

## Cohesive Features in Automatic Translation of Medical Texts Meriem BENHAMLAOUI<sup>(1)</sup> & Pr Hacene HAMADA<sup>(2)</sup>

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### Abstract

*Medical texts are as particular as the contexts they occur in. Characterized by the limitation of their vocabulary, automatic translation of such texts is generally correct due to the repetition of their already translated corpora. However, machine translation is still dependent on human revision and assistance while it comes to coherence and cohesive aspects. In this paper, some light will be shed on the lack of correct cohesive devices on Google translation between English and French especially in the medical domain.*

**Key words:** *Automatic translation, coherence, cohesive device, Google translate, medical texts.*

### التناسق في النص الطبي المترجم آليا

#### ملخص

نظرا لتميز النصوص الطبية بمفرداتها التقنية، فإن الترجمة الآلية لهذه النصوص عادة ما تكون صحيحة نظرا لتكرار المدونات-المترجمة مسبقا. ومع ذلك ما تزال تعتمد الترجمة الآلية على المساعدة والمراجعة البشرية حين يتعلق الأمر بتماسك وتناسق النص. وانطلاقا من فكرة أن عملية الترجمة تقوم على مبدأ احترام الخصائص النحوية واللغوية للغة الهدف، فإن الهدف من هذه الدراسة هو استعراض بعض الأخطاء النحوية واللغوية للمترجم الإلكتروني (جوجل) التي تحول دون الوصول إلى نص مترابط متناسق عند ترجمة النصوص الطبية من اللغة الإنجليزية إلى اللغة الفرنسية.

**الكلمات المفتاحية:** ترجمة آلية، تماسك، تناسق نص، جوجل ترجمة، نص الطبي.

### *Les aspects de la cohésion dans la traduction automatique des textes médicaux*

#### Résumé

*Caractérisée par un vocabulaire spécifique, la traduction automatique du texte médical est généralement correcte vu la répétition des corpus traduits auparavant. Cependant, la traduction automatique est toujours une matière de révision et d'assistance humaine surtout en ce qui concerne la cohérence et les aspects de la cohésion. L'objectif de cette étude est d'exposer le manque des dispositifs corrects de la cohésion dans Google traduction en ligne des textes médicaux allant de l'Anglais vers le Français.*

**Mots-clés:** *Traduction automatique, cohérence, aspects de la cohésion, Google traduction, texte médical.*

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## Introduction:

In the last decades, there has been too much done and said about translation and natural language processing. Thus, computers and technologies are more and more related to linguistic subjects and natural languages translation problems. However, technological representations of linguistic structures are not often quite easy; academics<sup>(1)(2)</sup> attempt to improve human translators' job, and try to bind linguistics to computers, algorithms, data structures, and automata theories. Meanwhile, the already-existing models and algorithms are not well defined, particularly tasks which involve semantic transfer and the probabilities to understand all the problems of meanings and textual coherence between original and target texts are not yet completely figured out<sup>(3)</sup>. Hence, this research's focus is not to correct automatic translation possible mistakes but to identify, classify, and evaluate them according to their textual coherence and linguistic development in the discourse. Accordingly, the obtained results will help machine translation programmers propose and process automatic solutions to the problems.

## Problem Statement:

Automatic translators today provide passwords to access any language up to date data. This research investigates the automatic translation of medical texts as a case study in order to understand the coherence of the automatic target texts in terms of identifying the appropriate cohesive features mainly while translated from English into French. It also tries to find out whether the automatic translation is able to create coherent automatic target texts employing Google Translate as a sample. Hence, it is hypothesized that machine translation of medical articles from English into French does not provide enough cohesive features.

The corpus is English of medical texts published on the net. Translated into French – with Google online translate – both English and French corpora are analysed and compared in terms of their appropriate cohesive features in order to delineate their coherence.

## 1- Translation and Machine Translation:

Translation is such a discipline where the target language message reflects an honest representation of the source language whether on meaning or on style aspect. "Translation consists on reproducing in the receptor language the closest natural equivalent message, first in terms of meaning and secondly in terms of style."<sup>(4)</sup>

Created as the software translation of natural languages, Machine Translation is the procedure by which computers programmes are deciphering messages from one language to another, where the original meaning must be completely restored in the target one. At first glance this seems straightforward, it is much more perplexing as translation is not a word-to-word substitution. The computer must interpret and break down all the text components and analyse the impact of each word on the other. Thus, the automatic translator requires broad skills in natural languages: structure, syntax, semantics, context, etc.

## 2- Google Online Translate:

Google Translate is an automatic online service which instantaneously translates from and into 58 languages<sup>(5)</sup>. It is possible to translate words, sentences, and web pages. Google Translate is freely accessible and simple to use. As indicated by CNET News (April 26th, 2012), Google is the worldwide translator. It translates around 64 languages and there are more than two hundred million clients of its accessible programmed translation.

As indicated by the mt-archive.info, Google online translate is characterised by:

Statistical Model: Google translate is a computing system which works better each time it translates; the system intends to search for examples among the colossal accumulated collection of already translated texts. The source text sentences have been possibly translated before, somewhere among the enormous collection of translated documents that Google has gathered. By detecting patterns in the archive of documents that have already been translated by human translators, the system computes probabilities concerning what a suitable translation ought to be. Hence, the system provides the most likely translation.

Improvement of the quality of its translators over time through automatic learning and information recovery mechanisms which help Google translate to learn from its own errors.

However, the limits of Google Translate as an automatic translator are, till now, identified by its inability to translate effectively some cohesive features, notably from English into French.

### 3- Medical Language:

Linguists analysed medical content through the different eras of medical language development<sup>(6)</sup>. Analysis went from the ancient Greek Hippocratic writings from the fifth and fourth centuries BC, passing by the Latin *De Medicina* of Aulus Cornelius Celsus at the beginning of the first century AD, to the Roman Empire, with the works of Galen of Pergamum (the prince of medicine) from the second century AD<sup>(7)</sup>. During the Middle Ages Arabs brought a huge contribution to the western medicine, although the Renaissance and the appearance of the printer were the starting of the Medical Latin era, and by 1478 many of the Arabic and Greek medical sources were printed in Latin. However, by the following centuries, national languages increasingly took place at the expense of Latin, although the majority of their medical terms are from Latin origin. Meanwhile, the different national medical languages spread was almost locally limited, as the widening of English gives birth to nowadays-medical English era. In effect, for linguists, “the language of medicine is fascinating for the flow of concepts and words from one tongue to another. For medical doctors, an appreciation of the history and original meaning of words offers a new dimension to their professional language.”<sup>(8)</sup>

### 4- English to French Automatic Coherence and Cohesive Feature:

Computational linguists are trying to develop Machine Translation programs based on comparison; where the given source sentence is compared to the maximum of target sentences, then the computer model will select the best sentence. The best target sentence is the one which maximises the probability of all possible target sentences. However, this objective is not yet one hundred per cent achieved<sup>(9)</sup>.

When it comes to coherence, automatic translators get into deep water. While transferring coherence from one language to another, Google Translate is confronted to several constraints related especially to the coherence of the target texts. Yet, what originally sounds to be coherence transfer problems could be solved by cohesive analysis. To separate cohesive problems from coherence ones is not an easy task while analysing such medical corpora. However, it is possible to focus on some general cohesive issues which are practically persistent for all natural languages.

