The clinical effectiveness of insulin glargine in patients with type 1 diabetes in Brazil; findings and implications

Lays P. Marra[1], Vânia E. Araújo[1], Gerusa C. C. Oliveira[1], Leonardo M. Diniz[2], Augusto A. Guerra Júnior[1,3], Francisco de Assis Acurcio[1,2,3], *Brian Godman[4,5], Juliana Álvares[1,3].

[1]Department of Social Pharmacy, School of Pharmacy, Federal University of Minas Gerais, Belo Horizonte, Brazil. Email: laysmarra@yahoo.com.br; vaniaearaujo@gmail.com; gerusacoliveira@yahoo.com.br; augustoguerramg@gmail.com; acurcio@ufmg.br; jualvares@gmail.com
[2]School of Medicine, Federal University of Minas Gerais, Belo Horizonte, Brazil. Email: lmdiniz.med@gmail.com
[3]SUS Collaborating Centre – Technology Assessment & Excellence in Health, College of Pharmacy, Federal University of Minas Gerais, Minas Gerais, Brazil
[4]Strathclyde Institute of Pharmacy and Biomedical Sciences, University of Strathclyde, Glasgow, UK. Email: Brian.godman@strath.ac.uk
[5]Department of Laboratory Medicine, Division of Clinical Pharmacology, Karolinska Institutet, Karolinska University Hospital Huddinge, Stockholm, Sweden. Email: Brian.Godman@ki.se

*Correspondence author: Brian Godman, Strathclyde Institute of Pharmacy and Biomedical Sciences, University of Strathclyde, Glasgow G4 0RE, United Kingdom. Email: Brian.godman@strath.ac.uk. Telephone: 0141 548 3825. Fax: 0141 552 2562 and Department of Laboratory Medicine, Division of Clinical Pharmacology, Karolinska Institutet, Karolinska University Hospital Huddinge, SE-141 86, Stockholm, Sweden. Email: Brian.Godman@ki.se. Telephone: 00468 585 81068; Fax: 00468 585 81070

(Accepted for publication Journal of Comparative Effectiveness Research – Please keep Confidential - DOI number is 10.2217/cer-2016-0099)

Abstract
Aims: Published studies have challenged the cost-effectiveness of insulin glargine versus NPH insulins in Brazil with limited evidence of increased effectiveness despite considerably higher acquisition costs. However, still a controversy. Consequently, a need to address this. ***Methods:*** Retrospective cohort study of type 1 diabetes patients receiving insulin glargine in Brazil following NPH insulin who met the criteria. ***Results:*** 580 patients were enrolled. HbA_{1c} varied from 8.80 ± 1.98% in NPH insulin users to 8.54 ± 1.88% after insulin glargine for six months, which is not clinically significant. Frequency of glycemic control varied from 22.6% with NPH insulin to 26.2% with insulin glargine. No statistically significant difference was observed between controlled and still uncontrolled groups for all analyzed factors including type and frequency of insulin use and carbohydrate counting. ***Conclusions:*** Limited differences between NPH insulins and insulin analogues in routine clinical care does not justify an appreciable cost difference.

Keywords: Brazil; Comparative effectiveness research; Insulin glargine; longitudinal studies; NPH insulin; Type 1 diabetes.

1. Introduction

Type 1 diabetes is a chronic disease resulting from the inability of the pancreas to produce insulin (1). In view of the natural history of type 1 diabetes, the use of insulin immediately after diagnosis is advocated to adequately treat these patients (2). The most widely used insulins are called NPH

insulins and fast-acting insulin (soluble insulin). However, in order to make the profile of injected insulins closer to physiological insulins, insulin analogues were created (insulin glargine and insulin detemir) which have a prolonged action.

