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Overweight and obesity in 6–12 year old children in Switzerland

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Summary

Objectives: Our aim was to estimate the national prevalence of overweight and obesity in Swiss primary schoolchildren and to determine if adiposity is increasing in this age group.

Methods: We used a cross-sectional, 3-stage, probability-proportionate-to-size cluster sampling of primary schools throughout Switzerland to obtain a representative national sample of 6–12 year old children (n = 2431). Height and weight were measured and used to calculate body mass index (BMI). BMI references from the U.S. Centers for Disease Control and Prevention (CDC) and the International Obesity Task Force (IOTF) were used to define adiposity. The triceps, biceps, subscapular and suprailiac skinfold thickness (SFT) was measured and used to calculate body fat percentage (BF%). BMI and BF% were compared to data from 6–12 year old Swiss children in the 1960's and 1980's.

Results: BMI and BF% were well correlated in both boys and girls ($r^2 = 0.74$). Using the IOTF references, the prevalence of overweight and obesity was 16.6% and 3.8% in boys and 19.1% and 3.7% in girls. Using the CDC references, the prevalence of overweight and obesity was 19.9% and 7.4% in boys and 18.9% and 5.7% in girls. There was no significant age or gender difference in the prevalence of overweight or obesity. At all ages, boys and girls had 50–100% higher mean BF% than Swiss children from the 1960's and 1980's. Using the current CDC BMI references, the prevalence of overweight has increased more than 5-fold in Swiss children since the mid-1980's.

Conclusions: These findings suggest there has been a striking increase in BF% and the prevalence of overweight and obesity in Swiss children in the last two decades.

Key words: body mass index; skinfold thickness; anthropometry; percentage body fat; obesity; overweight; children; Switzerland

Introduction

Paediatric obesity is becoming more common in the US and Western Europe [1, 2]. France, the Netherlands and the U.K. have reported recent increases in the prevalence of overweight among children and adolescents [1–4]. In the US, the prevalence of obesity increased from 8% to 14% in 6–12 year old children between 1976 and 1994 [5]. Obesity increases the risk for type 2 diabetes, hypertension and hyperlipidaemia during childhood and adolescence [6, 7]. It also has adverse affects on adult health. The risk of adult overweight is twofold greater for individuals who were overweight as children compared with individuals who were not overweight [8]. Compared to normal weight children, overweight children are at higher risk for developing coronary heart disease, Type 2 diabetes mellitus and respiratory disease as adults [9, 10].

There are no nationally representative data on the prevalence of adiposity in children in Switzerland. Previous studies have focused either on specific regions or were limited by small sample sizes [11]. In 1999, during a national iodine nutrition survey, we measured weight and height in 6–12 year old children in Switzerland and reported that the prevalence of obesity was ≈10% and the prevalence of overweight ≈22% [12]. However, these findings were subject to several limitations. Firstly, the moderate sample size (n = 595) may have reduced the study's precision. Secondly, we used body mass index (BMI) cut-offs of percentiles for age and sex relative to several reference populations (United Kingdom, France, U.S) that produced varying estimates of adiposity prevalence. Since then an international consensus definition of

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child overweight and obesity has been proposed [13]. New growth charts from the U.S. Centers for Disease Control and Prevention (CDC) also include an age and sex specific BMI reference for children [14].

However, BMI is an expression of weight not adiposity. Although practical and reproducible, the correlation coefficient of BMI with body fat percentage (BF%) by DXA or densitometry in children varies between 0.4 and 0.9 depending on age, ethnicity and gender [15, 16]. Moreover, the accuracy of the IOTF and CDC BMI references in classifying adiposity in children has not yet been validated in most countries [17]. In clinical and public health settings, body fatness has traditionally been estimated from skinfold thickness (SFT) [18]. Although single SFT measurements have only limited precision, reproducibility is improved using multisite measurements integrated into validated prediction equations [19–21]. Schaefer et al. [20] reported an intra-observer CV of 2%, corresponding to 0.4% of fractional fat mass, using multisite SFT in children. SFT measurements can accurately predict BF% in childhood [20, 22, 23].

Our study aim was to estimate the current national prevalence of overweight and obesity in 6–12 year old children in Switzerland. We assessed BF% using multisite SFT to judge the performance of BMI as a predictor of adiposity in our sample. Finally, we compared our BMI and BF% data to those from 6–12 year old Swiss children in the 1960's and 1980's.