**4-1- Word Order:** Word order is the way words are organised in a sentence. The most common order of words in English is Subject Verb Object (SVO). As “a sentence is like a giant puzzle, pieces of the puzzle need to fit together to make a complete though<sup>(10)</sup>”. Therefore, in English, word order is an important aspect to establish sentence constituents; the sentence is built on a conjugated verb preceded by a subject whether the verb is transitive or not<sup>(11)</sup>. The main rules to regulate English sentences word order are the following:

- 1- In affirmative and negative sentences, the verb is obligatory preceded by a subject.
- 2- The subject should be understood to be not only a noun or a pronoun but also any nominal or pronominal group that is on the head of the sentence before the conjugated verb.
- 3- The indirect object, when formed with the preposition to, follows the direct object: The prince gifted a castle to the princess. Without the preposition to, the indirect object is directly placed before the direct object: The prince gifted the princess a castle.
- 4- If a sentence comprises elements rather than subject, verb, and object including adverbs and/or adverbial phrases, they will be disposed in a specific order;
  - Before the subject: Yesterday, learners performed a play.
  - After the object: Learners performed a play on the school stage.
  - In the middle of the verbal phrase: learners have just performed their play<sup>(12)</sup>.

**5-** Interrogative sentences are almost formed following the same model:

(word or interrogative phrase) / auxiliary or modal + subject + verb + (the rest of the sentence)<sup>(13)</sup>.

**6-** Verbs in interrogative and negative sentences are usually formed of at least two elements; the auxiliary and the verb stem, the only exception is related to the conjugation of the verb 'to be' with some tenses.

- She is happy. – Is she happy?<sup>(14)</sup>

**7-** All the other verbs which are formed using one word in the affirmative sentences (simple present and simple past) are linked to the auxiliary 'to do' while included in an interrogative sentence.

- She has blue eyes. – Does she have blue eyes?

- He built a house. – Did he build a house?<sup>(15)</sup>

**8-** Some adverbs, especially short adverbs of frequency or adverbs of time can be –sometimes should be – placed between the auxiliary and the verb stem in the affirmative sentences. In the interrogative sentences, these adverbs are – or can be – placed between the subject and the verb stem.

- She has just finished working. – Has not she yet finished working?

- Could the office soon employ a new director?

- How do you generally like your tea?<sup>(16)</sup>

**9-** Although aligning adjectives in English depends on the nature and the type of the adjective, there are many exceptions. Thus, to apply two or three adjectives to modify a noun phrase seems to be conceivable in English<sup>(17)</sup>. When modifying a head noun or a noun phrase with more than one adjective, the order of adjectives is the following: determiner, observation, physical description (shape, age, size, and then colour), origin, material, and then qualifier.

Although, the word order between English and French obeys in general to the same alignment SVO (in French: Sujet, Verbe, Complément), there are various differences in the way elements are arranged in more complex sentences than 'I bought a car' or 'J'ai acheté une voiture'.

French sentence word order is syntactically important as it indicates the grammatical function of the sentence elements. The nominal phrase (Groupe Nominal GN) placed before the conjugated verb is usually the subject, and the nominal phrase following the verb is normally the object. In case the conjugated verb receives more than one Object, the direct object is placed at the first position after the verb, and then comes the indirect object. In some cases, the verb can receive a third object which is then placed in a third position.

Despite the commonly admitted notion of French sentence structure being rigid and static and the English one more flexible and dynamic, the opposite could be more acceptable while considering the freedom of aligning the French sentence constituents. French is more likely able to disturb the canonical word order by including different elements between the SVO constituents<sup>(18)</sup>.

**4-2- Referencing Cohesion:** Referencing cohesion is such a word or words which refer to data discovered somewhere else in the text. Meanwhile, different types of referencing cohesion could be identified. First, exophora implies abstract notions and thoughts surrounding the text, such as the text context, setting, genre, and register instead of its interior<sup>(19)</sup>. Exophora is neglected as part of cohesion<sup>(20)</sup>, as it does not divulge the connection between components inside the text itself. Second, endophora joins two or more components inside the text; two fundamental parts of endophora are recognised;

✓ Anaphoric referencing is the word or words that refer backward to somebody / something which has been already recognised in the text.

✓ Cataphoric referencing is the word or words that refer forward to somebody / something which is recognised earlier in the text<sup>(21)</sup>.

Referencing cohesion is achieved either by repetition, synonymy, antonymy, or pronouns, etc. The notion of gender agreement is clearly uncovered while identifying every pronoun and its corresponding gender. This identification could be an easy task while considering the French pronouns, as the majority of French pronouns refer to someone/something who/ which is either masculine or feminine- which is not the case in English.

English Pronouns				French Pronouns					
No Gender				Feminine / Masculine					
Personal Pronouns									
Singular		Plural		Singular			Plural		
Subject	Object	Subject	Object	Sujet	COD	COI	Sujet	COD	COI
It	It	They	Them	Il	Le	Lui	Ils	Les	Leur
				Elle	La	Lui	Elles	Les	Leur
Demonstrative Pronouns									
This / That		These / Those		Celui	Celle	Ceux	Celles		
				Celui-ci	Celle-ci	Ceux-ci	Celles-ci		
				Celui-la	Celle-la	Ceux-la	Celles-la		
				Ce	Cette	Ces	Ces		
Possessive Pronouns									
Its		Theirs		Le sien	La sienne	Les siens	Les siennes		
				Le leur	La leur	Les leurs	Les leurs		

Comparison of English and French Non-human Referencing Cohesive Pronouns

The table exposes the qualitative and quantitative differences between English and French pronouns. English pronouns referencing to non-human items; objects, animals, etc, are either ‘it, its’ for singular items or ‘they, them, their, theirs’ for plural ones. Therefore, programming the equivalent gender of all the French non-human words on the automatic translators is not an easy task.

One of the problems faced by computational linguists is semantic translation problem linked to the best translation of pronouns and pronominal anaphora<sup>(22)</sup>.

Examples:

- ‘I saw the movie and it ...’ (male or female in the target language)
- ‘Whenever I visit my uncle ..., I cannot decide who is my favourite cousin ...’ (male or female)

As they require very complex reasoning, pronouns and coherence are complex entrances and open problems which are not yet automatically well handled.

**5- Material and Methods:**

**5-1- Collection of Study Material:**

The article under analysis is entitled “Weight Loss and Health Status 3 Years after Bariatric Surgery in Adolescents”. It was published on January 14<sup>th</sup>, 2016, volume 374, number 2. The article is selected from the electronic site of the international medical journal the New England Journal of Medicine (NEJM). The journal is selected due to its reputation in the field of medicine, as it is regarded as a leading periodical in its domain. NEJM has a high impact factor (55.873)<sup>(23)</sup>.

**5-2- Description of the Corpus:**

Journal’s Title	The New England Journal of Medicine (NEJM)
Founded	1812
Copyright	Massachusetts Medical Society
URL	<a href="http://www.nejm.org">www.nejm.org</a>

Table 2. Journal



Title	Weight Loss and Health Status 3 Years after Bariatric Surgery in Adolescents
URL	<a href="http://www.nejm.org/doi/full/10.1056/NEJMoa1506699#t=article">http://www.nejm.org/doi/full/10.1056/NEJMoa1506699#t=article</a>
Number of Words	1085
Pages	11 (113 – 123)
Authors	12
Tables	4
Figures	1
References	25

Table 3. Article

**6- Methodology:**

In order to answer the hypothesis, the following steps were adopted:

- The article was copied from NEJM website.
- Using Google Translate, the article was translated automatically from English into French.
- The resulting text coherence was analysed.

NEJM is one of the medical journals which follow the ICMJE recommendations. The International Committee of Medical Journal Editors (ICMJE) is a group of general medical journal editors who gather every year in order to finance their own work on the recommendations of how to conduct, report, edit and publish Scholarly Work in Medical Journals. Subsequently, the article “Weight Loss and Health Status 3 Years after Bariatric Surgery in Adolescents” follows the Introduction, Methods, Results and Discussion structure; (IMRD) or (IMRaD) structure<sup>(24)</sup>.