There are concerns though with the cost-effectiveness of long acting insulins versus NPH insulins especially where there are appreciable cost differences as currently seen in Brazil (3,4). Published studies including systematic reviews and reviews by health authorities have demonstrated no superiority of insulin glargine in terms of effectiveness and safety compared with NPH insulin (3–11). Other studies, however, have found the opposite. Raskin et al (2000) showed a greater efficacy of insulin glargine in reducing HbA_{1c} (12). Herwig et al. (2007), Schreiber et al. (2007) and Salemyr et al. (2011) also showed that patients with type 1 diabetes using insulin glargine achieved a better response in terms of glycemic control and decreasing HbA_{1c} when compared with those using NPH insulin (13–15). The differences in the findings may reflect the study sponsors as seen in our recent meta analysis of cohort studies comparing the effectiveness of insulin glargine versus NPH insulin (4).

Consequently, in view of current controversies, we wished to undertake our own cohort study evaluating the effectiveness of insulin glargine versus NPH insulin for the treatment of patients with type 1 diabetes to support decision making for greater efficiency within our healthcare system. This study aimed to evaluate the effectiveness of insulin glargine compared with NPH insulin for patients with type 1 diabetes in routine clinical care within Brazil.

2. Materials and Methods

2.1 Sample

This study was conducted in accordance with the Declaration of Helsinki. A historical cohort was conducted from January 2011 to January 2015, including users of the Specialized Pharmaceutical Care Component (SPCC) of the Brazilian National Healthcare system (SUS) in Minas Grais, developed from the construction of a database of individuals with type 1 diabetes treatment, registered according to the Clinical Protocol and Therapeutic Guidelines (CPTG) for insulin glargine use in Brazil (16). Patients have to fulfil these criteria in order to have their insulin approved and reimbursed (17).

To analyze the clinical effectiveness, individuals were compared with themselves in an analysis of HbA_{1c} values before and after six months of using insulin glargine. In this way, each patient acted as their own control avoiding concerns with randomization in routine clinical care.

Individuals who met the eligibility criteria were included in the cohort. These included (1) patients who had been diagnosed with type 1 diabetes or latent autoimmune diabetes in adults (LADA); (2) whose cases met the inclusion criteria described in the CPTG (ESM Table 1); (3) were currently on NPH insulin and who had not used long-acting insulin analogues prior to the approved use of insulin glargine; (4) whose inclusion in the program was between January 2011 and January 2015; and (5) who had at least two renewal processes for insulin glargine evaluated by reviewers of *SUS* Collaborating Centre - Technology Assessment and Excellence in Health (CCATES). The *SUS* Collaborating Centre for Technology Assessment and Excellence in Health is part of the National Network for Technology Assessment in Health (REBRATS) in Brazil. CCATES has an institutional partnership with the Ministry of Health (MoH) and the Health Department of *Minas Gerais*. Among its many activities, CCATES undertakes the analysis of administrative and judicial requests for medicines medical procedures and devices and develops rapid advice on issues relevant to health for the MoH. Individuals who were excluded at the first request to administer of insulin glargine or

insulin detemir as part of SUS, or patients whose term renewal request had exceeded nine months from the last release date, were excluded.

2.2 Study variables

Outcomes were assessed from the following variables: (i) demographic variables - ethnicity, sex and age; (ii) clinical variables – time with a diagnosis of type 1 diabetes, age at diagnosis and reporting of comorbidities of individuals at baseline; (iii) treatment characteristics - type of treatment, carbohydrate counting, prescribed doses of insulin, administration frequency of NPH insulin and insulin glargine, insulin type and prescribed doses of rapid-acting insulin and/or ultrafast and (iv) laboratory results of HbA_{1c}.

Laboratory results of HbA_{1C} were used for clinical effectiveness analysis, by comparison of the HbA_{1c} values of each person after six months of insulin glargine use, with the reference values recommended in the literature for their age. For individuals between 6 and 18 years, $HbA_{1c} \leq 7.5\%$; between 19 and 59 years, $HbA_{1c} \leq 7.0\%$ and over 60 years, $HbA_{1c} \leq 8.0\%$ (18) were considered controlled and the individuals who were outside this reference range values were considered uncontrolled.