Subjects and methods

A probability-proportionate-to-size (PPS) cluster sampling was used to obtain a representative national sample of 2600 Swiss children aged 6–12 years. This represents about 1 in 250 children in this age group in Switzerland [24]. PPS cluster sampling is a widely used and recommended method for anthropometric school based surveys. Current census data was used to provide a systematic sampling of urban and rural communities based on the cumulative population. Sixty communities and schools across Switzerland were identified by stratified random selection. Schools that declined participation were systematically replaced by other randomly selected schools from the same strata. Three or four classrooms were then randomly selected from each school and all students from the selected classrooms were invited to participate. An average of 45 students was sampled at each school. The number varied depending on the size of the classrooms. We did not obtain data on the socio-economic class of the families or the national origin of the parents of the participating children. The location of the clusters is shown in figure 1 and included: 1. Western region: Avully, Fribourg, Genève, La Chaux-de-Fonds, Lausanne, Meyrin, Morges, Orbe, Porrentruy, Renens, Romont FR, Sierre, Yverdon-les-Bains; 2. Central and eastern region: Altdorf UR, Chur, Jona, Kriens, Luzern, Nottwil, Sargans, Schiers, Spiez, Thusis, Wittenbach; 3. Northcentral region: Basel, Bern, Biberist, Bolligen, Burgdorf, Münsingen, Niederwangen, Pratteln, Reinach BL, Zofingen; 4. Northeastern region: Aarau, Frauenfeld, Herrliberg, Lenzburg, Maur, Niederhasli, Oberbüren, Regensdorf, Schaffhausen, Villmergen, Wädenswil, Wetzikon, Winterthur, Zürich; 5. Southern region: Ascona, Bellinzona, Giubiasco, Locarno.

Ethical approval for the study was obtained from the Swiss Federal Institute of Technology, Zurich. Written informed consent was obtained from the school physician, the teachers and the parents of the children. For the measurements subjects removed their shoes, emptied their pockets and wore light indoor clothing. Height and weight were measured using standard anthropometric technique [18]. Body weight was measured to the nearest 0.1 kg using a TANITA Digital Scale HD-313 (Itin Scale, Brooklyn, USA) calibrated with standard weights. Height was measured to the nearest 0.1 cm using a pull-down metal measuring tape (personcheck® REF 44 444, Medizintechnik KaWe, Kirchner & Wilhelm, Germany).

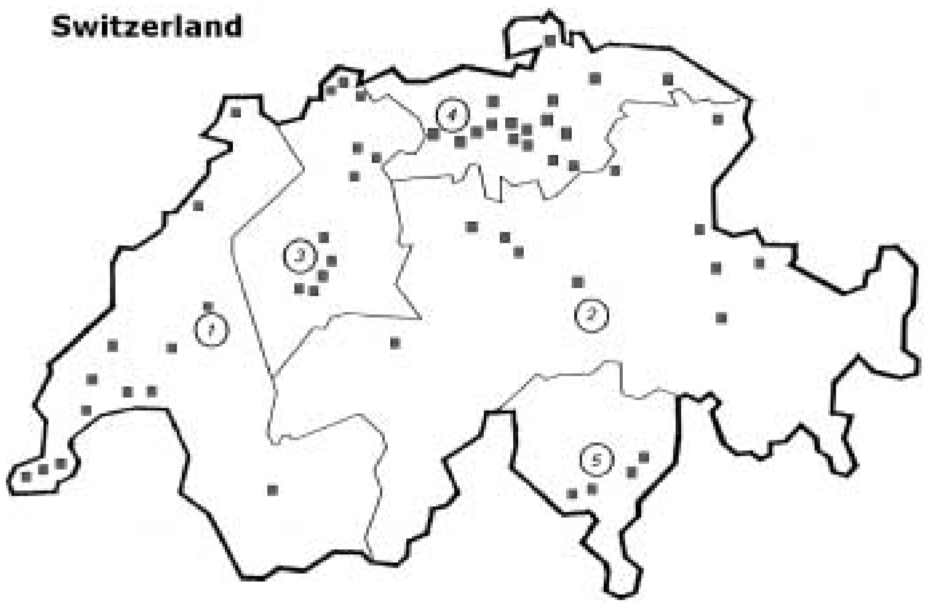

Figure 1

Map of Switzerland showing geographic regions and the location of the probability-proportionate-to-size sampling clusters (n = 60).