Medical research article consists of ten different moves (the term move means a text segment made up of a bundle of linguistic features)<sup>(25)</sup>. Each section of the IMRD structure comprises a given number of moves: three in the Introduction, three in the Methods, one in the Results, and three in the Discussion.

**7- Results:**

Cohesive devices ensure the smooth advancement of words in the text till the production of the potential coherent text.

**7-1- Word Order Transfer Problems:**

English and French possess basically the same word order; Subject + Verb + Object, although there is no consistent correspondence while translating from one of the languages to the other.

An example from the text under analysis;

Indeed, adolescent bariatric surgical case volumes doubled from approximately 800

[adjective][adjective][adjective][noun][noun]

cases in 2003 to 1600 procedures in 2009.

En effet, les adolescents volumes de cas chirurgie bariatrique doublé, passant d'environ 800 cas en 2003 à 1600 procédures en 2009.

Adding definite and non-definite articles to French noun phrases could correspond better to heavy English noun phrases;

En effet, le volume des cas de chirurgie bariatrique des adolescents a doublé, passant d'environ 800 cas en 2003 à 1600 procédures en 2009.

**Example 2:**

Few prospective studies have examined changes in body-mass index.

[adjective][adjective][noun]

Des études prospectives Peu ont examiné les changements dans l'indice de masse corporelle.

The French adverb peu is placed before the non-definite article des/d';

Peu d'études prospectives ont examiné les changements dans l'indice de masse corporelle.

In order to attend a correct translation computer parsing of the sentence should be correct. However, computers make mistakes too; they are unable to identify constantly which adjective qualifies which word and/or which noun qualifies which noun.

### Example 3:

The current report presents data on weight loss, coexisting conditions, weight-related quality of life, micronutrient levels, and additional abdominal procedures during the 3 years after the bariatric procedure.

Although weight and related are attached with a hyphen to create one adjective, and quality is directly linked to life with the preposition of to form possession, Google Translate could not order the words correctly within the target noun phrase la qualité liées au poids de la vie where poids is supposed to be lié à la qualité de vie.

Le présent rapport présente des données sur la perte de poids, les conditions coexistantes, la qualité liées au poids de la vie, les niveaux de micronutriments, et des procédures abdominales supplémentaires au cours des 3 années suivant la procédure bariatrique.

### 7-2- Reference Transfer Problems:

Referencing to a non-human linguistic antecedent creates ambiguities in the relation between words and/or phrases while translating from English to French.

#### Example 1:

Sensitivity analyses were performed to evaluate this assumption.

Des analyses de sensibilité ont été effectués pour évaluer cette hypothèse.

The French verb effectuer must agree in gender and in number with its antecedent feminine noun analyses;

Des analyses de sensibilité ont été effectuées pour évaluer cette hypothèse.

Moreover, plurality and singularity are troubling issues in the referencing transfer from English to French. For example;

At 3 years, 2% of the participants who underwent gastric bypass and 4% of those who underwent sleeve gastrectomy exceeded their baseline weight.

The possessive pronoun their placed before the nominal phrase baseline weight to generate the possessive case of 2% of the participants who underwent gastric bypass and 4% of those who underwent sleeve gastrectomy which could be replaced by the personal pronoun they.

A 3 ans, 2% des participants qui ont subi un pontage gastrique et 4% de ceux qui ont subi une gastrectomie manche dépassé leur poids de base.

The French possessive determiner leur agrees in gender and number with the noun placed after. Each one of the participants is supposed to have his/her own weight poids.

A 3 ans, 2% des participants qui ont subi un pontage gastrique et 4% de ceux qui ont subi une sleeve gastrectomie ont dépassé leurs poids de base.

Although the translation of the nominal phrase blood pressure was correctly done, Google Translate could not create a correct agreement while it comes to the past participle referring to it; La tension artérielle is feminine and the French past participle referring to it is rationally feminine. For example;

Elevated blood pressure was present in 96 participants at baseline, and at 3 years after bariatric surgery, blood pressure had normalized in 74% of the participants.

La tension artérielle élevée est présent dans 96 participants au départ, et à 3 ans après la chirurgie bariatrique, la pression artérielle était normalisée chez 74% des participants...

A better translation could be:

La tension artérielle élevée est présente chez 96 participants au départ, et à 3 ans après la chirurgie bariatrique, la pression artérielle était normalisée chez 74% des participants...

The following example illustrates another reference problem where Google Translate could not detect the correct antecedent whether it is A complete description or the statistical methods in order to create an agreement between the subject and the conjugated verb.

A complete description of the statistical methods is provided in the Supplementary Appendix.

Une description complète des méthodes statistiques sont fournies dans l'annexe supplémentaire.

### 7-3- Ambiguity Transfer Problems:

Ambiguity may appear in the original text, which would cause its existence in the target one. For example:

Poisson regression with the logarithm of person-years as an offset parameter was used to calculate unadjusted rates and 95% confidence intervals (expressed per 300 person-years).

La régression de Poisson avec le logarithme d'années-personnes en tant que paramètre de décalage a été utilisé pour calculer les taux non ajustés et les intervalles de confiance à 95% (exprimés par 300 personnes-années).

The automatic translator could not distinguish whether the antecedent of the past participle is Poisson regression or logarithm of person-years. Therefore, as the direct antecedent before the conjugated verb is the French noun le logarithme the past participle utilisé agrees with it rather than with the supposed French feminine antecedent La regression.

La régression de Poisson avec le logarithme d'années-personnes en tant que paramètre de décalage a été utilisée pour calculer les taux non ajustés et les intervalles de confiance à 95% (exprimés par 300 personnes-années).

### 7-4- Tense Transfer Problems

English and French share a satisfactory overlap of verb grammar features such as tenses, voices, auxiliaries, and participles. Yet, the number of nonconformities, which may generate hindrances to the target text production is remarkable. English simple past is generally translated to the French passé composé. Nonetheless, in the following examples Google Translator translates the conjugated verbs from the simple past to the past participles. For example:

Indeed, adolescent bariatric surgical case volumes doubled from approximately 800 cases in 2003 to 1600 procedures in 2009.

En effet, les adolescents volumes de cas chirurgie bariatrique doublé, passant d'environ 800 cas en 2003 à 1600 procédures en 2009. (a doublé rather than double)

The same tense transfer problem appears in the following example:

These models addressed missing data values by means of the maximum-likelihood method, under the data-missing-at-random assumption.

Ces modèles adressés valeurs manquantes de données au moyen de la méthode du maximum de vraisemblance, sous l'hypothèse de données manquantes au-aléatoire. (ont adressés/ ont traités rather than adressés)

### 7-5- Articles Transfer Problems:

Articles are notoriously constraints of translation between English and French, since French articles are tightly attached to the grammatical categories of the noun or the noun phrase they precede; a rule which English articles do not unconditionally follow. English definite article is consistently the (whatever the gender or the number of the preceded noun or noun phrase). Indefinite articles are only a and an agreeing exclusively with singular English nouns or noun phrases. French articles, on the other hand, depend on the preceded noun or noun phrase gender and number:

Definite articles: singular masculine un / singular feminine une / plural des – de

Indefinite articles: singular masculine le / singular feminine la (plus l' if the noun starts with a vowel sound) / plural les. For example:

Standard conventions were followed for the assessment of prevalence, remission, and incidence of coexisting conditions, and micronutrients were measured as described in the Supplementary Appendix. Information on additional surgical and endoscopic procedures that



were performed between 31 days after bariatric surgery and the 3-year study visit was collected with the use of a scripted interview at each visit.

As Google Translate is mainly translating word-to-word, it could not detect the necessity of articles an indefinite plural article des before the noun phrase conventions standard, and a definite plural article les before the noun informations.