This study did not assess glucose fasting values, since this measure has low validation to assess the efficacy and effectiveness of medicines for diabetes because of being susceptible to divergences with actual glycemic control (19).

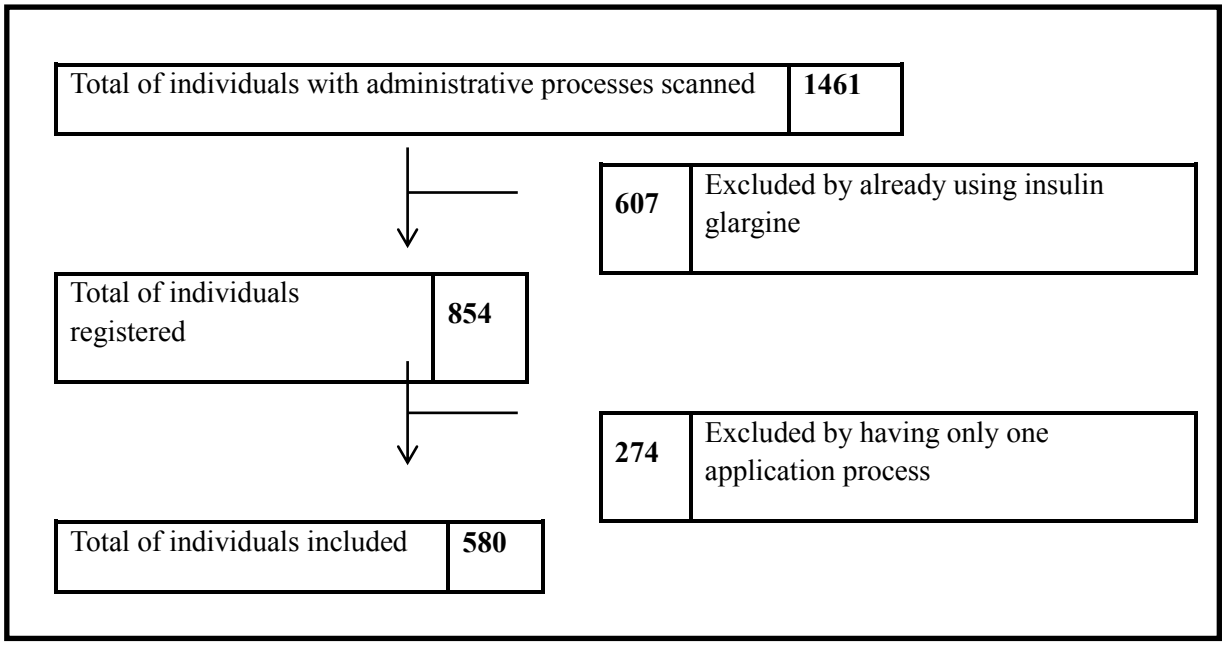
2.3 Statistical analysis

Categorical variables were analyzed using absolute and relative frequencies and continuous variables as mean, median and standard deviation. The difference between the mean doses of NPH insulin and insulin glargine were compared using the T test for paired samples. To identify factors associated with glycemic control of individuals after six months using insulin glargine, Chi-square test of Pearson was conducted for categorical variables and an analysis of variance, One Way ANOVA, for continuous variables. In case of a statistically significant difference, Tukey's test was used for multiple comparisons. Variables were considered significant with $p < 0.05$ in the multiple model. Statistical analysis was performed using the software SPSS® version 20 (SPSS Inc., Chicago, IL, USA).

3. Results

Individuals' demographic and clinical characteristics All administrative processes scanned by CCATES were evaluated. In all 1,461 individuals, received long acting insulins from January 2011 to January 2015. 854 patients were subsequently registered for the study, according to the eligibility criteria. After analyzing administrative procedures, 580 patients were finally included in the study sample (Figure 1).