SFT were measured by two trained examiners (CG and CP) using a Harpenden Skinfold Caliper (HSK-BI, British Indicators, UK) with a constant spring pressure of 10 g/mm^2 and a resolution of 0.2 mm. SFT were measured at the triceps, biceps, subscapular and suprailiac sites [25]. For the triceps, the mid-point of the back of the upper arm between the tip of the olecranon and acromial process was determined by measuring with the arm flexed at 90 degrees. With the arm hanging freely at the side, the caliper was applied vertically above the olecranon at the marked level. Over the biceps, the SFT was measured at the same level as the triceps, with the arm hanging freely and the palm facing outwards. At the subscapular site, the SFT was picked up just below the inferior angle of the scapula at 45° to the vertical along the natural cleavage lines of the skin. The suprailiac SFT was measured above the iliac crest, just posterior to the midaxillary line and parallel to the cleavage lines of the skin, the arm lightly held forward. All sites were measured on the right site of the body in duplicate. At each site, 10% of the SFT were repeated by a second examiner to calculate inter-observer variation.

Data and statistical analysis

Using the mean value of the repeated SFT, the body density and body fat percentage (BF%) were calculated using the following equations [26]:

BF(%) = ([562 – 4.2 (Age(y) – 2])/D – (525 – 4.7 [Age(y) – 2])

where D = body density

For boys: D (g/ml) = 1.169–0.0788 × log10 (sum of 4 SFT [mm])

For girls: D (g/ml) = 1.2063–0.0999 × log10 (sum of 4 SFT [mm])

The mean regression coefficients (SE) for prediction of BF% from logfour SFTs using these equations in prepubertal boys and girls are 26.56 (3.00) and 29.85 (3.25), respectively [26].

Statistical analysis was done using SPLUS 2000 (Insightful, Seattle, USA), Excel 97 (Microsoft, USA) and Prism3 (GraphPad, San Diego, USA). Inter- and intra-observer variation in SFT measurement was expressed as the coefficient of variation. The 85th and 95th centiles of BF%-for-age were calculated separately for boys and girls by quantile regression [27]. BMI was calculated as weight in kg divided by height in m^2. As BMI does not follow a Gaussian distribution, a shifted logarithmic transformation, log (x-11), was done to make the age-dependent distribution of BMI nearly Gaussian, as judged by its negligible skewness and kurtosis. Regression of BMI on BF% by gender was done to describe their relationship. The BMIs of the children were compared to the IOTF reference data [13] as well as to reference data from the CDC [14]. Children with a BMI at or above the age-specific cut-off values were defined as overweight or obese. Prevalence data were expressed as percentages and 95% confidence intervals and compared using chi-square tests. We compared our data to the findings of the 1st Zurich Longitudinal Study (1st ZLS), a prospective study of longitudinal growth in 232 healthy middle-class Swiss children who were 6–12 years old from 1960–1965 [28] and the 2nd Zurich Longitudinal Study (2nd ZLS), a prospective study of longitudinal growth in 205 healthy Swiss children who were 6–12 years old from 1980–1990 [29]. In the 2nd ZLS only triceps and subscapular skin folds were measured and Deurenberg's formula for BF% [26] could not be used. We estimated the regression of BF% on log (triceps) and log (subscapular) in the 1st ZLS and used this regression equation to estimate BF% in the 2nd ZLS. Prevalence rates were expressed as percentages and compared. *P* values <0.05 were considered significant.

Results

At the schools 3413 children were invited to participate and 2672 accepted. Of these, 64 were absent on the day of measurement. The overall response rate was 76.4%. Two percent of the subjects participated in the weight and height measurement but declined the SFT measurements. After discarding subjects with incomplete data and a small number of subjects 13 years or older, a sample of 2431 subjects remained. The sample included 1235 girls [age (mean ± SD) 9.8 ± 1.8 yrs] and 1196 boys [age (mean ± SD) 9.8 ± 1.8 yrs]. The inter-observer and intra-observer variation in the measurement of SFT were 3.1% and 1.8%, respectively. Table 1 shows the 85th and 95th percentiles for BF% calculated from the four SFT using the Deurenberg equation as calculated by quantile regression, by age (yr) and gender. The regression of BMI on percentage body fat (BF%) was highly significant for both boys and girls (R^2 = 0.74).