Conventions standard ont été suivies pour l'évaluation de la prévalence, la rémission, et l'incidence des conditions coexistantes, et en micronutriments ont été mesurées comme décrit dans l'annexe supplémentaire. Informations sur les procédures chirurgicales et endoscopiques supplémentaires qui ont été effectuées entre 31 jours après la chirurgie bariatrique et la visite d'étude de 3 ans ont été recueillis à l'aide d'une entrevue scriptée à chaque visite.

#### 7-6- Lexis Transfer Problems:

Obviously, a word within one language may possess different meanings and several functions. Hence, to translate any word to another language could create conflicts about the target word parts of speech and/or meaning. Moreover, some medical, scientific, and technical words or expressions are static and should remain the same while translated.

sleeve gastrectomy.

gastrectomie manche.

A sleeve gastronomy is, in French, la sleeve gastrectomie ou gastroplastie verticale calibrée avec résection gastrique.

#### 7-7- Negation Transfer Problems:

Apparently, French negation is based on ne and pas, and the conjugated verb or auxiliary between them. On the other side, English negation requisites the auxiliary do and the negation sign not, excluding modals and the verb to be.

At baseline, all the participants were obese (BMI >30), whereas at 3 years, 26% of the participants were no longer obese...

Google Translate did not detect the need to add the French negation sign ne;

Au départ, tous les participants étaient obèses (IMC > 30), alors qu'à 3 ans, 26% des participants étaient plus obèses ...

#### Conclusion:

Building a coherent target text depends on the process of translation itself. Cohesive devices are the linkers which step by step tie the words to form sentences, and tie sentences to form paragraphs and texts. Hence, on one side, cohesive devices should be identified as separate items from the other sentence parts with their own meanings and functions. On the other side, the way these devices tie to the other sentence parts is supposed to be well analysed. However, Google Translate fails to identify correctly some cohesive features between English and French in medical sentences. Therefore, a clear identification, classification, and evaluation of the automatic translation possible mistakes according to the cohesive devices, textual coherence, and linguistic development in the discourse could help machine translation programmers to propose and to process automatic solutions to the target texts coherence problems.

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**Appendix Article Cohesive Features in Automatic Translation of Medical Texts:**

English	French (Google Translate)
Original Article	Article original
Weight Loss and Health Status 3 Years after Bariatric Surgery in Adolescents	Perte de poids et l'état de santé 3 ans après la chirurgie bariatrique chez les adolescents
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N Engl J Med 2016; 374:113-123 January 14, 2016 DOI: 10.1056/NEJMoa1506699	N Engl J Med 2016; 374: 113-123 January 14, 2016 DOI: 10,1056 / NEJMoa1506699
Severe obesity affects 4.4 million children and adolescents in the United States, and few effective treatments are available. Particular concern has centered on health problems among severely obese adolescents and possible treatment with bariatric surgery. Indeed, adolescent bariatric surgical case volumes doubled from approximately 800 cases in 2003 to 1600 procedures in 2009. Few prospective studies have examined changes in body-mass index (BMI, the weight	L'obésité sévère affecte 4,4 millions d'enfants et d'adolescents aux États-Unis, et peu de traitements efficaces sont disponibles. Une préoccupation particulière est centrée sur les problèmes de santé chez les adolescents sévèrement obèses et le traitement possible avec la chirurgie bariatrique. En effet, les adolescents volumes de cas chirurgie bariatrique doublé, passant d'environ 800 cas en 2003 à 1600 procédures en 2009. Des études prospectives Peu ont examiné les changements dans l'indice de masse corporelle (IMC, le poids en kilogrammes

in kilograms divided by the square of the height in meters) and outcomes of the currently used surgical procedures, and little is known about clinical events after bariatric surgery in adolescents.

To address important questions regarding the efficacy and safety of bariatric surgery in adolescents, the Teen-Longitudinal Assessment of Bariatric Surgery (Teen-LABS) study collects longitudinal, prospective clinical and laboratory data on teenagers undergoing bariatric surgery at five centers in the United States. The current report presents data on weight loss, coexisting conditions, weight-related quality of life, micronutrient levels, and additional abdominal procedures during the 3 years after the bariatric procedure.

#### Methods

##### Study Design and Participants

In this prospective, multicenter, observational study, we enrolled consecutive adolescents (19 years of age) who were undergoing any bariatric surgical procedure from March 2007 through February 2012 at participating centers. The steering committee, which is made up of the principal investigator at each site, in collaboration with the data coordinating center and the project scientist from the National Institute of Diabetes and Digestive and Kidney Diseases, designed and implemented the study. The [protocol](#) and statistical analysis plan are available with the full text of this article at NEJM.org. The first author wrote the first draft of the manuscript, and all the authors participated in critical reviews and editing. The protocol and data and safety monitoring plans were approved by the institutional review board at each institution and by a data and safety monitoring board for the study as a whole. All participants provided written informed consent.

##### Data Collection

The standardized methods we used for data collection have been described previously. Follow-up data were collected at the 6-month, 1-year, 2-year, and 3-year postoperative research visits. Most visits occurred at the clinical centers or at the participant's home; in 22 instances, assessments were conducted through self-report (Fig. S1 in the [Supplementary Appendix](#), available at NEJM.org). Research coordinators, nurse

divisé par le carré de la taille en mètres) et les résultats du moment utilisé des procédures chirurgicales, et on sait peu sur les événements cliniques après la chirurgie bariatrique chez les adolescents.

Pour répondre à des questions importantes concernant l'efficacité et l'innocuité de la chirurgie bariatrique chez les adolescents, l'évaluation de la chirurgie bariatrique (Teen-LABS) étude Teen-longitudinale recueille longitudinales, des données cliniques et de laboratoire prospectives sur les adolescents subissant une chirurgie bariatrique dans cinq centres aux États-Unis. Le présent rapport présente des données sur la perte de poids, les conditions coexistantes, la qualité liées au poids de la vie, les niveaux de micronutriments, et des procédures abdominales supplémentaires au cours des 3 années suivant la procédure bariatrique.

#### Méthodes

##### Conception et participants Étude

Dans cette étude prospective, multicentrique, étude d'observation, nous avons inscrit des adolescents consécutifs (19 ans d'âge) qui faisaient l'objet d'une intervention chirurgicale bariatrique à partir de Mars 2007 à Février 2012 à des centres participants. Le comité de pilotage, qui est composée du chercheur principal sur chaque site, en collaboration avec les données de coordination centrale et le projet scientifique de l'Institut national du diabète et des maladies digestives et rénales, conçu et mis en œuvre l'étude. Le protocole et le plan d'analyse statistique sont disponibles avec le texte intégral de cet article à NEJM.org. Le premier auteur a écrit la première version du manuscrit, et tous les auteurs ont participé à un examen critique et édition. Les plans de protocole et de données et de surveillance de la sécurité ont été approuvés par le comité d'examen institutionnel à chaque institution et par un conseil de surveillance des données et de sécurité pour l'étude dans son ensemble. Tous les participants ont donné leur consentement éclairé écrit. Collecte de données Les méthodes normalisées que nous avons utilisés pour la collecte des données ont été décrites précédemment. Les données de suivi ont été recueillies lors des visites de 6 mois, 1 an, 2 ans, et de recherche postopératoire de 3 ans. La plupart des visites ont eu lieu dans les centres cliniques ou au domicile du participant; dans 22 cas, les évaluations ont été réalisées grâce à

practitioners, and physicians were trained in protocol procedures for the collection of data. For home visits, a field examiner who was trained in protocol procedures conducted a visit at the participant's residence. Data collected during study visits were maintained in a central database by the data coordinating center. Missed visits did not necessarily indicate withdrawal from the study, because participants commonly returned for later visits even after missing a visit. Weight-related quality of life was assessed with the use of the total score from the Impact of Weight on Quality of Life-Kids10 instrument (scores range from 0 to 100, with higher scores indicating a better quality of life).