Figure 1 – Study sample



The sex distribution was similar, the predominant ethnicity was white (33.8%) and most individuals were between 20 and 59 years old (63.1%). 79% of patients did not report the presence of comorbidities associated with type 1 diabetes (ESM Table 2).

The average age of participants was 33 years (SD = 17.3), with the average age at diagnosis of type 1 diabetes being 17.5 years (SD = 13.2). At the end of the study, the average time of treatment of patients was 14.8 years (ESM Table 3).

3.1 Treatment characteristics

When patients were administering NPH insulin, 41% were using conventional treatment - in which they receive insulin injections twice a day, nutritional assessment and quarterly clinic visits. After six months using insulin glargine, this number decreased to 25.9%. Either when using NPH insulin or insulin glargine, most patients followed intensive treatment in which they received multiple administrations of insulin each day along with extensive educational and medical support.

Carbohydrate counting, reported initially among 21% of patients, increased to 24.8% by the end of the study period. When using NPH insulin, 40% of patients used soluble insulin and 13.8% ultra-fast analogues. After six months using insulin glargine, the percentage of individuals using soluble insulin was 31% and ultrafast-acting insulin analogues 24.8% (ESM Table 4).

49% of patients when using of NPH insulin were injecting three times a day. When using insulin glargine, the frequency of administration once a day was 92.6% (ESM Table 4).

The average daily dose of basal insulin ranged from 35.23 ± 15 IU when using NPH insulin to 34.38 ± 15 IU after six months using insulin glargine ($p = 0.018$). The average daily dose of fast-acting and ultra-fast insulin ranged from 14.44 ± 11 IU when using NPH insulin to 14.69 ± 11 IU ($p = 0.130$) after six months using insulin glargine (Table 1).

Table 1 -Daily insulin doses in individuals included in the study.

Variable	Average	Standard Deviation	Median	Minimum	Maximun	p - Value
Daily dose of basal insulin (UI)						
NPH insulin dosage	35.23	15.524	34.00	5	122	0.018*
Insulin glargine dosage	34.38	15.219	32.00	6	120	
Difference in the daily dose of basal insulin (UI)						
	-0.8460	8.5725	0.00	-70.00	32.00	
Prescribed dose of rapid-acting/ultrafast insulin (UI)						
In NPH insulin use	14.44	11.079	12.00	6	90	0.130
In insulin glargine use	14.69	10.934	12.00	4	90	

Note: * Statistically significant variation by paired T test.

The doses of insulin glargine in six months of use were evaluated as a function of age. There was a statistically significant difference between the mean doses among the various age groups. The post hoc analysis showed a statistically significant difference in the mean dose in individuals from 6 to 12 years compared with other age groups (ESM Table 5).

3.2 Glycemic control

Comparison of glycated hemoglobin levels before and after six months using insulin glargine demonstrated a statistically significant reduction ranging from 8.80 ± 1.98% when using NPH insulin to 8.54 ± 1.88% (p = 0.001). The mean difference of glycated hemoglobin before and after six months of treatment with insulin glargine was 0.23% (Table 2).

Table 2 - Individuals' HbA_{1c} values

Variable	Average	Standard Deviation	Median	Minimum	Maximun	p - Value
HbA_{1c} value (%)						
In NPH insulin use	8.80	1.98	8.52	4.56	16.00	0.001*
In insulin glargine use	8.54	1.88	8.30	4.42	17.10	
Diference in HbA_{1c}(%)	-0.23	1.937	0.00	-8	9	-

*Value with a statistically significant difference between groups. Analysis by T test paired.

Individuals' glycemic control ranged from 22.6% when using NPH insulin and 26.2% when using insulin glargine - Table 3 (In ESM Figure 1, there is documentation of the percentage of people achieving glycemic control after 6 months using insulin glargine for different age groups during the study).

Table 3 - Proportion of individuals with and without blood glucose control.