The prevalence of overweight and obesity in the sample was measured by age (yr) and gender using the IOTF and CDC BMI references are shown in table 2. There was no significant gender difference and no significant age effect on the prevalence of either overweight or obesity. Table 3 shows the prevalence of overweight by geographic region and a comparison of the urban and rural clusters. There were no significant geographic and/or demographic differences in the prevalence of adiposity and no significant geographic and/or demographic differences in BF% (data not shown). Table 4 shows by age and gender the BF% in Swiss children in the 1st Zurich Longitudinal Study (1st ZLS), the 2nd Zurich Longitudinal Study (2nd ZLS) and the present study, for which the subjects were grouped within 1 year intervals (<6.5, 6.5–7.5, etc). Compared to the 1st and 2nd ZLS, BF% was clearly higher in both sexes at all ages in

Table 1
The 85th and 95th percentile cut-offs for body fat percentage by gender calculated from four measurements of skinfold-thickness in a national sample of 6–12 year old Swiss children.

Age	Percentage body fat			
	boys 85%	boys 95%	girls 85%	girls 95%
6 y	16.42	26.75	21.57	30.11
7 y	18.62	28.25	21.57	30.11
8 y	20.97	29.79	25.65	33.20
9 y	23.45	31.37	27.82	34.80
10 y	26.07	32.99	30.08	36.44
11 y	28.83	34.65	32.42	38.12
12 y	31.73	36.35	34.86	39.84

the present study, while no important difference was seen between the 1st and 2nd ZLS. Table 5 shows the prevalence of adiposity in Swiss children by gender in the 1st and 2nd ZLS and the present study. Compared to the 1st and 2nd ZLS the prevalence of overweight and obesity was markedly higher in both sexes in the present study.

Table 2
The prevalence* of overweight and obesity in a national sample of 6–12 year old Swiss children (n = 2431) by age and gender using the IOTF [12] and CDC [13] BMI reference criteria.

	IOTF references		CDC references	
Age N	overweight	obese	overweight	obese
6 y				
Boys 40	20.0 (6.3)	5.00 (3.35)	30.0 (7.2)	7.50 (4.16)
Girls 38	18.4 (6.3)	7.89 (4.37)	18.4 (6.3)	13.2 (5.5)
7 y				
Boys 227	15.0 (2.4)	3.96 (1.30)	20.3 (2.7)	8.37 (1.84)
Girls 236	20.3 (2.6)	4.66 (1.37)	20.8 (2.6)	7.63 (1.73)
8 y				
Boys 183	17.5 (2.8)	3.83 (1.42)	21.9 (3.1)	7.65 (1.96)
Girls 172	19.2 (3.0)	2.91 (1.28)	19.2 (3.0)	4.07 (1.51)
9 y				
Boys 167	18.6 (3.0)	4.19 (1.55)	21.0 (3.1)	8.98 (2.21)
Girls 178	19.1 (2.9)	3.37 (1.35)	19.1 (2.9)	6.74 (1.88)
10 y				
Boys 214	19.6 (2.7)	4.67 (1.44)	22.4 (2.9)	7.94 (1.85)
Girls 220	20.0 (2.7)	3.18 (1.18)	18.6 (2.6)	3.18 (1.18)
11 y				
Boys 207	13.0 (2.3)	2.90 (1.17)	15.0 (2.5)	5.31 (1.56)
Girls 213	17.8 (2.6)	3.29 (1.22)	17.8 (2.6)	5.63 (1.58)
12 y				
Boys 158	15.2 (2.9)	3.16 (1.39)	16.5 (2.9)	6.33 (1.94)
Girls 178	18.0 (2.9)	3.93 (1.46)	18.0 (2.9)	5.06 (1.64)
All				
Boys 1196	16.6 (1.1)	3.85 (0.56)	19.9 (1.2)	7.44 (0.76)
Girls 1235	19.1 (1.1)	3.72 (0.54)	18.9 (1.1)	5.67 (0.66)

* As percentages (SE)

Table 3
The prevalence*, ** of overweight and obesity in a national sample of 6–12 year old Swiss children (n = 2431) by geographic and demographic location.