#### Definitions

Standard conventions were followed for the assessment of prevalence, remission, and incidence of coexisting conditions, and micronutrients were measured as described in the [Supplementary Appendix](#). Information on additional surgical and endoscopic procedures that were performed between 31 days after bariatric surgery and the 3-year study visit was collected with the use of a scripted interview at each visit.

#### Statistical Analysis

A complete description of the statistical methods is provided in the [Supplementary Appendix](#). Weight loss, quality of life, coexisting conditions, and micronutrient outcomes were evaluated with the use of linear mixed and generalized mixed models, with separate models according to surgical procedure. Each model included only the study visit as the independent predictor term. Estimates of least-squares means and 95% confidence intervals were generated. These models addressed missing data values by means of the maximum-likelihood method, under the data-missing-at-random assumption. Sensitivity analyses were performed to evaluate this assumption. Using linear interpolation, we generated body-weight values from the values at previous and subsequent visits. For weights that were missing at the 3-year follow-up visit, we applied a conservative 10% increase from the latest visit. On the basis of these analyses, the missing-at-random assumption was considered to be reasonable (see the [Supplementary Appendix](#)).

Event rates for subsequent abdominal

l'auto-rapport (Fig. S1 dans l'annexe supplémentaire, disponible à [NEJM.org](#)). coordonnateurs de la recherche, des infirmières praticiennes et des médecins ont été formés dans les procédures de protocole pour la collecte des données. Pour les visites à domicile, un examinateur de terrain qui a été formé dans les procédures de protocole a effectué une visite à la résidence du participant. Les données recueillies lors de visites d'étude ont été maintenues dans une base de données centrale par les données du centre de coordination. visites manquées ne sont pas nécessairement le retrait de l'étude, parce que les participants sont retournés souvent pour des visites ultérieures, même après avoir raté une visite. qualité de vie liée poids a été évaluée à l'aide de la note totale de l'impact du poids sur la qualité de l'instrument Life-Kids10 (scores vont de 0 à 100, avec des scores plus élevés indiquant une meilleure qualité de vie).

#### Définitions

conventions standard ont été suivies pour l'évaluation de la prévalence, la rémission, et l'incidence des conditions coexistantes, et en micronutriments ont été mesurées comme décrit dans l'annexe supplémentaire. Informations sur les procédures chirurgicales et endoscopiques supplémentaires qui ont été effectuées entre 31 jours après la chirurgie bariatrique et la visite d'étude de 3 ans ont été recueillis à l'aide d'une entrevue scriptée à chaque visite.

#### Analyses

Une description complète des méthodes statistiques sont fournies dans l'annexe supplémentaire. La perte de poids, la qualité de vie, les conditions coexistantes et oligoéléments résultats ont été évalués à l'utilisation de modèles mixtes mixtes et linéaires généralisés, avec des modèles distincts selon la procédure chirurgicale. Chaque modèle ne comprenait que la visite d'étude comme le terme de facteur prédictif indépendant. Les estimations des moindres carrés moyens et intervalles de confiance à 95% ont été générés. Ces modèles adressés valeurs manquantes de données au moyen de la méthode du maximum de vraisemblance, sous l'hypothèse de données manquantes au-aléatoire. Des analyses de sensibilité ont été effectués pour évaluer cette hypothèse. En utilisant l'interpolation linéaire, nous avons généré des valeurs de poids corporel à partir des valeurs de visites précédentes et suivantes. Pour les poids qui manquaient à la visite de suivi de 3 ans, nous avons appliqué une augmentation conservatrice



procedures were calculated as the number of events that occurred from 31 days after the procedure through the 3-year study visit (visit window, 2.5 to 3.5 years), divided by person-years of observation. Poisson regression with the logarithm of person-years as an offset parameter was used to calculate unadjusted rates and 95% confidence intervals (expressed per 300 person-years).

## Results

### Participants

We enrolled 242 participants in the study; 161 (67%) underwent Roux-en-Y gastric bypass, 67 (28%) underwent sleeve gastrectomy, and 14 (6%) underwent adjustable gastric banding. Because of the small size of the gastric-band cohort, these results were not included in the main analyses (see the [Supplementary Appendix](#)). At baseline, 29% of the participants were in the early teenage age groups (13 to 15 years of age), 41% were in the middle age groups (16 to 17 years of age), and 30% were in the late age groups (18 to 19 years of age) ([Table 1](#)). The mean BMI was 53 (range, 34 to 88); 98% of the participants had a BMI higher than 40. The majority of participants were from families with household incomes of less than \$50,000 per year. The majority of caregivers had completed high school, and 40% had obtained some college education.

Through the 3-year study end point, 99% of the cohort (225 of 228 participants) participated actively and completed 88% of all postoperative visits (805 of 912 visits) ([Fig. S1 in the Supplementary Appendix](#)). The rates of visit completion according to follow-up time point were 89% at 6 months (203 of 228 participants), 90% at 1 year (205 of 228), 89% at 2 years (203 of 228), and 85% at 3 years (194 of 228). A total of 89% of the postoperative visits (715 of 805) were completed at the clinical center and 8% (68 of 805) were conducted at the participant's home; 3% (22 of 805) were self-reported assessments conducted through telephone contact or electronic correspondence.

### Anthropometric Changes

At 3 years, the mean weight reduction among all participants was 41 kg, with little increase in height ([Table 1](#)). The mean percent weight loss was 27% (95% confidence interval [CI], 25 to 29) in the overall cohort: 28% (95% CI, 25 to 30;  $P < 0.001$ ) in the group that

de 10% par rapport à la dernière visite. Sur la base de ces analyses, l'hypothèse manquante-à-aléatoire a été considéré comme raisonnable (voir l'annexe supplémentaire). Les taux d'événements pour les procédures abdominales suivantes ont été calculées comme le nombre d'événements qui ont eu lieu à partir de 31 jours après la procédure par la visite d'étude de 3 ans (fenêtre de visite, de 2,5 à 3,5 ans), divisé par personne-années d'observation. La régression de Poisson avec le logarithme d'années-personnes en tant que paramètre de décalage a été utilisé pour calculer les taux non ajustés et les intervalles de confiance à 95% (exprimés par 300 personnes-années). Résultats

Les participants Nous avons recruté 242 participants à l'étude; 161 (67%) ont subi Roux-en-Y bypass gastrique, 67 (28%) ont subi une gastrectomie, et 14 (6%) ont subi un anneau gastrique ajustable. En raison de la petite taille de la cohorte gastrique bande, ces résultats ne sont pas inclus dans les analyses principales (voir l'annexe supplémentaire). Au départ, 29% des participants étaient dans les groupes d'âge adolescent précoce (13 à 15 ans d'âge), 41% dans les groupes d'âge moyen (16 à 17 ans), et 30% dans les groupes d'âge fin (18 à 19 ans) ([tableau 1](#)). L'IMC moyen était de 53 (gamme, 34 à 88); 98% des participants avaient un IMC supérieur à 40. La majorité des participants étaient issus de familles dont le revenu du ménage est inférieur à 50 000 \$ par année. La majorité des aidants naturels avait terminé leurs études secondaires, et 40% avaient obtenu des études collégiales. Grâce à la 3 ans point de fin de l'étude, 99% de la cohorte (225 de 228 participants) a participé activement et a complété 88% de toutes les visites postopératoires (805 912 visites) ([Fig. S1 dans l'annexe supplémentaire](#)). Les taux de visite terminée selon la suivi point de temps étaient 89% à 6 mois (203 de 228 participants), 90% à 1 an (205 228), 89% à 2 ans (203 de 228), et 85% à 3 ans (194 de 228). Un total de 89% des visites postopératoires (715 de 805) ont été réalisées au centre clinique et 8% (68 805) ont été réalisées au domicile du participant; 3% (22 805) étaient des évaluations autodéclarées menées par contact téléphonique ou par correspondance électronique.

changements anthropométriques A 3 ans, la réduction du poids moyen entre tous les participants était de 41 kg, avec une légère



underwent gastric bypass and 26% (95% CI, 22 to 30;  $P < 0.001$ ) in the group that underwent sleeve gastrectomy (Figure 1A). The magnitude of BMI reduction was nearly identical to that of weight reduction (Table 1, and Fig. S3 in the Supplementary Appendix). Sensitivity analyses indicated that missing values had a negligible effect on the results for weight loss (Fig. S2 in the Supplementary Appendix). At baseline, all the participants were obese (BMI  $> 30$ ), whereas at 3 years, 26% of the participants were no longer obese (Fig. S3A and S3B in the Supplementary Appendix). The proportion of participants who had a 10% or greater reduction in BMI was 89% among participants who underwent gastric bypass and 85% among participants who underwent sleeve gastrectomy. At 3 years, 2% of the participants who underwent gastric bypass and 4% of those who underwent sleeve gastrectomy exceeded their baseline weight.

