**2758**		**266**	**375**
Gallstones	**38**	**US**	**direct**	**1998**	**US$**	**5´800**	**1.88**	**10´904**		**321**	**461**
Osteoarthritis (knee & hip)	**39**	**D**	**direct**	**2002**	**€**	**7´188**	**1.77**	**12´723**		**1194**	**1686**
Depression	**40**	**CH**	**direct**	**2007/08**	**€**	**3‘800**			**1.362**	**5345**	**6110**
Traffic accidents (sleep apnea)	**41**	**CH**	**direct**	**2011**	**CHF**			**264**		**264**	**264**
Asthma	**42**	**CH**	**direct**	**1997**	**CHF**			**762**		**870**	**1227**

* costs given in US$, converted to CHF with 1993 exchange course of 1.478
** Source: Schweiz. Nationalbank: Devisenkurse in der Schweiz; http//www.bfs.admin

country	year	population	country	year	population
CH	1993	6.968.570	D	2002	82.536.680
CH	1997	7.096.465	USA	1998	270.300.000
CH	1998	7.123.537			
CH	2000	7.204.055			
CH	2002	7.313.853			
CH	2004	7.415.102			
CH	2006	7.508.739			
CH	2008	7.701.856			
CH	2011	7.954.662			

Table 15a Attributable fraction of the total (direct and indirect) costs of (overweight and obesity-linked) disease in 2011

Disease	total disease costs (Mio CHF)	PAR in %		PAR based costs (Mio CHF)		
		BMI 25-30	BMI >30	BMI 25-30	BMI >30	attributable total costs BMI ≥25
Hypertension	**1933**	17.9	16.8	346	325	**673**
Diabetes (NIDDM)	**2563**	15,9	43.6	408	1‘117	**1‘525**
Stroke	**657**	18.3	16.2	120	106	**227**
Coronary heart disease	**3779**	10.2	11.5	385	435	**820**
Breast cancer	**202**	2.6	2.3	5	5	**10**
Colorectal cancer	**375**	6.1	3.2	23	12	**35**
Gallstones	**461**	21	19.7	97	91	**188**
Osteoarthritis (knee & hip)	**2989**	30.1	30.1	900	900	**1‘799**
Depression	**13439**	10.2	3.0	1371	403	**1‘774**
Traffic accidents	**264**		38.2*			**101**
Asthma	**2013**	20.4	17.4	411	350	**761**
Total costs of comorbidities (Mio CHF)				4‘066	3‘744	**7‘913**

*BMI >25

Table 15b Attributable fraction of the direct costs of (overweight and obesity-linked) comorbidities in 2011

Disease	direct disease costs (Mio CHF)	PAR in %		PAR based costs (Mio CHF)		
		BMI 25-30	BMI >30	BMI 25-30	BMI >30	Attributable direct costs BMI ≥25
Hypertension	**1933**	17.9	16.8	346	325	**673**
Diabetes (NIDDM)	**1315**	15,9	43.6	209	573	**782**
Stroke	**657**	18.3	16.2	120	106	**227**
Coronary heart disease	**1642**	10.2	11.5	167	189	**356**
Breast cancer	**202**	2.6	2.3	5	5	**10**
Colorectal cancer	**375**	6.1	3.2	23	12	**35**
Gallstones	**461**	21	19.7	97	91	**188**
Osteoarthritis (knee & hip)	**1686**	30.1	30.1	507	507	**1‘015**
Depression	**6110**	10.2	3.0	623	183	**807**
Traffic accidents	**264**		38.2*			**101**
Asthma	**1227**	20.4	17.4	250	213	**464**
Direct costs of comorbidities (Mio CHF)				2‘347	2‘204	**4‘658**

*BMI >25

3.5 Total costs

Direct treatment costs for obesity in Switzerland were estimated at CHF 77 Mio for the year 2011. Included in this sum are drug costs of CHF 24 million, counselling costs (nutritionists) of CHF 3 Mio and costs for surgical interventions (minimum) of CHF 50 Mio (Table 9).

The total costs, direct and indirect (caused by comorbidities) attributable to overweight and obesity for the year 2011 are given in Tables 15a and 15b. Of the total costs of about CHF 8 Bio, a bit more than half can be assigned to overweight (CHF 4'066 Mio), the rest to obesity (CHF 3'744 Mio). The direct treatment costs for obesity represent about 1% of the total cost estimate (direct and indirect costs for comorbidities) for the burden of overweight and obesity in Switzerland. When taking into account the direct comorbidity costs exclusively, then the actual direct treatment costs for overweight and obesity amount to 1.7% of total costs. Thus, in either case, the majority of the total costs (approx. 98%) are caused by comorbidities associated with overweight and obesity.

Table 16 Total costs of treatment of overweight and obesity as well as direct and indirect costs of obesity linked comorbidities

	Costs in CHF (Mio)
Direct costs:	
Medication	24
Bariatric surgery	50
Dietary councelling	3
Costs of comorbidities:	
Attributable costs	
- total (direct and indirect) costs of comorbidities	7'913
- direct costs of comorbidities only	4'658
Total costs of overweight and obesity:	
- direct and indirect (total costs of comorbidities) costs	**7´990**
- direct costs (incl. direct costs of comorbidities) only	**4'735**

For the comorbidities, the direct costs accounted for approx. 57% of the total costs, and the indirect costs for approx. 43%.

As the prevalence of overweight is much higher than the one of obesity (2.1 Mio vs 0.7 Mio persons) the per person costs are considerably higher for obesity (approx. CHF 9'250 vs CHF 3'200) taking into account the direct and indirect costs of the comorbidities. In case of the direct comorbidity costs only, the per person cost are 3-times higher (approx. CHF 5'300 vs CHF 1'800) for the obese than for overweight people.

Since the total healthcare expenses in Switzerland did amount to CHF 64.6 Bio in 2011 (Federal office of statistics (BFS) 2013), approx. 7% (direct costs only) of these

expenses were spent on the treatment of overweight and obesity-related comorbidities. In 2006, an identical percentage (7%) of total direct overweight and obesity-linked obesity cost had been determined compared to the total Swiss healthcare expenses at that time.

3.6 Sensitivity analysis

The above estimate regarding the cost of overweight and obesity in Switzerland is, like many other cost evaluations, based on input data subject to uncertainties or variations of unknown magnitude. With the following sensitivity analysis we attempted to incorporate possible influences of given uncertainties into the final numbers provided in this report and to discuss possible effects of unknown variations.

3.6.1 Direct treatment costs

Since the direct treatment costs represent approximately 1% of the total overweight and obesity related costs, even a doubling or tripling of the direct treatment costs would not substantially change the overall costs.

3.6.2 Costs related to comorbidities

Prevalence of overweight and obesity in Switzerland

The most sensitive parameter in the PAR formula is represented by the prevalence (p) values for overweight and obesity in Switzerland. These prevalence values are based on the results of the “Schweizerische Gesundheitsbefragung 2012” of the adult Swiss population. The prevalence data from the five available Health Surveys, conducted by telephone, from 1992/3, 1997, 2002, 2007 and 2012 show a remarkably consistent development as shown in chapter 3.1. Based on these data there is little uncertainty about the actual prevalence value for 2012. It is known, however, that public polls have limitations because they are based on self-reported weight and height. On average, body weight is underestimated and body height overestimated (6).

3.6.3 Relative risk ratios or odds ratios for comorbidities

The relative risks of developing various obesity-related diseases in the published literature show wide variability. To minimize publication-based uncertainties we preferably employed evidence linking obesity with given comorbidities, which were based on a meta-analysis of a substantial number of prospective observational studies such as depression (4), cancer (18, 19), osteoarthritis (24) or of large cohort studies of CHD (17).

For the same purpose we also used approaches such as ongoing longitudinal cohort investigations of more than 50´000 subjects with over 10 years of follow-up resulting in very reliable relative risk ratio between body weight increase and the incidence of a cost-intensive disease such as depression (4).

Depression represents one the most costly comorbidity of overweight and obesity (Table 14a & b). Any change in the relative risk of developing a depressive disease might therefore affect total costs associated with overweight and obesity. For example, the association between obesity and depression is more pronounced among Americans than among Europeans (4). Thus, using US prevalence rates instead of European ones would result in a too high cost estimate.

3.6.4 Costs of comorbidities (COI)

Cost estimates not only rely heavily on accurate prevalence, but also on adequate costing measures. In our cost assessment we have to rely on sensitivity analyses provided by the authors of the original burden of illness analysis for a given comorbidity. In our analysis five comorbidities (diabetes mellitus, coronary heart disease, osteoarthritis, depression and asthma) are responsible for approx. 80% of the total direct overweight and obesity related costs. Therefore, we checked the original publications for provision of a basic sensitivity analysis on their specific cost estimate. Unfortunately, for the direct medical cost of diabetes type 2 (33), for the direct osteoarthritis costs (39) as well as for the direct asthma costs (42), no sensitivity analysis was provided. In such cases we assume a cost variation of ± 10%. For coronary heart disease (CHD) (35), a hypothetical increase in patient numbers by 10% translated into a 10% increase in direct inpatients cost resulting in an actual cost increase by CHF 36 Mio translating into an increase in total direct obesity related costs in Switzerland (CHF 4'735 Mio) of less than 1%. In the case of depression, hospitalization costs were identified as the most sensitive cost driver, i.e. an increase in hospitalization expenses by 20% is estimated to result in increasing total cost of depression by 7%. Transferring this increase in depression costs increases the total direct obesity-linked comorbidity costs by about CHF 60 Mio or 1-2%.

In conclusion, based on the above sensitivity analysis and other unknown variations, we estimate that the total direct costs of the five most important overweight and obesity associated comorbidities lay somewhere between CHF 4'400 and 5´000 Mio representing between 7 and 8% of the total health care expenses in Switzerland in 2011.

4. Discussion

Between 1992 and 2012 a rapid and significant increase in the prevalence of overweight (BMI >25) in the adult Swiss population (> age 15 years) of 11.1%, from 30.3% to 41.2%, was observed with a predominant increase in the proportion of overweight individuals with BMI 25-30 by 6% (from 24.9% to 30.9%) and a concomitant doubling of the obese population by 4.8% (from 5.4% to 10.3%).

In other European countries the rate of obesity has doubled as well over the past 20 years, regardless of previous levels as reported by the most recently published report of the *Organisation for Economic Co-operation and Development (OECD)* (2). Obesity in 2010 is close to twice the rate of 1990 in both France and the United Kingdom, even though the rate in France (12.9%) is currently half that of the United Kingdom (26.1%). In Holland, another mid-European country, the obesity prevalence increased in a comparable fashion to Switzerland by 5.3% in the past 20 years, from 6.1% to 11.4%, whereas in the two Northern countries Sweden and Denmark the comparable increase in the obese population amounted to 7.4% and 7.9%, respectively, from 5.5% in both countries to 12.9% in Sweden and 13.4% in Denmark. Moreover, the prevalence of obesity as defined by BMI >30 has surpassed the 15% population mark in many European countries (Portugal, Cyprus, Finland, Spain, Estonia, Latvia, Slovak Republic, Czech Republic, Lithuania, Luxembourg, Malta, Ireland, UK and Hungary).