	Glicemic Control			
	Uncontrolled		Controlled	
	N	%	N	%
In NPH insulin use	449	77.4	131	22.6
In insulin glargine use	428	73.8	152	26.2

There were no statistically significant differences between the controlled and uncontrolled groups for variables including age, history of comorbidities, sex, ethnicity, type of insulin used, type of treatment, carbohydrate counting and frequency of use when using NPH insulin and after six months using insulin glargine (Table 4).

Table 4 - Univariate analysis of individuals with and without blood glucose control for categorical variables.

Variable		Uncontrolled		Controlled		p-Value
		N	%	N	%	
Comorbities	Yes	94	77.0	28	23.0	0.357
	No	334	72.9	124	27.1	
Sex	Male	211	72.8	79	27.2	0.571
	Female	217	74.8	73	25.2	
Ethnicity	White	151	77	45	23	0.758
	Black	11	73.3	4	26.7	
	Brown	48	72.7	18	27.3	
Type of treatment	Convencional	110	73.3	40	26.7	0.425
	Intensive	200	69.7	87	30.3	
Carbohydrate counting	Yes	99	68.8	45	31.3	0.248
	No	132	74.6	45	25.4	
Age	06-12	44	67.7	21	32.3	0.177
	13-19	71	74.0	25	26.0	
	20-59	279	76.2	87	23.8	
	>=60	34	64.2	19	35.8	
Type of insulin	Soluble insulin	130	72.2	50	27.8	0.385
	Short-acting analogue	107	74.3	37	25.7	
Frequency of use	once a day	394	73.4	143	26.6	0.414
	twice a day	34	79.1	9	20.9	
	3 times a day	0	0	0	0	

Factors associated with glycemic control were analyzed after six months using insulin glargine through differences between means for continuous variables including: age, age at diagnosis, time since diagnosis, basal-acting insulin dose and fast-acting and ultrafast-acting insulin dose. No

statistically significant difference was observed between controlled and uncontrolled groups for all variables (Table 5).

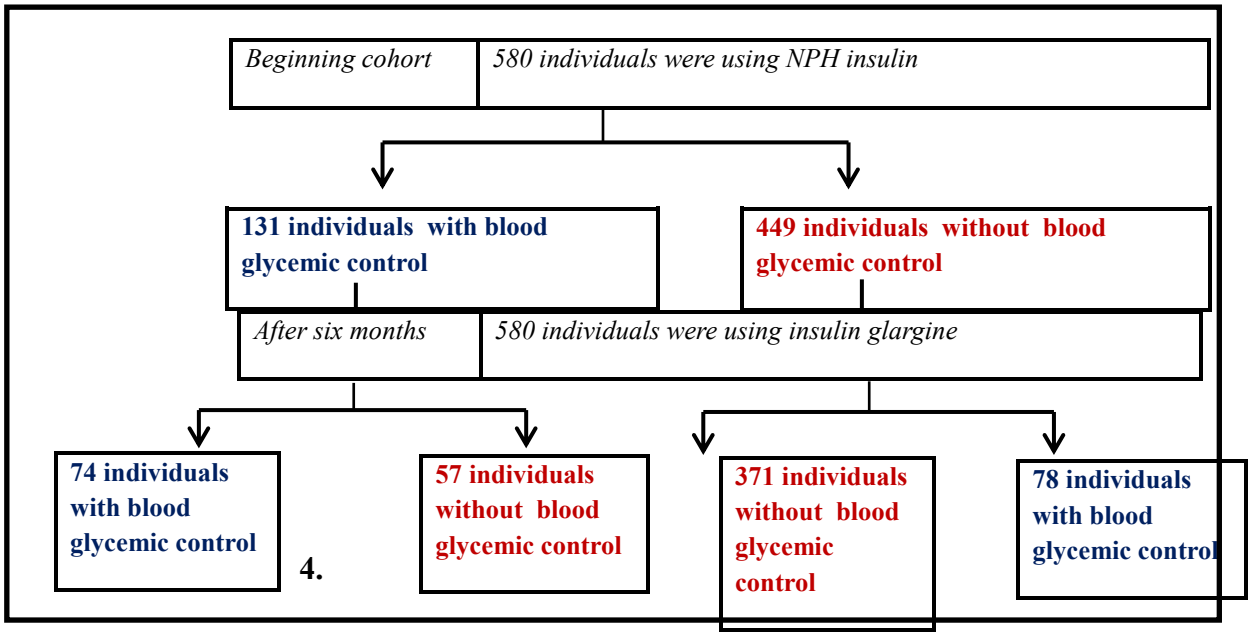
Table 5 - Univariate analysis of individuals with and without blood glucose control for continuous variables.