#### Coexisting Conditions and Weight-Related Quality of Life

Elevated blood pressure was present in 96 participants at baseline, and at 3 years after bariatric surgery, blood pressure had normalized in 74% of the participants (95% CI, 64 to 84) who had had the condition at baseline and for whom data were available (Table 2, and Fig. S3C in the Supplementary Appendix). Four incident cases of elevated blood pressure were observed among the 98 participants with available data who had not had the condition at baseline (4%; 95% CI, 0 to 8). Dyslipidemia was present in 171 participants at baseline; at 3 years, lipid levels had normalized (without lipid-lowering therapy) in 66% of the participants (95% CI, 57 to 74) who had had the condition at baseline and for whom data were available ( $P < 0.001$ ) (Table 2 and Figure 1B, and Fig. S4 in the Supplementary Appendix). Among the 39 participants with available data who had not had dyslipidemia at baseline, 3 incident cases had developed by 3 years (8%; 95% CI, 0 to 16). At 3 years, resolution of abnormal kidney function (defined by low glomerular filtration rate or proteinuria) was observed in 86% (95% CI, 72 to 100) of the participants with available data who had had this condition at baseline, and 12 incident cases of abnormal kidney function had developed among the 124 participants with

augmentation de la hauteur (tableau 1). La perte de poids pour cent en moyenne était de 27% (95% intervalle de confiance [IC], 25 à 29 ans) dans la cohorte globale: 28% (IC 95%, 25 à 30;  $P < 0,001$ ) dans le groupe qui a subi un pontage gastrique et 26 % (IC 95%, 22-30,  $p < 0,001$ ) dans le groupe ayant subi une gastrectomie manchon (figure 1A). L'ampleur de la réduction de l'IMC était presque identique à celle de la réduction de poids (tableau 1, et la Fig. S3 à l'annexe supplémentaire). Les analyses de sensibilité indiquent que les valeurs manquantes ont eu un effet négligeable sur les résultats pour la perte de poids (Fig. S2 dans l'annexe supplémentaire). Au départ, tous les participants étaient obèses (IMC  $> 30$ ), alors qu'à 3 ans, 26% des participants étaient plus obèses (Fig. S3A et S3B dans l'annexe supplémentaire). La proportion de participants qui ont eu une réduction de 10% ou plus de l'IMC était de 89% chez les participants qui ont subi un pontage gastrique et 85% chez les participants ayant subi une gastrectomie manche. A 3 ans, 2% des participants qui ont subi un pontage gastrique et 4% de ceux qui ont subi une gastrectomie manche dépassé leur poids de base. Coexistence Conditions et poids liés à la qualité de

La tension artérielle élevée est présent dans 96 participants au départ, et à 3 ans après la chirurgie bariatrique, la pression artérielle était normalisée chez 74% des participants (95% CI, 64 à 84) qui avait eu la condition au départ et pour lesquels les données étaient (Tableau 2, et la Fig. S3C dans l'annexe supplémentaire). Quatre nouveaux cas de pression artérielle élevée ont été observées parmi les 98 participants ayant des données disponibles qui n'a pas eu la condition au départ (4%; IC à 95%, 0 à 8]). Dyslipidémie était présent dans 171 participants au départ; à 3 ans, les taux de lipides avaient normalisé (sans traitement hypolipémiant) dans 66% des participants (95% CI, 57 à 74) qui avait eu la condition au départ et pour lesquels des données étaient disponibles ( $P < 0,001$ ) (tableau 2 et la figure 1B, et Fig. S4 dans l'annexe supplémentaire). Parmi les 39 participants ayant des données disponibles qui n'avaient pas dyslipidémie au départ, 3 cas d'incident avaient mis au point par 3 ans (8%; IC à 95%, 0 à 16). A 3 ans, la résolution de la fonction rénale anormale (définie par un faible taux de filtration glomérulaire ou protéinurie) a été observée dans 86% (IC à 95%, 72 à 100) des participants ayant

data who had not had the condition at baseline (10%; 95% CI, 5 to 15).

A total of 32 participants had diabetes at baseline; 3 of these participants had type 1 diabetes, and no participants with type 1 diabetes had resolution of the condition after the surgical procedure. At baseline, among the 29 participants (13% of all participants) who had type 2 diabetes, the median glycated hemoglobin level was 6.3%, the median fasting glucose level was 110 mg per deciliter (6.1 mmol per liter), and the median insulin level was 43 IU per milliliter. At 3 years, 19 of 20 participants (95%; 95% CI, 85 to 100) with data that could be evaluated were in remission (Table 2), with a median glycated hemoglobin of 5.3%, a median fasting glucose of 88 mg per deciliter (4.9 mmol per liter), and a median insulin level of 12 IU per milliliter. No incident cases of diabetes were observed. Prediabetes was found in 19 participants (10%; 95% CI, 6 to 14) at baseline; of the participants for whom data were available, 76% (95% CI, 56 to 97) no longer had prediabetes at 3 years. Incident prediabetes had developed in 1 participant by 3 years.

We found improvements in participant-reported weight-related quality of life from baseline to the 3-year follow-up. The mean quality-of-life total score was 63 (95% CI, 61 to 65) at baseline and had increased to 83 (95% CI, 81 to 86) by 3 years ( $P < 0.001$ ) (Table S2 in the [Supplementary Appendix](#)).

#### Nutritional Measures

Low ferritin levels were found in 5% (95% CI, 2 to 8) of the participants at baseline, but at 3 years, 57% (95% CI, 50 to 65) had abnormally low levels ( $P < 0.001$ ). Vitamin B<sub>12</sub> levels declined by 35% (Table S3 in the [Supplementary Appendix](#)), and 8% of the participants had a deficiency at 3 years (Table 3). Deficiencies in vitamin A (levels  $< 301$   $\mu$ g per liter) were found at baseline in 6% (95% CI, 2 to 9) of the participants who underwent gastric bypass; at 3 years, vitamin A deficiencies were found in 16% of participants who underwent this procedure (95% CI, 9 to 24;  $P = 0.008$ ). Levels of 25-hydroxyvitamin D were insufficient ( $< 20.1$  ng per milliliter) in 37% of the participants (95% CI, 31 to 44) before the surgical procedure and did not increase significantly over time.