Evidence from a number of European countries, including Austria, England, France, Italy and Spain, indicates that obesity tends to be more common in disadvantaged socio-economic groups, and especially among women (43). There is also a relationship between the number of years of education and obesity, with the most educated individuals displaying lower rates. Similar findings have been reported recently for Switzerland (44).

Besides the social inequalities of obesity, the association of overweight and obesity with major chronic diseases such as hypertension, coronary heart disease, diabetes type 2 and depression are well established (4, 14-17).

In our first report on the burden of overweight and obesity in Switzerland (45), 26 diseases were identified as overweight and obesity related comorbidities. In the previous study this number was slightly increased to 32 diseases indicating that more and more information on the relationship between obesity and yet other diseases were reported by the year. In the present study the number of obesity-related comorbidities was reduced by one since kidney disease was demonstrated to not being linked to an increased BMI (46).

The relative risks of developing various obesity-related diseases show wide variability in the published literature. Cost estimates not only rely heavily on accurate prevalence, but on accurate relative risk ratios or odds ratios for comorbidities as well as on adequate costing measures. For in depth the discussion of these aspects we are referring to our sensitivity analysis above.

In 2004 costs were assigned to 18 diseases considered as comorbidities clearly associated with obesity (45). In 2009, in the second study (5), a smaller number of comorbidities, i.e. 12 obesity-linked, cost-relevant diseases were identified for Switzerland. In our present assessment in 2014, the number of cost-relevant comorbidities was reduced further by one (elimination of kidney disease) to a total of 11 comorbidities. Irrespective of these restrictions in cost-relevant diseases, the total disease costs related to overweight and obesity increased threefold from CHF 2´648 (cost basis 2001), to CHF 5´755 Mio (cost basis 2006) to CHF 7'990 Mio (cost basis 2011) in the time period from 2002 till 2012. For the cost estimate reported in 2004 (45), four diseases contributed to a large part (89%) to the final result: diabetes mellitus type 2 (54%), coronary heart disease (16%), hypertension (10%), and depression (9%). Depression, based on findings of a lower attributable risk with overweight and obesity as previously anticipated, and hypertension did drop out of the top four cost-relevant diseases in the 2009 study (5) and were replaced by osteoarthritis (knee & hip) and asthma. These four diseases amounted to a total sum of CHF 4´548 Mio representing 79% of the total obesity-attributable costs. In the present study, the four most costly comorbidities were osteoarthritis (knee & hip) (23%), depression (22%), diabetes mellitus type 2 (19%) and coronary heart disease (10%), amounting to CHF Mio, i.e. 75% of the total costs of obesity-linked comorbidities of CHF 7'913.

In contrast to our first study (45) where costs estimates of only three of the comorbidities were based on actual Swiss data, the 2009 cost evaluation (9) did rely on seven Swiss based cost estimates, three of them (diabetes type 2, coronary heart disease and asthma) belonging to the top four with regard to cost relevance. In the present study, cost estimates of seven of the total 11 cost-relevant comorbidities were based on Swiss cost data with three of them – depression, diabetes mellitus type 2 and coronary heart disease – being part of the four most costly comorbidities.

The attributable fraction of the direct overweight- and obesity-linked disease costs of CHF 3´830 Mio in the year 2007 represented about 7.3% of the total healthcare expenses in Switzerland of CHF 52.7 billions in 2006 (Federal office of statistics (BFS) 2007). In 2012, the attributable fraction of the direct overweight- and obesity-linked disease costs of CHF 4´658 Mio represent 7.2% of the total Swiss healthcare expenses of 64.6 billions (Federal office of statistics (BFS) 2013) in 2011 remaining practically unchanged with respect to our previous assessment. The total obesity-linked direct costs of CHF 2'204 Mio represent 3.4% of these overall Swiss healthcare costs. For comparison, in Germany, obesity was reported to result in 4´854 Mio EUR in direct costs corresponding to 2.1% of the overall German health expenditures in 2002 (47). Total direct costs attributable to overweight and obesity in Canada were $ 6.0 billion in 2006, with 66% attributable to obesity (48). This corresponds to 4.1% of the total health expenditures in Canada in 2006. Using also a prevalence-based approach to costing in New Zealand health care costs attributable to overweight and obesity were estimated to be NZ$ 686 Mio or 4.5% of New Zealand's total health care expenditure in 2006 (49).

The exclusively obesity-linked costs (direct comorbidity costs only) of CHF 2'204 Mio represent about 0.38% of the national gross domestic product (GDP) of CHF 585.1 billions in 2011 (Federal office of statistics (BFS) 2013), a basically identical percentage when compared to the situation in 2006, i.e. exclusively obesity-linked

costs (direct comorbidity costs only) of CHF 1'866 Mio representing about 0.37% of the national gross domestic product (GDP) of CHF 508 billions in 2006. According to a study published in 2008 on the health-economic burden of obesity in Europe (50), the estimated obesity related costs range from 0.09 to 0.61% of the total annual gross domestic income in Western European countries indicating that the economic costs of obesity in Switzerland are comparable to estimates from other European countries.

Our study has certain limitations. One problem is represented by the double or triple accounting of certain comorbidity costs. For example, diabetics quite often suffer also from hypertension as well as coronary heart disease. Thus, the expenses of treating hypertension and/coronary heart disease besides the high blood glucose are an integral part of diabetic treatment cost. For this reason, it is most likely, that such costs are double or triple counted in the context of comorbidities with multimorbid chronic conditions such as coronary heart disease and diabetes. As a consequence, the actual estimate of the costs linked to overweight and obesity, based on the approach described in this report may be somewhat overestimated.
As mentioned earlier, based on in the available literature, the relative risks of developing various obesity-related comorbidities show substantial variability. Consequently, any change in the relative risk of developing a certain comorbidity affects total costs associated with overweight and obesity. In addition, despite our efforts to identify costs of obesity-linked comorbidities based on Swiss estimates, it was only possible to provide Swiss-based data on seven comorbidities out of the eleven diseases considered to be cost-relevant. Three cost estimates of comorbidities were based on German data and for one disease (gallstones) US data were used for a corresponding cost estimate. Furthermore, direct as well as indirect costs represent an underestimation of the true costs for the Swiss society since obesity and obesity-linked comorbidities are cause for additional problems such as increased postoperative complications, prolonged rehabilitation periods, increased incidence of invalidity and unemployment, which are all not taken into account in this report.

In summary, in 2012 over 40% of the adult Swiss population (age >15 years) were either overweight (30.9%) or obese (10.3%) with a BMI > 25. More than 10% (11.2% of the males, 9.3% of the female population) were considered obese (BMI > 30). In 2002 a prevalence of 7.7% for obesity and 29.4% for overweight was observed in a randomly selected cohort of the Swiss population, yielding a total of 37.1%. Within a decade, the obese portion of the Swiss population increased by 25% from 7.7% to 10.3%.

From the societal point of view, the estimate of the total economic burden for overweight and obesity and associated comorbidities has exactly tripled over the past ten years from CHF 2´648 Mio (cost basis 2001) in 2002 to CHF 5´755 Mio (cost basis 2006) in 2007, to CHF 7'990 Mio (cost basis 2011) in 2012. The contribution of overweight and obesity to these costs are approximately equal.

In conclusion, overweight and obesity continue to represent a considerable financial burden for the Swiss health care system and the Swiss society as a whole. However, the development of this financial burden has been in line with the general increase in health care costs over the past five years – between 7 and 8% of total Swiss health

care costs in 2007 as well as 2012 - and is expected to remain this way in the years to come, provided no unexpected increase occurs in the prevalence of overweight and obesity in the near future.

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PART 2: STATISTICAL EVALUATION

1. Effect of chronic diseases (General linear regression model with BMI vs. various chronic diseases) - Statistical evaluation of data from the Swiss Health Survey 2012

Method

BMI was used as the dependent variable, more exactly, the logarithm of the BMI value, since the distribution of the BMI value is not perfectly normal but is rather logarithmic. A set of arbitrarily selected variables from all questions concerning chronic diseases were used as covariables or factors. Since these covariables are either continuous or categorical, a general linear regression analysis (GLM) model was used starting with all covariables and stepwise elimination of the covariable with the highest p-value until only covariables with significant p-values ($p<0.05$) were left in the model. Covariables like AGE or SEX where not eliminated even if their p-value was above 0.05. Since this is a very rough analysis of possible correlation between BMI and indicators of chronic diseases, no weighting of the population was used.

First, we analysed the whole population of participants (M&F all) and then the male (M all) and female (F all) population separately, and finally the population excluding young adults (M&F > 25).

(For each of the 5 models presented in this report, a separate technical statistical report with detailed results of the stepwise regression method has been delivered.)

Covariables related to Chronic Diseases

The covariables identified as related to chronic diseases are listed in Table 1.