Variable		Uncontrolled	Controlled	p-Value *
Age (years)	Average	33.04	33.07	0.326
	Standard Deviation	17.14	18.01	
Age at diagnosis (years)	Average	17.19	18.38	0.6154
	Standard Deviation	13.14	13.31	
Time since diagnosis (Years)	Average	15.09	13.97	0.386
	Standard Deviation	12.31	14.01	
Basal-acting insulin dose (UI)	Average	35.64	31.07	0.888
	Standard Deviation	15.32	14.50	
Fast/ultrafast-acting insulin dose (UI)	Average	15.35	12.51	0.256
	Standard Deviation	12.47	7.38	
Total	N	428	152	

Note: * p-value between NPH insulin and insulin glargine controlled.

At the beginning of the cohort, when 580 patients were using NPH insulin, 449 of had not showed good control of the disease and 131 had good blood glycemic control. After six months using insulin glargine, only 78 of these patients achieved glycemic control whilst the others (371 patients) continued without control (Figure 2). Of the individual patients who had early glycemic control (131 individuals), 74 patients kept it whilst the others lost it.

Figure 2 - Flowchart of patients and glycaemic control



4.

Discussion

The analysis of the effectiveness and safety of insulin glargine use in patients with type 1 diabetes is an important tool for decision makers, especially where there are considerable differences in acquisition costs and resources are limited.

In this cohort of 580 patients, insulin glargine reduced by an average of 0.23% patients' HbA_{1c} levels (Table 2), which is less than considered clinically significant (0.7% to 1%) (20). The same was observed in the study by Singh et al. (2009) in which the differences between insulin glargine and NPH insulin in terms of HbA1c were considered only marginal among adults with type 1 diabetes (weighted mean difference for insulin glargine: -0.11%; 95% CI (-0.21; -0.02%) (21). According to the ADA (2015) and Mendes et al. (2010), children aged between 6 and 12 reach glycemic control more easily when compared with the other age groups (18,22). Even taking into account this influence of age in controlling the disease, this study did not find significant differences between the groups with and without glycemic control, in individuals who were using insulin glargine (Tables 4 and 5).

When assessing the basal insulin dose, we perceived a slight decrease (2.4%), but significant ($p = 0.018$) after six months using insulin glargine (Table 1). This has important clinical consequences since this value differs from the insulin glargine manufacturer's guidelines (Lantus® brand), which states that the average starting dose of insulin glargine is 80% of the NPH insulin dose. This though is in line with Garg et al. (2014) who showed similar results, i.e. the average dose of insulin glargine showed a significant decrease ($p = 0.03$) when compared with the group that used NPH insulin (23). There is a relationship between insufficient guidance for self-care and unsatisfactory adherence to treatment with 95% of hypoglycaemic crisis occurrences. Individuals with type 1 diabetes who follow intensive treatment also have a 3kg weight gain versus individuals submitted to conventional therapy (16).

In a cost-effectiveness study, the results obtained suggest that treatment with insulin analogues is associated with a reduction of complications related to diabetes (in other words, more years of quality-adjusted life) compared with conventional insulins. However, benefits conferred and associated to this reduction complications are not compensatory when we add in the high acquisition costs of insulin analogues versus NPH insulin particularly in Brazil (3,24).