#### Complications and Deaths

des données disponibles qui ont eu cette condition au départ, et 12 incidents cas de la fonction rénale anormale avaient développé parmi les 124 participants avec des données qui n'avaient pas la condition au départ (10%; IC à 95%, de 5 à 15). Un total de 32 participants ont eu le diabète à l'inclusion; 3 de ces participants avaient un diabète de type 1, et aucun participant avec le diabète de type 1 a résolution de l'état après l'intervention chirurgicale. Au départ, parmi les 29 participants (13% de tous les participants) qui ont eu le diabète de type 2, le niveau médian de l'hémoglobine glyquée était de 6,3%, le niveau médian de glycémie à jeun était de 110 mg par décilitre (6,1 mmol par litre), et l'insuline médiane niveau était de 43 UI par millilitre. A 3 ans, 19 des 20 participants (95%; IC à 95%, 85 à 100) avec des données qui pourraient être évalués étaient en rémission (tableau 2), avec un taux d'hémoglobine glyquée médiane de 5,3%, une glycémie à jeun médiane de 88 mg par décilitre (4,9 mmoles par litre), et un niveau d'insuline médiane de 12 UI par ml. Aucun cas d'incidents de diabète ont été observés. Prédiabète a été trouvé dans 19 participants (10%; IC à 95%, de 6 à 14) au départ; des participants pour lesquels les données étaient disponibles, 76% (IC 95%, 56 à 97) n'a plus de prédiabète à 3 ans. prédiabète d'incidents avaient développé en 1 participant de 3 ans. Nous avons trouvé des améliorations dans la qualité liées au poids des participants déclarés de vie de base à 3 ans de suivi. Le score total moyen de qualité de vie était de 63 (IC 95%, 61 à 65) au départ et avait augmenté à 83 (IC 95%, 81 à 86) de 3 ans ( $P < 0,001$ ) (Tableau S2 dans le complémentaire Annexe).

mesures nutritionnelles les taux de ferritine bas ont été trouvés dans 5% (IC à 95%, 2 à 8) des participants au départ, mais à 3 ans, 57% (IC à 95%, 50 à 65) avaient des niveaux anormalement bas ( $P < 0,001$ ). Les niveaux de vitamine B<sub>12</sub> ont diminué de 35% (tableau S3 dans l'annexe supplémentaire), et 8% des participants avaient une carence à 3 ans (tableau 3). Les carences en vitamine A (niveaux  $< 301$  pg par litre) ont été trouvés à l'inclusion dans 6% (IC à 95%, 2 à 9) des participants qui ont subi un pontage gastrique; à 3 ans, les carences en vitamine A ont été trouvés dans 16% des participants qui ont subi cette procédure (IC à 95%, de 9 à 24;  $P = 0,008$ ). Les niveaux de 25-hydroxyvitamine D étaient insuffisantes ( $< 20,1$

Within 3 years, 47 intraabdominal procedures were performed in 30 participants (13% [95% CI, 9 to 18]) (Table 4). Three procedures (1 appendicostomy and 2 appendectomies) were unrelated to the previous bariatric procedure, whereas all others were considered to be related to the procedure. A total of 24% of the procedures were performed within the first year after the bariatric procedure, 55% within the second year, and 21% within third year. Upper endoscopic procedures (including stricture dilations) were performed in 29 participants (13%). One participant with known type 1 diabetes died 3.3 years after gastric bypass surgery, from complications of a hypoglycemic event.

#### Discussion

A majority of participants in our study had marked improvements with respect to weight, obesity-related coexisting conditions, and quality of life. The emergence of specific micronutrient deficiencies and the need for subsequent abdominal procedures indicate that there are also risks associated with bariatric surgery in this age group.

The outcomes of bariatric surgery among adolescents beyond 1 year after the procedure have rarely been described. The mean decrease in BMI after 1 year among Teen-LABS participants who underwent gastric bypass was similar to that reported in seven previous studies involving 256 adolescents (decreases of 16.5 and 17.2, respectively). In a study involving 53 younger adolescents (mean age, 14 years), a decrease of 20 in mean BMI and an increase of 5 cm in mean height was observed 3 years after sleeve gastrectomy. This decrease in BMI was greater than the decrease of 13.1 that was observed among participants who underwent sleeve gastrectomy in our study, probably in part because of the linear growth in the younger cohort, which was not seen in our cohort. In aggregate, these results suggest that adolescents can lose a clinically significant amount of weight after bariatric surgery, with the majority of patients maintaining meaningful weight loss for at least 3 years.

Among adults who undergo gastric bypass, remission of type 2 diabetes occurs in 50 to 70%, and remission of elevated blood pressure occurs in 40%. We found remission of diabetes in 95% of participants who had type 2 diabetes at baseline in our study, a

ng par millilitre) dans 37% des participants (95% CI, 31 à 44) avant l'intervention chirurgicale et n'a pas augmenté de manière significative au fil du temps.

Complications et décès  
 Dans les 3 ans, 47 procédures intraabdominales ont été effectuées dans les 30 participants (13% [IC 95%, 9 à 18]) (tableau 4). Trois procédures (1 appendicostomie et 2 appendicectomies) étaient sans rapport avec la procédure bariatrique précédente, alors que tous les autres ont été considérés comme liés à la procédure. Un total de 24% des procédures ont été réalisées dans la première année après la procédure bariatrique, 55% dans la deuxième année, et 21% en troisième année. procédures endoscopiques supérieures (y compris dilatations sténoses) ont été effectuées dans 29 participants (13%). Un participant avec le diabète de type 1 connu est mort 3,3 ans après la chirurgie de pontage gastrique, de complications d'un événement hypoglycémique.

#### Discussion

La majorité des participants à notre étude avait marqué des améliorations en ce qui concerne le poids, les conditions coexistantes liées à l'obésité, et la qualité de vie. L'apparition de carences en micronutriments spécifiques et la nécessité de procédures abdominales ultérieures indiquent qu'il ya aussi des risques associés à la chirurgie bariatrique dans ce groupe d'âge. Les résultats de la chirurgie bariatrique chez les adolescents au-delà de 1 année après la procédure ont rarement été décrits. La diminution moyenne de l'IMC après 1 an chez les adolescents-LABS participants qui ont subi un pontage gastrique était similaire à celle rapportée dans sept études antérieures portant sur 256 adolescents (baisse de 16,5 et 17,2, respectivement). Dans une étude portant sur 53 adolescents plus jeunes (âge moyen, 14 ans), une diminution de 20 IMC moyen et une augmentation de 5 cm de hauteur moyenne a été observée 3 ans après sleeve gastrectomie. Cette diminution de l'IMC était supérieur à la baisse de 13,1 qui a été observé chez les participants ayant subi une gastrectomie dans notre étude, probablement en partie à cause de la croissance linéaire de la cohorte plus jeune, qui n'a pas été vu dans notre cohorte. Dans l'ensemble, ces résultats suggèrent que les adolescents peuvent perdre une quantité cliniquement significative de poids après la chirurgie bariatrique, avec la majorité des patients en maintenant la perte de

finding consistent with our previous findings in adolescents. This result, coupled with the findings of normalization of elevated blood pressure in nearly 80% of our participants, leads us to hypothesize that adolescents may have a greater potential than adults for reversal of the cardiometabolic consequences of obesity. We further speculate that these improvements with regard to weight, glycemic control, blood pressure, and dyslipidemia in adolescents may mitigate the progression of adverse anatomical and physiological cardiovascular changes — changes that may be less reversible after the accumulation of more pound-years later in life. Additional research may clarify the way in which age, obesity duration, and the timing of surgery could modify the response to surgical treatment.

Gastric bypass and gastric resection may affect the absorption of numerous micronutrients that are necessary for normal metabolism and for good bone, hematologic, and nervous system health; therefore, multivitamin and mineral supplementation is needed, as was prescribed in this cohort. The greatest changes that we observed were in measures related to iron and vitamin B<sub>12</sub>. Iron-deficiency anemia and vitamin B<sub>12</sub> deficiency after gastric bypass are well described. Vitamin B<sub>12</sub> deficiency was not unexpected after sleeve gastrectomy, and it presumably relates to a reduction in intrinsic factor production after the procedure. These results, as well as the decreased vitamin A levels after gastric-bypass surgery, highlight the importance of long-term follow-up to evaluate nutritional measures, as well as the importance of ensuring that appropriate supplementation is provided to minimize the development of clinically significant nutritional deficiencies in adolescents after bariatric surgery.