Table 1

VarName	VarLabel	Value	LABEL
BMI	Body-Mass-Index (Wert) - Abhängige Variable	Num	Numerisch
SKRAN14b	S03 Migräne: Krankheit (12 Monate)	0	Nein
		1	Ja
SKRAN15b	S03 Asthma: Krankheit (12 Monate)	0	Nein
		1	Ja
SKRAN16b	S03 Diabetes: Krankheit (12 Monate)	0	Nein
		1	Ja
SKRAN17b	S03 Arthrose: Krankheit (12 Monate)	0	Nein
		1	Ja
SKRAN18b	S03 Magen-, Zwölffingerdarmgeschwür: Krankheit (12 Monate)	0	Nein
		1	Ja
SKRAN19b	S03 Osteoporose: Krankheit (12 Monate)	0	Nein
		1	Ja
SKRAN21b	S03 Bluthochdruck: Krankheit (12 Monate)	0	Nein

VarName	VarLabel	Value	LABEL
		1	Ja
SKRAN22b	S03 Herzinfarkt: Krankheit (12 Monate)	0	Nein
		1	Ja
SKRAN23b	S03 Schlaganfall: Krankheit (12 Monate)	0	Nein
		1	Ja
SKRAN24b	S03 Nierenkrankheit, Nierensteine: Krankheit (12 Monate)	0	Nein
		1	Ja
SKRAN25b	S03 Krebs, Geschwulst: Krankheit (12 Monate)	0	Nein
		1	Ja
SKRAN26b	S03 Heuschnupfen, Allergien: Krankheit (12 Monate)	0	Nein
		1	Ja
SKRAN27b	S03 Depression: Krankheit (12 Monate)	0	Nein
		1	Ja
ALTER	Alter (telefonischer Fragebogen)	Num	Numerisch
AgeGrp	Altergruppe	1	Alter 15 bis 24
		2	Alter >= 25
SEX	Geschlecht	1	Mann
		2	Frau

Results

Important Note: As with all statistical model calculations, a high or low correlation between dependent variable and independent covariables does NOT imply a high or low causal relationship between these variables.

a) All, men and women

The model equation of the final result of the stepwise backward regression is:

```
log(BMI) =
   3.14    * Male
 + 3.04    * Female
 + 0.0113  * Asthma
 + 0.0711  * Diabetes
 + 0.0287  * Art rose
 - 0.0800  * GI
 + 0.0739  * Hypertension
 - 0.0462  * Stroke
 - 0.0179  * Cancer
 + 0.0243  * Depression
 + 0.00140 * Male   * Age
 + 0.00207 * Female * Age
```

In order to get the final numeric result for the BMI value of a particular person, the variables need to be replaced by the appropriate value, e.g. for a male, Male=1 and of course Female=0. In contrast, for a female, Male=0 and Female=1. For people

with asthma, Asthma=1, and no asthma, Asthma=0 and so forth. Since Age is a continuous variable, the actual value of a person's age is used.

For example, the average BMI of a 45 years old woman with arthrosis and depression would be 24.1 kg/m^2, calculated as follows:

```
log(BMI) = 3.04 + 0.0287 + 0.0243 + 0.00207 * 45 = 3.18
BMI      = exp(3.18) = 24.1 kg/m2
```

A positive sign of a coefficient indicates a BMI increase, while a negative sign indicates a BMI decrease. The coefficients of dichotomous covariables (0 or 1) can be directly used to compare the effect size of the covariable on the BMI. For example, the strongest negative impact on the BMI has GI (-0.08), then stroke (-0.0462) and cancer (-0.0179). The strongest positive effect has hypertension (+0.0739), then diabetes (+0.0711), arthrosis (+0.0287), depression (+0.0243) and asthma (+0.0113). Since these effect sizes are on a logarithmic scale, they need to be converted back to BMI values, e.g. log(BMI) = 3.18 → BMI = 24.1.

Coefficients of continuous variables need to be first multiplied by the actual value before the effect size can be assessed, e.g. the effect size of a 50 year old man is 0.0014*50 = 0.07 which is similar in size as diabetes. Comparing the Age coefficients of men and women indicate that women have a (0.00207/0.00140) 1.5-times stronger "Age effect" (on a logarithmic scale) than men.

b) All men

The model equation of the final result of the stepwise backward regression for men is:

```
log(BMI) = 3.14
 + 0.00155 * Age
 + 0.0567  * Diabetes
 + 0.0151  * Art rose
 - 0.0667  * GI
 + 0.0639  * Hypertension
 - 0.0332  * Cancer
```

Compared to the full population, asthma, stroke and depression are not significant factors for men.

As an example, the average BMI of a 50 years old man with diabetes and GI-problems would be 24.7 kg/m^2, calculated as follows:

```
log(BMI) = 3.14 + 0.00155 * 50 + 0.0567 - 0.0667 = 3.21
BMI      = exp(3.21) = 24.7 kg/m2
```

Besides the positive correlation of age, GI and cancer have negative effect sizes, while hypertension, diabetes and arthrosis have positive effect sizes.

c) All women

The model equation of the final result of the stepwise backward regression for women is:

```
log(BMI) = 3.04
 + 0.00190 * Age
 + 0.0961  * Diabetes
 + 0.0393  * Art rose
 - 0.0805  * GI
 + 0.0862  * Hypertension
 - 0.0515  * Heartattack
 - 0.0537  * Stroke
 + 0.0323  * Depression
```

Compared to the full population, asthma and cancer are not significant factors for women and in addition heart-attack seems to have a significant impact.
Besides age, GI, stroke and heart-attack have negative effect sizes, while diabetes, hypertension, arthrosis and depression have positive effect sizes.

As an example, the average BMI of a 45 years old woman with hypertension and depression would be 25.7 kg/m^2, calculated as follows:

```
log(BMI) = 3.04 + 0.0019 * 45 + 0.0862 + 0.0323 = 3.25
BMI      = exp(3.25) = 25.7 kg/m2
```

Besides the positive correlation of age, GI, stroke and heart-attack have negative effect sizes, while diabetes, hypertension, arthrosis and depression have positive effect sizes.

d) Adults > 24, men and women

The model equation of the final result of the stepwise backward regression for all adults > 24 years, men and women is:

```
log(BMI) =
   3.21     * Male
 + 3.07     * Female
 - 0.00982  * Migraine
 + 0.0142   * Asthma
 + 0.0751   * Diabetes
 + 0.0317   * Art rose
 - 0.0772   * GI
 + 0.0803   * Hypertension
 - 0.0431   * Stroke
 - 0.0151   * Cancer
 + 0.0216   * Depression
 + 0.000159 * Male*Age
 + 0.00157  * Female*Age
```

Compared to the full population, migraine seems to be an additional small but significant factor in this model.

With males the continuous covariable age has a slight, with women an important positive correlation. GI, stroke, cancer and migraine have negative effect sizes, while hypertension, diabetes, arthrosis, depression and asthma have positive effect sizes.

e) Adults > 24, men only

The model equation of the final result of the stepwise backward regression for all adult men > 24 years is:

```
log(BMI) = 3.21
 + 0.000306 * Age
 + 0.0624   * Diabetes
 + 0.0191   * Art rose
 - 0.0650   * GI
 + 0.0702   * Hypertension
 - 0.0300   * Cancer
 - 0.0111   * Allergies
```

Compared to all adults > 24, migraine, asthma, stroke and depression are not significant factors in this model. In contrast, Allergies appears as a new significant factor with adult men.

The continuous covariable age has a slight positive correlation. GI, cancer and allergies have negative effect sizes, while hypertension, diabetes and arthrosis have positive effect sizes.

As an example, the average BMI of a 50 years old man with hypertension and allergies would be 26.7 kg/m^2.

f) Adults > 24, women only

The model equation of the final result of the stepwise backward regression for all adult women > 24 years is:

```
log(BMI) = 3.07
 + 0.00144 * Age
 + 0.0197  * Asthma
 + 0.0975  * Diabetes
 + 0.0403  * Art rose
 - 0.0785  * GI
 + 0.0925  * Hypertension
 - 0.0521  * Heartattack
 - 0.0600  * Stroke
 + 0.0300  * Depression
```

Compared to all adults > 24, migraine, and cancer seem not to be significant factors

in this model. In contrast, heart-attack seems to be a new significant factor with adult women.

The continuous covariable age has a positive correlation. GI, stroke and heart-attack have negative effect sizes, while diabetes, hypertension, osteoarthritis (Arthrose), depression and asthma have positive effect sizes.

g) Summary of results – Correlation BMI vs. Chronic Diseases

The following graphic shows all significant correlations of BMI with chronic diseases:

Multifaktorielle Analyse: signifikante Korrelationen zwischen BMI und Komorbiditäten

								direct cost*
SGB 12	**Variable**	**all**	**all >25**	**men**	**men >25**	**women**	**women >25**	**cost ranking**
SKRAN14b	Migräne		neg					
SKRAN15b	*Asthma*	pos	pos					**5**
SKRAN16b	*Diabetes*	pos	pos	pos	pos	pos	pos	**3**
SKRAN17b	*Arthrose*	pos	pos	pos	pos	pos	pos	**1**
SKRAN18b	Magen, Zwölffingerdarmgeschwür							
SKRAN19b	Osteoporose	neg	neg	neg	neg	neg	neg	
SKRAN21b	*Bluthochdruck*	pos	pos	pos	pos	pos	pos	**4**
SKRAN22b	Herzinfarkt					neg	neg	
SKRAN23b	Schlaganfall	neg	neg		neg	neg	neg	
SKRAN24b	Nierenkrankheit, Nierensteine							
SKRAN25b	Krebs, Geschwulst	neg	neg	neg	neg			
SKRAN26b	Heuschnupfen, Allergien				neg			
SKRAN27b	*Depression*	pos	pos			pos	pos	**2**

kursiv: Kosten eingeschlossen in COI

* cover 80% of direct costs of obesity-linked comorbidities

Using a general linear regression analysis model on the Swiss population interviewed for the fifth Health Survey carried out in 2012, it was possible to confirm that six of the 11 obesity-linked comorbidities are indeed statistically significantly correlated to body weight. Five of them, i.e. asthma, diabetes type 2, osteoarthritis, high blood pressure, and depression, representing the five most costly comorbidities (covering 80% of all direct costs of comorbidities) were actually significantly correlated to increased body weight. Stroke, however, was negatively correlated with body weight, i.e. the chances to suffer from a stroke did decrease as body weight, respectively BMI increased.
The well-known fact, that osteoporosis is negatively correlated to increased body weight was confirmed by our analysis of the investigated segment of the Swiss population and all its subgroups. Interestingly enough, the occurrence of cancer appeared also to be negatively correlated to increased body weight, at least in the entire population and the male subsegment. On the other hand, in the female

subsegment, it was found that heart infarction events were less likely to occur with increased body weight.

2. Effect of physical complaints (General linear regression model with BMI vs. factors of physical complaints) Evaluation of data from the Swiss Health Survey 2012

Method

BMI was used as the dependent variable, more exactly, the logarithm of the BMI value, since the distribution of the BMI value is not perfectly normal but is rather logarithmic. A set of arbitrarily selected variables from all questions concerning chronic diseases were used as covariables or factors. Since these covariables are either continuous or categorical, a general linear regression analysis (GLM) model was used starting with all covariables and stepwise elimination of the covariable with the highest p-value until only covariables with significant p-values ($p<0.05$) were left in the model. Covariables like AGE or SEX where not eliminated even if their p-value was above 0.05. Since this is a very rough analysis of possible correlation between BMI and indicators of chronic diseases, no weighting of the population was used.

First, we analysed the whole population of participants (M&F all) and then the male (M all) and female (F all) population separately, and finally the population excluding young adults (M&F > 24).

Covariables related to Physical Complaints

The covariables identified as related to physical complaints are listed in Table 2.