Geographic region		population of cluster			
		>150,000	10,000–150,000	<10,000	Total
South (Italian language)	overweight	NA	22.8 (5.6)	18.4 (3.8)	20.0 (3.2)
	obese	NA	8.8 (3.7)	5.8 (2.3)	6.9 (2.0)
Northeast (German language)	overweight	20.0 (2.3)	16.6 (2.3)	15.2 (3.5)	17.9 (1.5)
	obese	5.0 (1.3)	4.5 (1.3)	3.8 (1.9)	4.6 (0.8)
Northwest (German language)	overweight	17.6 (2.3)	26.2 (4.8)	29.3 (4.6)	21.6 (1.9)
	obese	7.4 (1.6)	9.5 (3.2)	7.1 (2.6)	7.7 (1.2)
Central east (German language)	overweight	23.2 (4.7)	20.9 (4.3)	16.1 (1.9)	18.0 (1.7)
	obese	6.1 (2.6)	9.9 (3.1)	5.4 (1.2)	6.3 (1.1)
West (French language)	overweight	23.5 (2.8)	18.0 (3.0)	19.2 (2.7)	20.5 (1.6)
	obese	10.2 (2.0)	7.4 (2.1)	5.9 (1.6)	7.9 (1.1)
Total	overweight	20.4 (1.3)	19.3 (1.5)	18.5 (1.3)	19.4 (0.8)
	obese	7.2 (0.9)	7.0 (1.0)	5.6 (0.8)	6.5 (0.5)

* As percentages (SE)
** Using the CDC BMI reference criteria [13].

Table 4
Body fat percentage* in Swiss children in the 1st Zurich Longitudinal Study [28], the 2nd Zurich Longitudinal Study [29] and the present study by age and sex.

	Boys			girls		
Age (yr)	1st ZLS (1960–65)	2nd ZLS (1980–90)	2002	1st ZLS (1960–65)	2nd ZLS (1980–90)	2002
6	7.6 (3.5)	7.0 (2.9)	7.5 (4.7)**	6.2 (4.5)	4.3 (4.4)	17.6 (10.9)***
7	7.5 (3.5)	7.5 (3.7)	11.8 (6.0)	6.7 (5.1)	5.6 (5.0)	13.9 (8.3)
8	8.1 (3.8)	7.8 (4.0)	13.9 (7.4)	7.7 (6.0)	6.2 (5.0)	15.2 (8.3)
9	8.5 (3.9)	9.0 (4.4)	15.4 (7.4)	9.0 (6.0)	8.8 (5.2)	17.3 (8.6)
10	9.2 (4.2)	10.7 (4.8)	19.0 (8.3)	10.8 (7.2)	10.4 (5.6)	20.6 (9.6)
11	10.3 (4.5)	NA	18.3 (7.9)	11.5 (7.4)	NA	21.6 (8.9)
12	11.6 (5.2)	NA	21.3 (8.6)	13.6 (7.8)	NA	22.9 (9.3)

* As means (SE) ** n = 4 *** n = 5

Discussion

The prevalence estimates reported here for Swiss children aged 6–12 years (table 2) are similar to those recently reported in French children aged 7–9 years, where, using the IOTF and CDC criteria, 18.1 and 20.9% of children were overweight and 3.8 and 6.4% were obese [3]. They are also comparable with 1998 national prevalence data from England, where circa 20% and 4% of children are overweight and obese, respectively [4] but lower than the prevalence of childhood overweight reported from Italy, Germany and Hungary [30]. They are also lower than data from US children. In the U.S. NHANES III Study, the prevalence of overweight in boys aged 9–11 years was 25.2 and 27.8%, using the IOTF and CDC references, respectively, and the prevalence of obesity was 6.5 and 12.8%. In the NHANES III the prevalence of overweight in U.S. girls aged 9–11 y was 26.4 and 25.6%, using the IOTF and CDC references, respectively and the prevalence of obesity was 8.8 and 11.0% [5].

Several European countries and the U.S. have reported an increasing prevalence of overweight among children and adolescents. Our data suggests a similar increase is occurring in Switzerland. As shown in tables 4 and 5, there was no significant difference in BF% or adiposity between children in the 1st and 2nd ZLS. However, since the 2nd ZLS in the mid-1980's, BF% has increased 50–100% at all ages in both sexes (table 4) and, using the CDC BMI references, the prevalence of overweight has increased 5-fold in boys and 6-fold in girls (table 5). Because the 1st and 2nd ZLS data are regional, from northern Switzerland, they allow only limited comparisons with the present national sample. However, the findings do suggest a sharp increase in adiposity among 6–12 year old children over the past 20 years in Switzerland.