There are currently few available data regarding the need for subsequent abdominal operations after bariatric surgery in adolescents. Our data, which include information on additional conditions and procedures, may elucidate the types and frequencies of the adverse effects of bariatric surgery in this age group. Previously, we reported that 8% of the participants in our study had major complications within 30 days after the bariatric procedure, and here we

poids significative pendant au moins 3 ans. Parmi les adultes qui subissent un pontage gastrique, la rémission du diabète de type 2 se produit dans 50 à 70%, et la remise de la tension artérielle élevée se produit dans 40%. Nous avons trouvé la rémission du diabète dans 95% des participants qui avaient le diabète de type 2 à l'inclusion dans notre étude, ce qui concorde avec nos résultats précédents chez les adolescents. Ce résultat, couplé avec les conclusions de la normalisation de la pression artérielle élevée dans près de 80% de nos participants, nous conduit à l'hypothèse que les adolescents peuvent avoir un plus grand potentiel que les adultes pour l'inversion des conséquences de l'obésité cardiometaboliques. Nous pensons en outre que ces améliorations en ce qui concerne le poids, le contrôle glycémique, la pression artérielle et la dyslipidémie chez les adolescents peuvent atténuer la progression des effets indésirables des changements cardiovasculaires anatomiques et physiologiques - les changements qui peuvent être moins réversibles après l'accumulation de plus de livres-ans plus tard dans la vie. Des recherches supplémentaires peuvent clarifier la façon dont l'âge, la durée de l'obésité, et le moment de la chirurgie peuvent modifier la réponse au traitement chirurgical. Le bypass gastrique et la résection gastrique peut affecter l'absorption de nombreux oligo-éléments qui sont nécessaires pour le métabolisme normal et pour une bonne ossature, hématologique, et de la santé du système nerveux; par conséquent, de multivitamines et des suppléments minéraux est nécessaire, comme cela a été prescrit dans cette cohorte. Les plus grands changements que nous avons observés étaient dans des mesures liées au fer et de la vitamine B<sub>12</sub>. L'anémie ferriprive et la carence en vitamine B<sub>12</sub> après un pontage gastrique sont bien décrits. La carence en vitamine B<sub>12</sub> était pas inattendue après sleeve gastrectomie, et elle se rapporte vraisemblablement à une réduction de la production de facteur intrinsèque après la procédure. Ces résultats, ainsi que les niveaux ont diminué de vitamine A après la chirurgie gastrique bypass, mettent en évidence l'importance de long terme de suivi pour évaluer les mesures nutritionnelles, ainsi que l'importance d'assurer que la supplémentation appropriée est fournie pour réduire au minimum le développement de la clinique carences nutritionnelles importantes chez les adolescents après la chirurgie bariatrique.



report that 13% of the participants underwent additional intraabdominal procedures within the subsequent 3 years. The risks of complications may differ according to the type of bariatric procedure; however, the current study was not designed to identify such differences. Further study of larger cohorts and other populations may provide insight regarding this question.

The strengths of the current study include the prospective enrollment of consecutive patients at geographically distinct sites, the standardized methods used to collect data, and strong cohort maintenance over time. The limitations of our study include the small size of certain important subpopulations, such as patients with diabetes. In addition, the observational nature of the study introduces heterogeneity into the data set, including unmeasured covariates and imbalances in race, sex, and socioeconomic status. Without a non-surgically treated control group, it is difficult to place the postoperative changes in weight and health status completely into perspective, since behavioral treatment can result in modest improvements in weight and cardiometabolic health. However, it has been reported that severely obese adolescents who undergo nonsurgical treatment do not have major reductions in weight, and the reductions that they do have are not maintained over 2 years of follow-up. Finally, despite a relatively low 3-year missed-visit rate of 15%, missing data — particularly data from laboratory testing, which were missing in 24% of participants — is a limitation. However, statistical techniques that address missing data were applied, and sensitivity analyses indicated that our assumptions with regard to patterns of missing data were reasonable.

In conclusion, we documented the durability of clinically meaningful weight loss and improvements in key health conditions and weight-related quality of life among adolescents who underwent gastric bypass surgery or sleeve gastrectomy. These benefits must be viewed in the context of the risks of micronutrient deficiencies and the possibility that future abdominal procedures will be needed in some patients. Studies that assess the longer-term durability of weight loss, potential improvements with respect to coexisting conditions, and the risk of adverse

Il existe actuellement peu de données disponibles concernant la nécessité pour les opérations abdominales ultérieures après la chirurgie bariatrique chez les adolescents. Nos données, qui comprennent des informations sur les conditions et procédures supplémentaires, peuvent élucider les types et les fréquences des effets indésirables de la chirurgie bariatrique dans ce groupe d'âge. Auparavant, nous avons rapporté que 8% des participants à notre étude ont eu des complications majeures dans les 30 jours suivant la procédure bariatrique, et ici nous rapportons que 13% des participants ont subi des procédures intraabdominales supplémentaires dans les 3 années suivantes. Les risques de complications peuvent varier selon le type de procédure bariatrique; Cependant, l'étude actuelle n'a pas été conçue pour identifier de telles différences. Une étude plus poussée des cohortes plus importantes et d'autres populations peut donner un aperçu sur cette question. Les points forts de l'étude comprennent l'inscription prospective de patients consécutifs sur des sites géographiquement distincts, des méthodes normalisées utilisées pour recueillir des données, et forte d'entretien de cohorte au fil du temps. Les limites de notre étude comprennent la petite taille de certaines sous-populations importantes, comme les patients atteints de diabète. En outre, la nature observationnelle de l'étude présente une hétérogénéité dans l'ensemble de données, y compris les covariables non mesurées et des déséquilibres dans la race, le sexe et le statut socio-économique. Sans un groupe témoin non-traité chirurgicalement, il est difficile de placer les changements postopératoires de poids et de l'état de santé complètement en perspective, puisque le traitement comportemental peut se traduire par des améliorations modestes dans le poids et la santé cardiometabolique. Cependant, il a été rapporté que les adolescents sévèrement obèses qui subissent un traitement non chirurgical ne disposent pas d'importantes réductions de poids, et les réductions qu'ils ne sont pas ont maintenu plus de 2 ans de suivi. Enfin, malgré un taux manqué-visite relativement faible de 3 ans de 15%, les données manquantes - en particulier les données de tests de laboratoire, qui étaient absents dans 24% des participants - est une limitation. Cependant, les techniques statistiques qui traitent les données manquantes ont été appliquées, et les analyses de sensibilité indiquent que nos hypothèses en ce



events, as well as the cost, may provide a better understanding of the role of bariatric surgery in the treatment of severe obesity in adolescents.

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A complete list of investigators in the Teen-Longitudinal Assessment of Bariatric Surgery (Teen-LABS) Consortium is provided in the Supplementary Appendix, available at NEJM.org

qui concerne les modèles de données manquantes étaient raisonnables.

En conclusion, nous avons documenté la durabilité de la perte cliniquement significative de poids et l'amélioration des conditions de santé et de qualité clés liées au poids de la vie chez les adolescents qui ont subi une chirurgie de pontage gastrique ou sleeve gastrectomie. Ces avantages doivent être considérés dans le contexte des risques de carences en micronutriments et la possibilité que des procédures abdominales futures seront nécessaires chez certains patients. Les études qui évaluent la durabilité à long terme de perte de poids, les améliorations possibles en ce qui concerne les conditions coexistantes, et le risque d'effets indésirables, ainsi que le coût, peuvent fournir une meilleure compréhension du rôle de la chirurgie bariatrique dans le traitement de l'obésité sévère chez les adolescents.

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