Table 2

VarName	VarLabel	Value	LABEL
BMI	Body-Mass-Index (Wert) - Abhängige Variable	Num	Numerisch
TKOBW01	T36.00 : Körperliche Aktivität mit Schwitzen in der Freizeit 1x /Woche	1	Ja
		2	Nein
TKOBW06	T36.30 Gymnastik, Fitness, Sport treiben	1	Ja
		2	Nein
TKRSY01	T21.00 Rücken- oder Kreuzschmerzen (4 Wochen): Intensität	1	Überhaupt nicht
		2	Ein bisschen
		3	Stark
TKRSY02	T21.00 Schwächegefühl (4 Wochen): Intensität	1	Überhaupt nicht
		2	Ein bisschen
		3	Stark
TKRSY03	T21.00 Schmerzen, Druckgefühl im Bauch (4 Wochen): Intensität	1	Überhaupt nicht

VarName	VarLabel	Value	LABEL
		2	Ein bisschen
		3	Stark
TKRSY04	T21.00 Durchfall, Verstopfung (4 Wochen): Intensität	1	Überhaupt nicht
		2	Ein bisschen
		3	Stark
TKRSY05	T21.00 Einschlaf-, Durchschlafstörungen (4 Wochen): Intensität	1	Überhaupt nicht
		2	Ein bisschen
		3	Stark
TKRSY06	T21.00 Kopfschmerzen, Gesichtsschmerzen (4 Wochen): Intensität	1	Überhaupt nicht
		2	Ein bisschen
		3	Stark
TKRSY07	T21.00 Herzklopfen, Herzjagen, -stolpern (4 Wochen): Intensität	1	Überhaupt nicht
		2	Ein bisschen
		3	Stark
TKRSY08	T21.00 Schmerzen, Druck im Brustbereich (4 Wochen): Intensität	1	Überhaupt nicht
		2	Ein bisschen
		3	Stark
TKRSY09	T21.00 Fieber (4 Wochen): Intensität	1	Überhaupt nicht
		2	Ein bisschen
		3	Stark
TKRSY34	T21.00 Schmerzen in Schultern, Nacken, Armen (4 Wochen): Intensität	1	Überhaupt nicht
		2	Ein bisschen
ALTER	Alter (telefonischer Fragebogen)	Num	Numerisch
AgeGrp	Altergruppe	1	Alter 15 bis 24
		2	Alter >= 25
SEX	Geschlecht	1	Mann
		2	Frau

Results

Important Note: As with all statistical model calculations, a high or low correlation between dependent variable and independent covariables does NOT imply a high or low causal relationship between these variables.

a) All, men and women

The model equation of the final result of the stepwise backward regression is:

```
log(BMI) =
   3.11    * Male
```

```
 + 3.01    * Female
 + 0.0197  * Backpain
 - 0.00783 * AbdomPain
 + 0.00505 * Headache
 + 0.0131  * Chestpain
 + 0.0323  * Fitness
 + 0.0019  * Male*Age
 + 0.00242 * Female*Age
```

In order to get the final numeric result for the BMI value of a particular person, the variables need to be replaced by the appropriate value, e.g. for a male, Male=1 and of course Female=0. In contrast, for a female, Male=0 and Female=1. For people with a little backpain, Backpain=2 and so forth. Please note that “no backpain”=1. Since Age is a continuous variable, the actual value of a person’s age is used. Interesting to note, that in this model Fitness has a positive coefficient meaning people who do fitness training have a higher BMI value as compared to people with no fitness training.

For example, the average BMI of a 50 years old woman with little backpain would be 24.0 kg/m^2, calculated as follows:

```
log(BMI) = 3.01 + 0.0197*2 - 0.00783 + 0.00505 + 0.0131 + 0.00242*50
log(BMI) = 3.179
BMI      = exp(3.179) = 24.03 kg/m2
```

A positive sign of a coefficient indicates a BMI increase, while a negative sign indicates a BMI decrease.

b) All men

The model equation of the final result of the stepwise backward regression for men is:

```
log(BMI) = 3.12
 + 0.00193 * Age
 + 0.0113  * Backpain
 + 0.0137  * Chestpain
 + 0.00655 * Shoulderpain
 + 0.0256  * Fitness .
```

As an example, the average BMI of a 50 years old man with strong chestpain doing fitness would be 27.1 kg/m^2, calculated as follows:

```
log(BMI) = 3.12 + 0.00193*50 + 0.0113 + 0.0137*3 + 0.00655 + 0.0256
log(BMI) = 3.299
BMI      = exp(3.299) = 27.08 kg/m2
```

c) All women

The model equation of the final result of the stepwise backward regression for women is:

```
log(BMI) = 3.01
 + 0.00236 * Age
 + 0.0247  * Backpain
 + 0.0068  * Weakness
 - 0.01139 * AbdomPain
 + 0.0375  * Fitness
```

As an example, the average BMI of a 50 years old woman with strong weakness and doing fitness would be 24.4 kg/m^2, calculated as follows:

```
log(BMI) = 3.01 + 0.00236*50 + 0.0247 + 0.0068*3 - 0.01139 + 0.0375
log(BMI) = 3.197
BMI      = exp(3.197) = 24.448 kg/m2
```

d) Adults > 24, men and women

(see statistical report of Model 2)

e) Adults > 24, men only

(see statistical report of Model 2)

f) Adults > 24, women only

(see statistical report of Model 2)

g) Summary of results – Correlation BMI vs. Physical Complaints

The following graph shows all significant correlations of BMI with physical complaints:

SGB 12	Variable	all	all >25	men	men >25	women	women >25
TKRSY01	Rücken- oder Kreuzschmerzen (4 Wochen)	pos	pos	pos	pos	pos	pos
TKRSY02	Schwächegefühl (4 Wochen)		pos			pos	pos
TKRSY03	Schmerzen, Druckgefühl im Bauch (4 Wochen)	neg	neg			neg	neg
TKRSY06	Kopfschmerzen, Gesichtsschmerzen (4 Wochen)	pos					
TKRSY34	Schmerzen in Schultern, Nacken, Armen (4 Wochen)			pos	pos		
TKRSY07	Herzklopfen, Herzjagen, -stolpern (4 Wochen)		pos				
TKRSY08	Schmerzen, Druck im Brustbereich (4 Wochen)	pos	pos	pos	pos		
TKOBW06	Gymnastik, Fitness, Sport treiben	pos	pos	pos	pos	pos	pos

It was of interest to evaluate a possible interaction between physical complaints - representing general stress symptoms - and body weight. A typical stress symptom such as back pain and lower back pain, respectively, was statistically significantly correlated with increasing body weight. Other pain symptoms such as breast and

shoulder/neck pain were basically confined to the male subsegment of the interviewed part of the Swiss population, whereas stomach/lower abdominal pain was negatively correlated with BMI in the female subsegment, i.e. in Swiss women the occurrence of lower abdominal pain increases as body weight decreases.
Interestingly, increased body weight significantly correlates positively with increased physical activity, i.e. when body weight increases, so does physical activity.

3. Diabetes mellitus type 2 vs. possible factors (Logistic regression model) Evaluation of data from the Swiss Health Survey 2012

Method

The basic model equation of the logistic regression is as follows:

$$Logit(Y) = \beta_0 + \beta_1 X_1 + \cdots + \beta_n X_n$$

In contrast to the general linear regression model, Y is usually a dependent dichotomous variable with the values 0 and 1. In our model here Y is the probability of the disease diabetes mellitus type 2, the dependent variable, and $X_1 \ldots X_n$ are the independent variables or factors. In contrast to the earlier general linear regression model, we used in the logistic regression model at least the variable BMI, or better the transformed variable log(BMI), as one obligate independent variable. Other variables we try to keep in the stepwise regression analysis are: gender and age. Since we need to limit somehow the number of factors (independent variables) we take arbitrarily those responses of the survey questionnaire, which we identified as related to the disease. The estimated values $\beta_0 \ldots \beta_n$ (coefficients) are then a measure of relationship between the factors and the disease. The interpretation of these coefficients (effect size) is somewhat more difficult than for a normal linear regression. In the logistic regression, the coefficients are on a logarithmic scale. A better feel for the effect size gives the odds ratio (OR) which is the exponential of the coefficient, exp(coefficient). Therefore, a value of 1 means no relationship, while a value lower than 1 means negative impact and a value above 1 means positive impact.

Again, we analysed first the whole population of participants (M&F all) and then the male (M all) and female (F all) population separately, and finally the population excluding young adults (M&F > 25).

Covariables explored to be related to diabetes mellitus type 2

The covariables identified as related to disease diabetes mellitus II are listed in Table 3.

Table 3

VarLabel	VarName	VarShort	Wert	LABEL

VarLabel	VarName	VarShort	Wert	LABEL
Altersgruppen	AgeGrp	AgeGrp	1	Alter 15 bis 24
			2	Alter >= 25
S03 Diabetes: Krankheit (12 Monate)	SKRAN16b	DiabetesNY	0	Nein
			1	Ja
Diät aus medizinischen Gründen	DIAET2	DIAET2	0	Keine Diät oder nicht aus med. Gründen
			1	Diät aus med. Gründen
Diät und wenn Ja, Grund (4 Antworten)	DIAET4	DIAET4	0	Nein
			1	Abnehmen, ohne med. Grund
			2	Aus medizinischen Gründen
			3	Aus anderen Gründen
T37.11 Diät (12 Monate): Grund	TERNA15	DiätGrund	1	Abnehmen, ohne med. Grund
			2	Aus medizinischen Gründen
			3	Aus anderen Gründen
T37.50 Fisch: Häufigkeit (Tage/Woche)	TERNA05	EFischFrq	0	Nie
			1	1 Tag pro Woche
			2	2 Tage pro Woche
			3	3 Tage pro Woche
			4	4 Tage pro Woche
			5	5 Tage pro Woche
			6	6 Tage pro Woche
			7	7 Tage pro Woche
			8	Seltener
T37.40 Fleisch, Wurstwaren: Häufigkeit (Tage/Woche)	TERNA03	EFleischFrq	0	Nie
			1	1 Tag pro Woche
			2	2 Tage pro Woche
			3	3 Tage pro Woche
			4	4 Tage pro Woche
			5	5 Tage pro Woche
			6	6 Tage pro Woche
			7	7 Tage pro Woche
			8	Seltener
T37.30 Früchte, Fruchtsäfte: Häufigkeit (Tage/Woche)	TERNA22	EFrüchteFrq	0	Nie
			1	1 Tag pro Woche
			2	2 Tage pro Woche
			3	3 Tage pro Woche
			4	4 Tage pro Woche
			5	5 Tage pro Woche
			6	6 Tage pro Woche
			7	7 Tage pro Woche
			8	Seltener
T37.31 Früchte, Fruchtsäfte: Menge (Portionen/Tag)	TERNA23	EFrüchtePort	0	Weniger als 1 Portion pro Tag
			1	1 Portion pro Tag
			2	2 Portionen pro Tag
			3	3 Portionen pro Tag
			4	4 Portionen pro Tag