Although the study was designed to obtain a representative sample of schoolchildren in Switzerland, its findings are subject to several limitations. Seventeen of 60 schools initially contacted declined participation. Although they were replaced by other randomly selected schools from the same strata, the health profile of students in schools not willing to participate may have been different from that of those in the participating schools. Also, the data may contain some responder bias. The overall response rate in the participating schools was 76% and parents with obese children may have been less likely to provide informed consent. In several schools, teachers reported that obese children tended to decline participation in order to avoid having to partly undress for the SFT measurements. Although we emphasized in the information to parents that their children would be examined in a private setting, the data are likely to contain some responder bias and our prevalence estimates, particularly for obesity, may be somewhat low. Another limitation to this study is that we did not obtain data on pubertal status. Particularly in the older girls, pubertal status is an important determinant of BF%.

In 6–12 year old Swiss children, BMI is a good proxy measure of adiposity. We found a strong and age-independent association between BMI and BF% calculated from SFT. By regression, 74% of variability of BF% was explained by BMI, in both boys and girls. Similarly, Mei et al. [31], using data from 6–11 year old U.S. children, found excellent correlation between BMI-for-age and the average of the triceps and subscapular SFT (correlation coefficients were 0.88 and 0.85 for boys and girls, respectively). In our sample comparing the CDC and IOTF references, the IOTF cut-offs produced a lower prevalence estimate for overweight in boys, as well as a markedly lower prevalence estimate for obesity in boys and girls [32]. This is because for ages 6–12 years the IOTF BMI cut-offs are generally higher than the CDC reference values. The CDC and IOTF BMI criteria were generated using different data sets and smoothing methods and their approach to setting cut-off points was different. Our findings are similar to those of Flegal et al. [5]. They reported that in 6–11 year old US children the IOTF criteria gave lower prevalence estimates for overweight and obesity in boys and for obesity in girls compared to the CDC criteria.

Our data suggest that the prevalence of overweight in Swiss children and its attendant health and social consequences are important public

Table 5
Prevalence*,** of overweight and obesity in Swiss children in the 1st Zurich Longitudinal Study [28], the 2nd Zurich Longitudinal Study [29] and the present study by sex.

	IOTF references		CDC references	
n	overweight	obese	overweight	obese
1st ZLS (1960–1965)				
Boys 120	3.5 (0.5)	0 (0)	5.1 (0.6)	0.25 (0.2)
Girls 112	5.7 (0.7)	0 (0)	5.8 (0.7)	0.41 (0.2)
2nd ZLS (1980–1990)				
Boys 114	1.83 (0.61)	0.61 (0.35)	3.87 (0.87)	0.81 (0.41)
Girls 91	3.10 (0.85)	0 (0)	3.10 (0.85)	0.48 (0.34)
2002				
Boys 1196	16.6 (1.1)	3.8 (0.6)	19.9 (1.2)	7.4 (0.8)
Girls 1235	19.1 (1.1)	3.7 (0.5)	18.9 (1.1)	5.7 (0.7)

* As percentages (SE)

health concerns. As treatment is often unsuccessful, prevention is the best way of controlling overweight. Health programs in Switzerland that could address these issues include education on nutrition and appropriate physical activity targeted at primary and early secondary school children. As excessive caloric restriction and/or skipping meals may be detrimental in rapidly growing children, the emphasis should be placed on increasing energy expenditure through physical activity.

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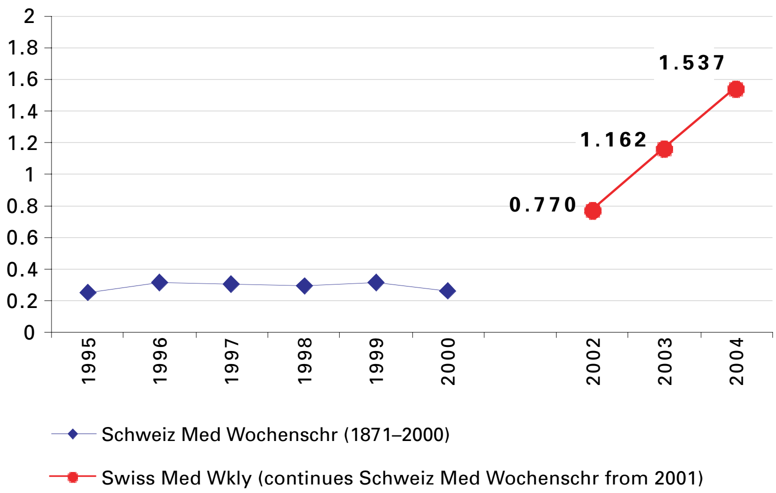

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