Two other studies of effectiveness (5,25) corroborate the data found in this study that the clinical evidence does not support the superiority of insulin glargine compared with NPH insulin. Sanches et al. (2011) also found no statistically significant reduction of HbA_{1c} when comparing insulin glargine and NPH insulin (25).

However, Tricco et al. (2014) in their study, when evaluating the safety, effectiveness and cost-effectiveness among insulin analogues and NPH insulin in individuals with type 1 diabetes, concluded that long-acting insulin analogues are probably superior to NPH insulin, although it is by a small difference in HbA_{1c} levels (26). This suggests that patients and their physicians should adapt their insulin choice according to preference, cost and accessibility.

Although an economic evaluation has not been the subject of this study, the fact that there are higher acquisition costs and lack of therapeutic superiority of insulin glargine over NPH insulin suggests a favorable cost-effectiveness relation of the use of NPH insulin, mirroring the findings from our two published meta analysis (3,4). Consequently, we believe it is up to managers and decision makers to renegotiate therapy costs with insulin glargine since NPH insulin in this and other studies appears to

offer the same patient benefits as insulin glargine but with substantially lower acquisition costs within public health systems certainly in Brazil. This is similar to the suggestions of Laranjeira et al who worked on a discount of 37.5% when calculating the potential budget impact of insulin glargine used in restricted cases (27).

We acknowledge though that there are limitations with this study design. Firstly, we confined our analysis to patients within Minas Gerais. However, this is one of the most populated regions in Brazil with similar age and sex characteristics to other regions in Brazil, representing well Brazil as a whole. Secondly, only patients with completed and approved report forms for insulin glargine where included, which limited some of the analysis. The variable reporting of comorbidities was also an optional field in the report. The fact that the individuals with type 1 diabetes did not report the presence of comorbidities (79% of individuals) does not mean they do not have these. It wasn't possible to also evaluate the reduction of hypoglycaemic episodes from the data entered onto the SUS database. In addition, the use of a retrospective data limits access to important data. The conditions of observational studies are also not under the control of the investigator, and the researcher does not intervene in the allocation of participants. This is a characteristic of this type of design. We tried, however, to minimize possible biases by confirming the results through laboratory tests and reviews of medical reports where we could. Despite these limitations, we believe our findings are robust giving direction to Ministry of Health personnel in Minas Gerais and Brazil to potentially re-negotiate prices for insulin glargine. Prices of insulin glargine may start falling anyway now that biosimilars have been approved in the US and Europe (28,29).

It is noteworthy that the evaluation of insulin glargine for the treatment of type 1 diabetes demonstrated in this study that analog insulins were not superior to insulin NPH in terms of their effectiveness. These results impact on the likely scenario of the new analogues such as insulin degludec. Having said this, recent studies have indicated insulin degludec is a more cost effective option than insulin glargine [30,31]. However, studies in patients in routine clinical care are needed that directly compare the effectiveness of these analogues, as well as their effectiveness versus NPH insulins, to conclude about their cost-effectiveness within universal healthcare systems such as Brazil. We await further evidence.

5. Conclusion

Insulin glargine showed no clinical advantage over NPH insulin in reducing HbA_{1c} values and glycemic control in our cohort study, confirming the findings from our previous meta analyses. Whilst insulin glargine has an appreciably higher cost than NPH insulin, we believe it is mandatory for health authority personnel to review the pricing strategy of insulin glargine in Brazilian States that provide insulin free of charge to their citizens and renegotiate prices where pertinent in order to ensure the sustainability of public health systems. The availability of biosimilar insulin glargine may facilitate this in Brazil

Summary Points

- This is an observational, longitudinal, analytical and prospective study that evaluates the comparative clinical effectiveness of two insulins for the treatment of type 1 diabetes. This type of design is useful to generate evidence about the benefits and harms of the different interventions in routine clinical care (real-world)
- The cost of medicines, specifically insulin glargine, has grown considerably in Brazil in recent years, which raises the need for rationalization and optimization of financial resources in order to guarantee the sustainability of the health system as well as access to an effective and safe therapy to people with diabetes.