VarLabel	VarName	VarShort	Wert	LABEL
			5	5 Portionen und mehr pro Tag
T37.20 Gemüse, Salat: Häufigkeit (Tage/Woche)	TERNA20	EGemüseFrq	0	Nie
			1	1 Tag pro Woche
			2	2 Tage pro Woche
			3	3 Tage pro Woche
			4	4 Tage pro Woche
			5	5 Tage pro Woche
			6	6 Tage pro Woche
			7	7 Tage pro Woche
			8	Seltener
T37.21 Gemüse, Salat: Menge (Portionen/Tag)	TERNA21	EGemüsePort	0	Weniger als 1 Portion pro Tag
			1	1 Portion pro Tag
			2	2 Portionen pro Tag
			3	3 Portionen pro Tag
			4	4 Portionen pro Tag
			5	5 Portionen und mehr pro Tag
T37.60 Milch, Milchprodukten: Häufigkeit (Tage/Woche)	TERNA18	EMilchFrq	0	Nie
			1	1 Tag pro Woche
			2	2 Tage pro Woche
			3	3 Tage pro Woche
			4	4 Tage pro Woche
			5	5 Tage pro Woche
			6	6 Tage pro Woche
			7	7 Tage pro Woche
			8	Seltener
T37.61 Milch, Milchprodukten: Menge (Portionen/Tag)	TERNA24	EMilchPort	0	Weniger als 1 Portion pro Tag
			1	Etwa 1 Portion pro Tag
			2	2 Portionen pro Tag
			3	3 Portionen pro Tag
			4	4 Portionen und mehr pro Tag
Fisch, Score (Produkt aus Häufigkeit und 1 Portion)	FISCHr	FISCHr	NA	Numerisch
Fisch, Häufigkeit	FISCH	FISCH	0	Wenig
			1	Mässig
			2	Viel
Fleisch, Score (Produkt aus Häufigkeit und 1 Portion)	FLEISCHr	FLEISCHr	NA	Numerisch
Fleisch, Häufigkeit	FLEISCH	FLEISCH	0	Wenig
			1	Mässig
			2	Viel
Früchte, Score (Produkt aus Häufigkeit und Portion/Menge)	FRUECHTEr	FRUECHTEr	NA	Numerisch
Früchte, Häufigkeit und Menge	FRUECHTE	FRUECHTE	0	Wenig
			1	Mässig
			2	Viel
Gemüse, Score (Produkt aus Häufigkeit und Portion/Menge)	GEMUESEr	GEMUESEr	NA	Numerisch
Gemüse, Häufigkeit and Menge	GEMUESE	GEMUESE	0	Wenig

VarLabel	VarName	VarShort	Wert	LABEL
			1	Mässig
			2	Viel
Milchprodukte, Score (Produkt aus Häufigkeit und Portion/Menge)	MILCHr	MILCHr	NA	Numerisch
Milchprodukete, Häufigkeit und Menge	MILCHPROD	MILCHPROD	0	Wenig
			1	Mässig
			2	Viel
S35.1 IPAQ SF: Mässig anstrengende Aktivitäten (7 Tage): Gesamtdauer (Minuten/Tag)	SKOBW06	Q_Mod_Dur	NA	Numerisch
S35 IPAQ SF: Mässig anstrengende Aktivitäten (7 Tage): Häufigkeit (Tage/Woche)	SKOBW05	Q_Mod_Frq	NA	Numerisch
S37 IPAQ SF: sitzende Stellung (Montag bis Freitag): Gesamtdauer (Minuten/Tag)	SKOBW09	Q_Sit_Dur	NA	Numerisch
S34.1 IPAQ SF: Intensive körperliche Aktivitäten (7 Tage): Gesamtdauer (Minuten/Tag)	SKOBW04	Q_Vig_Dur	NA	Numerisch
S34 IPAQ SF: Intensive körperliche Aktivitäten (7 Tage): Häufigkeit (Tage/Woche)	SKOBW03	Q_Vig_Frq	NA	Numerisch
S36.1 IPAQ SF: Zu Fuss gehen mindestens 10 Minuten (7 Tage): Gesamtdauer (Minuten/Tag)	SKOBW08	Q_Wlk_Dur	NA	Numerisch
S36 IPAQ SF: Zu Fuss gehen mindestens 10 Minuten (7 Tage): Häufigkeit (Tage/Woche)	SKOBW07	Q_Wlk_Frq	NA	Numerisch
Geschlecht	SEX	SEX	1	Mann
			2	Frau
T36.30 Gymnastik, Fitness, Sport treiben	TKOBW06	TKOBW06	1	Ja
			2	Nein
T36.10 Körperliche Aktivität mit ausser Atem kommen: Häufigkeit (Tage/Woche)	TKOBW09	TKOBW09	NA	Numerisch
T36.11 Körperliche Aktivität mit ausser Atem kommen: Gesamtdauer (Minuten/Tag)	TKOBW11	TKOBW11	NA	Numerisch
T36.21 Fortbewegung zu Fuss oder Velo: Gesamtdauer (Minuten/Tag)	TKOBW12	TKOBW12	NA	Numerisch
T36.31 Gymnastik, Fitness, Sport: Häufigkeit	TKOBW13	TKOBW13	1	(Fast) täglich
			2	Mehrmals wöchentlich
			3	Etwa 1 Mal pro Woche
			4	Etwa 1-3 Mal pro Monat
			5	Seltener als 1 Mal pro Monat
T36.40 Genügende körperliche Bewegung für die Gesundheit (Meinung)	TKOBW14	TKOBW14	1	Ja
			2	Nein
T36.32 Gymnastik, Fitness, Sport: Gesamtdauer (Minuten/Woche)	TKOBW15	TKOBW15	NA	Numerisch

Included in this list of covariables are a set of physical activity variables from a standardized questionnaire, called International Physical Activity Questionnaire (IPAQ) - Short Form (http://www.ipaq.ki.se):

S35, “moderate intensive activity” (frequency and duration),
S34, “vigorous intensive activity” (frequency and duration) and
S36, “walking activity” (frequency and duration).
An additional optional question is the duration of “sitting position (Monday through Friday)”.
These questions are combined to a total MET (multiple of resting metabolic rate) score in minutes. MET-minutes scores are equivalent to kilocalories for a 60 kg person. The final score for each participant is therefore adjusted to its body weight to give the total **METkcl** score in kilocalories.

Results

Important Note: As with all statistical model calculations, a high or low correlation between dependent variable and independent covariables does NOT imply a high or low causal relationship between these variables.

a) All, men and women

The model equation of the final result of the stepwise backward logistic regression is:

```
logit(Diabetes) =
 - 15.7       * Male
 - 16.2       * Female
 + 0.0409     * Age
 + 3.32       * logBMI
 - 0.0000195  * MET_kcal
 - 0.364      * Fitness
 + 1.97       * MedDiet
```

In order to get the final numeric result for logit(Diabetes) of a particular person, the variables need to be replaced by the appropriate values, e.g. for a male, Male=1 and of course Female=0. In contrast, for a female, Male=0 and Female=1. For people with medical diet, MedDiet=1, and no medical diet, MedDiet=0 and so forth. Since Age and MET_kcal are continuous variables, the actual value of a person's age and physical activity score are multiplied by its coefficient.

For example, the probability of a 60 years old man with BMI=30 (i.e. log(BMI)=1.477), a rather low physical activity score of 1000 kcal, with no fitness activity and with medical diet (most probably because of diabetes) would be 0.16%, calculated as follows:

```
logit(Diabetes) = - 15.7 + 0.0409 * 60 + 3.32 * 1.477 - 0.0000195 *
1000 + 1.97 = -6.39
prob(Diabetes) = exp(-6.39) / (1 + exp(-6.39)) = 0.00163 = 0.163%
```

The odds ratios of each statistically significant variable are as follows:

Factor	OR
Male	0.0000
Female	0.0000
Age	1.0417
logBMI	27.6147
MET_kcal	1.0000
Fitness	0.6946
MedDiet	7.1443

An odds ratio of 1 indicates “no effect”. For MET_kcal, it seems there is no effect but the full digits value is 0.999980503 and the median MET_kcal is around 3500 kcal, meaning a very small but statistically significant negative effect. A similar negative effect, reducing the probability of diabetes, has the factor Fitness. The OR of logBMI is very high, but this is due to the fact that the BMI is transformed to its logarithmic value log(BMI). The OR of Male/Female is around 0 and corresponds to an intercept of 0, meaning the probability for diabetes extrapolated to age 0, BMI 0 etc.

b) All men

The model equation of the final result of the stepwise backward logistic regression for men is:

```
logit(Diabetes) = - 17.6
 + 0.0478    * Age
 + 3.76      * logBMI
 - 0.0000162 * MET_kcal
 - 0.35      * Fitness
 + 2.05      * MedDiet
```

For example, the probability of a 60 years old man with BMI=30 (i.e. log(BMI)=1.477), an over average physical activity score of 5000 kcal and doing fitness training would be 0.0065%, calculated as follows:

```
logit(Diabetes) =  - 17.6 + 0.0478 * 60 + 3.76 * 1.477 - 0.0000162 *
5000 - 0.35 = -9.64
prob(Diabetes) = exp(-9.64) / (1 + exp(-9.64)) = 0.00649%
```

(all final numbers are the results of full precision calculation)

The odds ratios of each statistically significant variable are as follows:

Factor	OR
Intercept	0.0000
Age	1.0490
logBMI	42.8125
MET_kcal	1.0000
Fitness	0.7045
MedDiet	7.7305

Except for the much higher logBMI effect, the OR for men are comparable to the full population.

c) All women

The model equation of the final result of the stepwise backward logistic regression for women is:

```
logit(Diabetes) = -14.7
 + 0.0327    * Age
 + 3.12      * logBMI
 - 0.0000286 * MET_kcal
 - 0.346     * Fitness
 + 1.91      * MedDiet
 - 0.199     * Fisheater
```

A new significant factor, eating fish, appears here as compared with the full population and men only. The score for the frequency of eating fish seems to have a negative impact on the probability to suffer from diabetes mellitus type 2 in women. All other factors are qualitatively similar to men and the full population.

The odds ratios of each statistically significant variable are as follows:

Factor	OR
Intercept	0.0000
Age	1.0332
logBMI	22.6641
MET_kcal	1.0000
Fitness	0.7074
MedDiet	6.7368
Fisheater	0.8199

The OR for women are comparable to the full population, except for the additional negative factor (OR below 1) of eating fish.

d) Adults > 25, men and women

(see statistical report of Model 3)

e) Adults > 25, men only

(see statistical report of Model 3)

f) Adults > 25, women only

(see statistical report of Model 3)

g) Summary of results – Correlation Diabetes vs. various factors

The following graphic shows all significant correlations between diabetes and various factors:

Logistische Regression: signifikante Korrelationen zwischen **Diabetes und verschiedenen Faktoren** (OR)

SGB 12	Variable	all	all >25	men	men >25	women	women >25
	Alter	1.042	1.047	1.049	1.054	1.033	1.038
	BMI	27.6	32.0	42.8	48.8	22.7	26.4
TKOBW06	Gymnastik, Fitness, Sport treiben	0.695	0.685	0.705	0.696	0.707	0.688
MET_kcal	Kalorienverbrauch aus körp. Aktivitäten (IPAQ)	Im Bereich von 0.999971 and 0.999984					
DIAET2	Diät aus medizinischen Gründen	7.14	7.69	7.73	8.28	6.74	7.20
TERNA03	Konsum von mässig-viel Fleisch, Wurstwaren		1.045		1.059		
TERNA18/24	Konsum von mässig-viel Fisch					0.820	0.822
	positive Korrelation						
	negative Korrelation						

Using a logistic regression model, various factors - considered important in the context of suffering from diabetes type 2 – were tested for their influence on the manifestation of diabetes type 2. BMI was most impressively positively linked to the occurrence of diabetes type 2 in the entire segment of the Swiss population investigated, i.e. as body weight increases the chances of being a diabetic are much bigger independant of sex. As expected, participating in a dietary program for medical reasons was also an important factor of positive nature in the context of diabetes type 2. On the other hand, physical activity had a moderate negative effect on diabetes, whereas consumption of a moderate-to-large amount of fish was negatively linked to diabetes in the female subsegment.

4. Depression vs. possible factors (Logistic regression model) Evaluation of data from the Swiss Health Survey 2012

Method

For the method of the logistic regression model please refer to point 3, Diabetes mellitus type 2 vs. possible factors.

Analogous to the previous models, we analysed first the whole population of participants (M&F all) and then the male (M all) and female (F all) population separately, and finally the population excluding young adults (M&F ≥ 25).

Covariables explored to be related to depression

The covariables identified as related to depression are listed in Table 4.

Table 4

VarLabel	VarName	VarShort	Wert	LABEL
Altersgruppen	AgeGrp	AgeGrp	1	Alter 15 bis 24
			2	Alter >= 25
S03 Depression: Krankheit (12 Monate)	SKRAN27b	DiabetesNY	0	Nein
			1	Ja
Diät aus medizinischen Gründen	DIAET2	DIAET2	0	Keine Diät oder nicht aus med. Gründen
			1	Diät aus med. Gründen
Diät und wenn Ja, Grund (4 Antworten)	DIAET4	DIAET4	0	Nein
			1	Abnehmen, ohne med. Grund
			2	Aus medizinischen Gründen
			3	Aus anderen Gründen
T37.11 Diät (12 Monate): Grund	TERNA15	DiätGrund	1	Abnehmen, ohne med. Grund
			2	Aus medizinischen Gründen
			3	Aus anderen Gründen
T37.50 Fisch: Häufigkeit (Tage/Woche)	TERNA05	EFischFrq	0	Nie
			1	1 Tag pro Woche
			2	2 Tage pro Woche
			3	3 Tage pro Woche
			4	4 Tage pro Woche
			5	5 Tage pro Woche
			6	6 Tage pro Woche
			7	7 Tage pro Woche
			8	Seltener
T37.40 Fleisch, Wurstwaren: Häufigkeit (Tage/Woche)	TERNA03	EFleischFrq	0	Nie
			1	1 Tag pro Woche
			2	2 Tage pro Woche
			3	3 Tage pro Woche
			4	4 Tage pro Woche
			5	5 Tage pro Woche
			6	6 Tage pro Woche
			7	7 Tage pro Woche
			8	Seltener
T37.30 Früchte, Fruchtsäfte: Häufigkeit (Tage/Woche)	TERNA22	EFrüchteFrq	0	Nie
			1	1 Tag pro Woche
			2	2 Tage pro Woche
			3	3 Tage pro Woche
			4	4 Tage pro Woche
			5	5 Tage pro Woche
			6	6 Tage pro Woche
			7	7 Tage pro Woche
			8	Seltener
T37.31 Früchte, Fruchtsäfte: Menge (Portionen/Tag)	TERNA23	EFrüchtePort	0	Weniger als 1 Portion pro Tag
			1	1 Portion pro Tag
			2	2 Portionen pro Tag

VarLabel	VarName	VarShort	Wert	LABEL
			3	3 Portionen pro Tag
			4	4 Portionen pro Tag
			5	5 Portionen und mehr pro Tag
T37.20 Gemüse, Salat: Häufigkeit (Tage/Woche)	TERNA20	EGemüseFrq	0	Nie
			1	1 Tag pro Woche
			2	2 Tage pro Woche
			3	3 Tage pro Woche
			4	4 Tage pro Woche
			5	5 Tage pro Woche
			6	6 Tage pro Woche
			7	7 Tage pro Woche
			8	Seltener
T37.21 Gemüse, Salat: Menge (Portionen/Tag)	TERNA21	EGemüsePort	0	Weniger als 1 Portion pro Tag
			1	1 Portion pro Tag
			2	2 Portionen pro Tag
			3	3 Portionen pro Tag
			4	4 Portionen pro Tag
			5	5 Portionen und mehr pro Tag
T37.60 Milch, Milchprodukten: Häufigkeit (Tage/Woche)	TERNA18	EMilchFrq	0	Nie
			1	1 Tag pro Woche
			2	2 Tage pro Woche
			3	3 Tage pro Woche
			4	4 Tage pro Woche
			5	5 Tage pro Woche
			6	6 Tage pro Woche
			7	7 Tage pro Woche
			8	Seltener
T37.61 Milch, Milchprodukten: Menge (Portionen/Tag)	TERNA24	EMilchPort	0	Weniger als 1 Portion pro Tag
			1	Etwa 1 Portion pro Tag
			2	2 Portionen pro Tag
			3	3 Portionen pro Tag
			4	4 Portionen und mehr pro Tag
Fisch, Score (Produkt aus Häufigkeit und 1 Portion)	FISCHr	FISCHr	NA	Numerisch
Fisch, Häufigkeit	FISCH	FISCH	0	Wenig
			1	Mässig
			2	Viel
Fleisch, Score (Produkt aus Häufigkeit und 1 Portion)	FLEISCHr	FLEISCHr	NA	Numerisch
Fleisch, Häufigkeit	FLEISCH	FLEISCH	0	Wenig
			1	Mässig
			2	Viel
Früchte, Score (Produkt aus Häufigkeit und Portion/Menge)	FRUECHTEr	FRUECHTEr	NA	Numerisch
Früchte, Häufigkeit und Menge	FRUECHTE	FRUECHTE	0	Wenig
			1	Mässig
			2	Viel
Gemüse, Score (Produkt aus Häufigkeit und Portion/Menge)	GEMUESEr	GEMUESEr	NA	Numerisch

VarLabel	VarName	VarShort	Wert	LABEL
Gemüse, Häufigkeit and Menge	GEMUESE	GEMUESE	0	Wenig
			1	Mässig
			2	Viel
Milchprodukte, Score (Produkt aus Häufigkeit und Portion/Menge)	MILCHr	MILCHr	NA	Numerisch
Milchprodukete, Häufigkeit und Menge	MILCHPROD	MILCHPROD	0	Wenig
			1	Mässig
			2	Viel
S35.1 IPAQ SF: Mässig anstrengende Aktivitäten (7 Tage): Gesamtdauer (Minuten/Tag)	SKOBW06	Q_Mod_Dur	NA	Numerisch
S35 IPAQ SF: Mässig anstrengende Aktivitäten (7 Tage): Häufigkeit (Tage/Woche)	SKOBW05	Q_Mod_Frq	NA	Numerisch
S37 IPAQ SF: sitzende Stellung (Montag bis Freitag): Gesamtdauer (Minuten/Tag)	SKOBW09	Q_Sit_Dur	NA	Numerisch
S34.1 IPAQ SF: Intensive körperliche Aktivitäten (7 Tage): Gesamtdauer (Minuten/Tag)	SKOBW04	Q_Vig_Dur	NA	Numerisch
S34 IPAQ SF: Intensive körperliche Aktivitäten (7 Tage): Häufigkeit (Tage/Woche)	SKOBW03	Q_Vig_Frq	NA	Numerisch
S36.1 IPAQ SF: Zu Fuss gehen mindestens 10 Minuten (7 Tage): Gesamtdauer (Minuten/Tag)	SKOBW08	Q_Wlk_Dur	NA	Numerisch
S36 IPAQ SF: Zu Fuss gehen mindestens 10 Minuten (7 Tage): Häufigkeit (Tage/Woche)	SKOBW07	Q_Wlk_Frq	NA	Numerisch
Geschlecht	SEX	SEX	1	Mann
			2	Frau
T36.30 Gymnastik, Fitness, Sport treiben	TKOBW06	TKOBW06	1	Ja
			2	Nein
T36.10 Körperliche Aktivität mit ausser Atem kommen: Häufigkeit (Tage/Woche)	TKOBW09	TKOBW09	NA	Numerisch
T36.11 Körperliche Aktivität mit ausser Atem kommen: Gesamtdauer (Minuten/Tag)	TKOBW11	TKOBW11	NA	Numerisch
T36.21 Fortbewegung zu Fuss oder Velo: Gesamtdauer (Minuten/Tag)	TKOBW12	TKOBW12	NA	Numerisch
T36.31 Gymnastik, Fitness, Sport: Häufigkeit	TKOBW13	TKOBW13	1	(Fast) täglich
			2	Mehrmals wöchentlich
			3	Etwa 1 Mal pro Woche
			4	Etwa 1-3 Mal pro Monat
			5	Seltener als 1 Mal pro Monat
T36.40 Genügende körperliche Bewegung für die Gesundheit (Meinung)	TKOBW14	TKOBW14	1	Ja
			2	Nein
T36.32 Gymnastik, Fitness, Sport: Gesamtdauer (Minuten/Woche)	TKOBW15	TKOBW15	NA	Numerisch

Included in this list of covariables are a set of physical activity variables from a standardized questionnaire, called International Physical Activity Questionnaire (IPAQ) - Short Form (http://www.ipaq.ki.se):
S35, “moderate intensive activity” (frequency and duration),
S34, “vigorous intensive activity” (frequency and duration) and
S36, “walking activity” (frequency and duration).
An additional optional question is the duration of “sitting position (Monday through Friday)”.
The 3 first questions are combined to a total MET (multiple of resting metabolic rate) score in minutes. MET-minutes scores are equivalent to kilocalories for a 60 kg person. The final score for each participant is therefore adjusted to its body weight to give the total **METkcl** score in kilocalories.

Results

Important Note: As with all statistical model calculations, a high or low correlation between dependent variable and independent covariables does NOT imply a high or low causal relationship between these variables.

a) All, men and women

The model equation of the final result of the stepwise backward logistic regression is:

```
logit(Depression) =
 - 6.15       * Male
 - 5.62       * Female
 + 1.20       * logBMI
 - 0.00001063 * MET_kcal
 - 0.311      * Fitness
 + 0.816      * MedDiet
 - 0.00993    * VegEater
 - 0.0639     * MeatEater
 - 0.125      * FishEater
```

In order to get the final numeric result for logit(Depression) value of a particular person, the variables need to be replaced by the appropriate values, e.g. for a male, Male=1 and of course Female=0. In contrast, for a female, Male=0 and Female=1. For people with medical diet, MedDiet=1, and no medical diet, MedDiet=0 and so forth. Since BMI and MET_kcal are continuous variables, the actual value of a person's BMI and physical activity score are used. Interestingly, Age seems not to be a statistically significant factor in this model.

For example, the probability of a man with BMI=30 (i.e. log(BMI)=1.477), a rather low physical activity score of 1000 kcal, with no fitness activity, with medical diet (most probably because of diabetes) and moderate vegetable eater would be 2.7%, calculated as follows:

```
logit(Depression) =  - 6.15 + 1.20 * 1.477 - 0.00001063 * 1000 +
0.816 - 0.00993 = -3.58
prob(Depression) = exp(-3.58) / (1 + exp(-3.58)) = 0.02712 = 2.71%
```

The odds ratios of each statistically significant variable are as follows:

Factor	OR
Male	0.0021
Female	0.0036
logBMI	3.3277
MET_kcal	1.0000
Fitness	0.7330
MedDiet	2.2603
VegEater	0.9901
MeatEater	0.9381

FishEater	0.8829

An odds ratio of 1 indicates "*no effect*". For MET_kcal, it seems there is no effect but the full digits value is 0.9999894 and the median MET_kcal is around 3500 kcal, meaning a very small but statistically significant negative effect. A similar negative effect, reducing the probability of depression, have the factors Fitness, eating of vegetables, meat and/or fish. The OR of BMI is compared to the "Diabetes model" quite small, and it is transformed to its logarithmic value log(BMI). The OR of Male/Female is close to 0 and corresponds to an intercept of nearly 0, indicating the probability of a man/woman for depression with all other factors kept 0. Since the OR of females is slightly greater, this indicates that the incidence of depression in women is slightly higher compared to men.

b) All men

The model equation of the final result of the stepwise backward logistic regression for men is:

```
logit(Depression) = -5.34
 + 0.913    * logBMI
 + 0.000501 * Sitting
 - 0.507    * Fitness
 + 0.636    * MedDiet
 - 0.0199   * FruitsEater
 - 0.0849   * MeatEater"
```

For example, the probability of a man with BMI=30 (i.e. log(BMI)=1.477), an over average physical activity score of 5000 kcal, sitting 8*60 minutes per day, doing fitness training but taking a medical diet would be 2.6%, calculated as follows:

```
logit(Depression) =  - 5.34 + 0.913 * 1.477 + 0.000501 * 480 - 0.507
+ 0.636 = -3.62
prob(Diabetes) = exp(-3.62) / (1 + exp(-3.62)) = 2.60%
```

(all final numbers are the results of full precision calculation)

The odds ratios of each statistically significant variable is as follows:

Factor	OR
Intercept	0.0048
logBMI	2.4909
Sitting	1.0005
Fitness	0.6022
MedDiet	1.8897
FruitsEater	0.9803
MeatEater	0.9186

Fitness seems to have a considerable, eating meat and fruits a small negative effect on depression with men, while higher BMI, medical diet and long duration of sitting position increase the probability of having a depression.

c) All women

The model equation of the final result of the stepwise backward logistic regression for women is:

```
logit(Depression) = -6.11
 + 1.31       * logBMI
 - 0.0000137  * MET_kcal
 - 0.239      * Fitness
 + 0.85       * MedDiet
 - 0.0612     * MeatEater
 - 0.151      * FishEater
```

As compared to the full population, eating a lot of vegetable does not seem to influence the incidence of depression with women. In contrast to men, where eating fruits is a significant factor for men, this factor seems not to appear with women. In contrast, eating fish is a significant factor with women but not with men.

The odds ratios of each statistically significant variable give a better effect measure and are as follows:

Factor	OR	
Intercept	0.0022	
logBMI	3.7157	
MET_kcal	1.0000	full precision: 0.9999863
Fitness	0.7875	
MedDiet	2.3398	
MeatEater	0.9407	
FishEater	0.8602	

Fitness, eating substantial amounts of fish and/or meat exerts a reducing effect on the frequency of depression in women. Increased BMI and following a medical diet are linked to an increasing probability for suffering from depression for women.

d) Adults > 25, men and women

(see statistical report of Model 4)

e) Adults > 25, men only

(see statistical report of Model 4)

f) Adults > 25, women only

(see statistical report of Model 4)

g) Summary of results – Correlation Depression vs. various factors

The following graph shows essential, statistically significant correlations between depression (without diabetics) and various other factors (OR):

SGB 12	Variable	all	all >24	men	men >24	women	women >24
	Log(BMI)	3.32	3.39	2.49		3.72	3.97
TKOBW06	Gymnastik, Fitness, Sport treiben	0.733	0.752	0.602	0.644	0.788	0.807
DIAET2	Diät aus medizinischen Gründen	2.26	2.18	1.89	1.85	2.34	2.26
TERNA03	Konsum von mässig-viel Fleisch, Wurstwaren	0.938	0.946	0.919	0.930	0.941	0.951
TERNA18/24	Konsum von mässig-viel Fisch	0.883	0.901			0.860	0.876

positive correlation
negative correlation

Using a logistic regression model, various factors - considered important in the context of suffering from depression – were tested for their influence on the manifestation of depression.
Although regarding the occurrence of depression, BMI was significantly linked to depression in the entire segment of the Swiss population investigated, i.e. as body weight increases the chances of becoming depressive increases simultaneously. In addition, participating in a dietary program for medical reasons was found as an important factor in the context of manifestation of depression. This effect was still clearly seen after exclusion of all diabetic patients from the investigated population.
As seen with diabetes, physical activity had a moderate negative effect on the occurrence of depression, whereas consumption of a moderate-to-large amount of meat and meat products as well as fish was negatively linked to depression across the entire population segment investigated and in the female subsegment.

5. Hypertension vs. possible factors (Logistic regression model) Evaluation of data from the Swiss Health Survey 2012

Method

For the method of the logistic regression model please refer to chapter 3, Diabetes mellitus type 2 vs. possible factors.

As with the previous models, we analysed first the entire population of survey participants (M&F all) followed by the male (M all) and female (F all) population separately, and finally by the populations excluding young adults (M&F > 25).

Covariables explored to be related to hypertension

The covariables identified as related to depression are listed in Table 5.

Table 5

VarLabel	VarName	VarShort	Wert	LABEL
Altersgruppen	AgeGrp	AgeGrp	1	Alter 15 bis 24
			2	Alter >= 25
S03 Hypertesnion: Krankheit (12 Monate)	SKRAN21b	HypertensNY	0	Nein
			1	Ja
Diät aus medizinischen Gründen	DIAET2	DIAET2	0	Keine Diät oder nicht aus med. Gründen
			1	Diät aus med. Gründen
Diät und wenn Ja, Grund (4 Antworten)	DIAET4	DIAET4	0	Nein
			1	Abnehmen, ohne med. Grund
			2	Aus medizinischen Gründen
			3	Aus anderen Gründen
T37.11 Diät (12 Monate): Grund	TERNA15	DiätGrund	1	Abnehmen, ohne med. Grund
			2	Aus medizinischen Gründen
			3	Aus anderen Gründen
T37.50 Fisch: Häufigkeit (Tage/Woche)	TERNA05	EFischFrq	0	Nie
			1	1 Tag pro Woche
			2	2 Tage pro Woche
			3	3 Tage pro Woche
			4	4 Tage pro Woche
			5	5 Tage pro Woche
			6	6 Tage pro Woche
			7	7 Tage pro Woche
			8	Seltener
T37.40 Fleisch, Wurstwaren: Häufigkeit (Tage/Woche)	TERNA03	EFleischFrq	0	Nie
			1	1 Tag pro Woche
			2	2 Tage pro Woche
			3	3 Tage pro Woche
			4	4 Tage pro Woche
			5	5 Tage pro Woche
			6	6 Tage pro Woche
			7	7 Tage pro Woche
			8	Seltener
T37.30 Früchte, Fruchtsäfte: Häufigkeit (Tage/Woche)	TERNA22	EFrüchteFrq	0	Nie
			1	1 Tag pro Woche
			2	2 Tage pro Woche
			3	3 Tage pro Woche
			4	4 Tage pro Woche

VarLabel	VarName	VarShort	Wert	LABEL
			5	5 Tage pro Woche
			6	6 Tage pro Woche
			7	7 Tage pro Woche
			8	Seltener
T37.31 Früchte, Fruchtsäfte: Menge (Portionen/Tag)	TERNA23	EFrüchtePort	0	Weniger als 1 Portion pro Tag
			1	1 Portion pro Tag
			2	2 Portionen pro Tag
			3	3 Portionen pro Tag
			4	4 Portionen pro Tag
			5	5 Portionen und mehr pro Tag
T37.20 Gemüse, Salat: Häufigkeit (Tage/Woche)	TERNA20	EGemüseFrq	0	Nie
			1	1 Tag pro Woche
			2	2 Tage pro Woche
			3	3 Tage pro Woche
			4	4 Tage pro Woche
			5	5 Tage pro Woche
			6	6 Tage pro Woche
			7	7 Tage pro Woche
			8	Seltener
T37.21 Gemüse, Salat: Menge (Portionen/Tag)	TERNA21	EGemüsePort	0	Weniger als 1 Portion pro Tag
			1	1 Portion pro Tag
			2	2 Portionen pro Tag
			3	3 Portionen pro Tag
			4	4 Portionen pro Tag
			5	5 Portionen und mehr pro Tag
T37.60 Milch, Milchprodukten: Häufigkeit (Tage/Woche)	TERNA18	EMilchFrq	0	Nie
			1	1 Tag pro Woche
			2	2 Tage pro Woche
			3	3 Tage pro Woche
			4	4 Tage pro Woche
			5	5 Tage pro Woche
			6	6 Tage pro Woche
			7	7 Tage pro Woche
			8	Seltener
T37.61 Milch, Milchprodukten: Menge (Portionen/Tag)	TERNA24	EMilchPort	0	Weniger als 1 Portion pro Tag
			1	Etwa 1 Portion pro Tag
			2	2 Portionen pro Tag
			3	3 Portionen pro Tag
			4	4 Portionen und mehr pro Tag
Fisch, Score (Produkt aus Häufigkeit und 1 Portion)	FISCHr	FISCHr	NA	Numerisch
Fisch, Häufigkeit	FISCH	FISCH	0	Wenig
			1	Mässig
			2	Viel
Fleisch, Score (Produkt aus Häufigkeit und 1 Portion)	FLEISCHr	FLEISCHr	NA	Numerisch
Fleisch, Häufigkeit	FLEISCH	FLEISCH	0	Wenig

VarLabel	VarName	VarShort	Wert	LABEL
			1	Mässig
			2	Viel
Früchte, Score (Produkt aus Häufigkeit und Portion/Menge)	FRUECHTEr	FRUECHTEr	NA	Numerisch
Früchte, Häufigkeit und Menge	FRUECHTE	FRUECHTE	0	Wenig
			1	Mässig
			2	Viel
Gemüse, Score (Produkt aus Häufigkeit und Portion/Menge)	GEMUESEr	GEMUESEr	NA	Numerisch
Gemüse, Häufigkeit and Menge	GEMUESE	GEMUESE	0	Wenig
			1	Mässig
			2	Viel
Milchprodukte, Score (Produkt aus Häufigkeit und Portion/Menge)	MILCHr	MILCHr	NA	Numerisch
Milchprodukte, Häufigkeit und Menge	MILCHPROD	MILCHPROD	0	Wenig
			1	Mässig
			2	Viel
S35.1 IPAQ SF: Mässig anstrengende Aktivitäten (7 Tage): Gesamtdauer (Minuten/Tag)	SKOBW06	Q_Mod_Dur	NA	Numerisch
S35 IPAQ SF: Mässig anstrengende Aktivitäten (7 Tage): Häufigkeit (Tage/Woche)	SKOBW05	Q_Mod_Frq	NA	Numerisch
S37 IPAQ SF: sitzende Stellung (Montag bis Freitag): Gesamtdauer (Minuten/Tag)	SKOBW09	Q_Sit_Dur	NA	Numerisch
S34.1 IPAQ SF: Intensive körperliche Aktivitäten (7 Tage): Gesamtdauer (Minuten/Tag)	SKOBW04	Q_Vig_Dur	NA	Numerisch
S34 IPAQ SF: Intensive körperliche Aktivitäten (7 Tage): Häufigkeit (Tage/Woche)	SKOBW03	Q_Vig_Frq	NA	Numerisch
S36.1 IPAQ SF: Zu Fuss gehen mindestens 10 Minuten (7 Tage): Gesamtdauer (Minuten/Tag)	SKOBW08	Q_Wlk_Dur	NA	Numerisch
S36 IPAQ SF: Zu Fuss gehen mindestens 10 Minuten (7 Tage): Häufigkeit (Tage/Woche)	SKOBW07	Q_Wlk_Frq	NA	Numerisch
Geschlecht	SEX	SEX	1	Mann
			2	Frau
T36.30 Gymnastik, Fitness, Sport treiben	TKOBW06	TKOBW06	1	Ja
			2	Nein
T36.10 Körperliche Aktivität mit ausser Atem kommen: Häufigkeit (Tage/Woche)	TKOBW09	TKOBW09	NA	Numerisch
T36.11 Körperliche Aktivität mit ausser Atem kommen: Gesamtdauer (Minuten/Tag)	TKOBW11	TKOBW11	NA	Numerisch
T36.21 Fortbewegung zu Fuss oder Velo: Gesamtdauer (Minuten/Tag)	TKOBW12	TKOBW12	NA	Numerisch
T36.31 Gymnastik, Fitness, Sport: Häufigkeit	TKOBW13	TKOBW13	1	(Fast) täglich
			2	Mehrmals wöchentlich
			3	Etwa 1 Mal pro Woche
			4	Etwa 1-3 Mal pro Monat
			5	Seltener als 1 Mal pro Monat
T36.40 Genügende körperliche Bewegung für die Gesundheit (Meinung)	TKOBW14	TKOBW14	1	Ja
			2	Nein
T36.32 Gymnastik, Fitness, Sport: Gesamtdauer (Minuten/Woche)	TKOBW15	TKOBW15	NA	Numerisch

Included in this list of covariables are a set of physical activity variables from a standardized questionnaire, called International Physical Activity Questionnaire (IPAQ) - Short Form (http://www.ipaq.ki.se):
S35, “moderate intensive activity” (frequency and duration),

S34, “vigorous intensive activity” (frequency and duration) and
S36, “walking activity” (frequency and duration).
An additional optional question is the duration of “sitting position (Monday through Friday)”.
The first 3 questions are combined to a total MET (multiple of resting metabolic rate) score in minutes. MET-minutes scores are equivalent to kilocalories for a 60 kg person. The final score for each participant is therefore adjusted to its body weight to give the total **METkcl** score in kilocalories.

Results

Important Note: As with all statistical model calculations, a high or low correlation between dependent variable and independent covariables does NOT imply a high or low causal relationship between these variables.

a) All, men and women

The model equation of the final result of the stepwise backward logistic regression is:

```
logit(Hypertension) =
 - 16.3        * Male
 - 16.3        * Female
 + 0.0601      * Age
 + 3.48        * logBMI
 - 0.00000595  * MET_kcal
 + 0.42        * MedDiet
 + 0.047       * MeatEater
 - 0.00937     * Milchprod
```

In order to get the final numeric result for logit(Hypertension) of a particular person, the variables need to be replaced by the appropriate values, e.g. for a male, Male=1 and of course Female=0. In contrast, for a female, Male=0 and Female=1. For people with medical diet, MedDiet=1, and no medical diet, MedDiet=0 and so forth. Since BMI and MET_kcal are continuous variables, the actual value of a person’s BMI and physical activity score are used.

For example, the probability of a 50 years old woman with BMI=30 (i.e. log(BMI)=1.477), a physical activity score of 3000 kcal, with no medical diet and moderate eater of milk products would be 0.027%, calculated as follows:

```
logit(Hypertension) = - 16.3 + 0.0601 * 50 + 3.48 * 1.477
 - 0.00000595 * 3000 - 0.00937 * 2 = -8.21
prob(Hypertension) = exp(-8.21) / (1 + exp(-8.21)) = 0.0271%
```

The odds ratios of each statistically significant variable are as follows:

Factor	OR
Male	0.0000
Female	0.0000

Age	1.0619
logBMI	32.4874
MET_kcal	1.0000
MedDiet	1.5215
MeatEater	1.0482
Milchprod	0.9907

An odds ratio of 1 indicates "*no effect"*. For MET_kcal, it seems there is no effect but the full digits value is 0. 0.9999941and the median MET_kcal is around 3500 kcal, meaning a very small but statistically significant negative effect. A similar negative effect, reducing the probability of hypertension, has the factor eating milk products. The OR of BMI (transformed to its logarithm) is compared to the depression model much higher and similar to the value of the diabetes model. The OR of Male/Female is close to 0 and corresponds to an intercept of nearly 0, indicating the probability of a man/woman for hypertension, at 0 age and with all other factors kept to 0. There seems to be no difference in probability for hypertension between men and women.

b) All men

The model equation of the final result of the stepwise backward logistic regression for men is:

```
logit(Hypertension) =
 - 18.5    * Intercept
 + 0.0591  * Age
 + 4.14    * logBMI
 + 0.502   * MedDiet
 + 0.00972 * VegEater
 + 0.0591  * MeatEater
 - 0.0182  * MilchProd
```

For example, the probability of a 50 years old man with BMI=30 (i.e. log(BMI)=1.477), eating 5 times per week a lot of meat (5*2=10) would be 0.015%, calculated as follows:

```
logit(Hypertension) =  - 18.5 + 0.0591 * 50 + 4.14 * 1.477 + 0.0591
* 10 = -8.84
prob(Hypertension) = exp(-8.84) / (1 + exp(-8.84)) = 0.0145%
```

(all final numbers are the results of full precision calculation)

The odds ratios of each statistically significant variable is as follows:

Factor	OR
Intercept	0.0000
Age	1.0609
logBMI	62.5932
MedDiet	1.6520

VegEater	1.0098
MeatEater	1.0609
Milk Prod	0.9819

Most interestingly, Fitness and physical activity seem to have no statistical significant effect on the probability of hypertension in men. The highest impact comes from the BMI. Positively related are also medical diet, age, eating meat and eating vegetables. Milk products seem to have a slight reducing effect on the probability for hypertension with men.

c) All women

The model equation of the final result of the stepwise backward logistic regression for women is:

```
logit(Hypertension) =
 - 15.2      * Intercept
 + 0.0622    * Age
 + 3.08      * logBMI
 - 0.0000115 * MET_kcal
 + 0.357     * MedDiet
 + 0.0365    * Meateater
```

As compared to men, there is at least a small reducing effect of physical activity on the probability for hypertension with women. In contrast, milk products, fish and vegetables are absent, but eating meat is not favourable.

The odds ratios of each statistically significant variable give a better effect measure and is as follows:

Factor	OR
Intercept	0.0000
Age	1.0642
logBMI	21.8581
MET_kcal	1.0000
MedDiet	1.4294
MeatEater	1.0371

Also with women, BMI is the most important adverse factor for hypertension but the effect is smaller compared to men. In contrast to men, physical activity (full precision 0.9999885) reduces slightly the risk for hypertension. Medical diet and eating a lot of meat seem to increase the risk for hypertension with women. No other reducing or increasing factors are statistically significant.

d) Adults > 25, men and women

(see statistical report of Model 5)

e) Adults > 25, men only

(see statistical report of Model 5)

f) Adults > 25, women only

(see statistical report of Model 5)

g) Summary of results – Correlation Hypertension vs. various factors

The following graph shows essential, statistically significant correlations between hypertension and various other factors (OR)

SGB 12	Variable	all	all >24	men	men >25	women	women >25
	BMI	32.5	38.3	62.6	72.7	21.9	26.2
DIAET2	Diät aus medizinischen Gründen	1.52	1.52	1.65	1.60	1.43	1.46

positive correlation

negative correlation

Using a logistic regression model, various factors - considered important in the context of suffering from hypertension – were tested for their influence on the manifestation of hypertension.
BMI was most impressively linked to the occurrence of hypertension in the entire segment of the Swiss population investigated, i.e. as body weight increases the chances of suffering from hypertension increases drastically. Furthermore, participating in a dietary program for medical reasons was also an important factor in the context of the manifestation of hypertension.