- This review of clinical data did not show any additional clinical benefit in type 1 diabetes patients using insulin glargine in relation to NPH insulin, confirming the results from other previous studies and reviews.
- There appeared to be no association between glycemic control and individual's characteristics or treatment between patients receiving NPH insulin and then switched to insulin glargine.
- Insulin glargine reduced by an average of 0.23% patients' HbA1c, which is less than considered clinically significant (0.7% to 1%). The limited benefits conferred are not compensated by the high acquisition cost of insulin analogues vs NPH insulin in Brazil
- There are higher costs and lack of therapeutic superiority of insulin glargine over NPH insulin suggests a favorable cost-effectiveness for NPH insulin vs, insulin glargine
- This review provides a basis for health system managers to maintain or exclude insulin glargine from the reimbursed list of medicines offered for the treatment of diabetes whilst there is still appreciable differences in acquisition costs between the two insulins
- It is up to managers and decision makers to renegotiate therapy costs, or even discuss the possibility of disinvestment, once proven that NPH insulin offers the same benefits as insulin glargine but with substantially lower costs within public health systems.

6. REFERENCES

'*' – of interest, or "**" – of considerable interest

1. World Health Organization (WHO). Global Report on Diabetes. Available at URL: http://apps.who.int/iris/bitstream/10665/204871/1/9789241565257_eng.pdf?ua=1

2. Branchtein L, Matos MCG. Antidiabéticos. In: Fuchs FD, Wannmacher L, Ferreira MBC. Farmacologia clínica: fundamentos da terapêutica racional. 3. ed. Rio de Janeiro: Guanabara Koogan p. 832 - 844 (2006)

3. Caires de Souza AL, de Assis Acurcio F, Guerra Júnior AA, Rezende Macedo do Nascimento RC, Godman B, Diniz LM. Insulin glargine in a Brazilian state: should the government disinvest? An assessment based on a systematic review. A*ppl Heal Econ Heal Pol* 12(1):19–32 (2014)
**Good meta analysis of the effectievenss and safety of NPH insulin vs. insulin glargine based on RCTs

4. Marra LP, Araújo VE, Silva TBC, Diniz LM, Guerra Junior AA, Acurcio FA, et al. Clinical Effectiveness and Safety of Analog Glargine in Type 1 Diabetes: A Systematic Review and Meta-Analysis. *Diabetes Ther.* 7:241–58 (2016)
**Good study assess the effectievenss and safety of NPH insulin versus NPH insulin in cohort patients

5. Olivera GC, Melo LM , Guerra Júnior AA, Alvares J. Efetividade Clínica Comparativa Do Análogo De Insulina Glargina Para Tratamento De Pacientes Acometidos Por Diabetes Mellitus Tipo 1. *Value Heal*. 18(7):A862–A863 (2015). Available at URL: http://www.valueinhealthjournal.com/article/S1098-3015(15)02574-7/pdf

6. German Institute for Quality and Efficency in Healthcare (IQWiG). Long-acting insulin analogues in the treatment of diabetes mellitus type 1: Executive Summary Commission No. A05-01. (2010) Available from: https://www.iqwig.de/en/projects_results/projects/drug_assessment/a05_01_long_acting_insulin_analogues_in_the_treatment_of_diabetes_mellitus_type_1.1197.html

7. World Health Organisation (WH). Review of the Evidence Comparing Insulin (Human or Animal) With Analogue Insulins. 18th Expert Committee on the Selection and Use of Essential Medicines. 1–51. (2011). Available from: http://www.who.int/selection_medicines/committees/expert/18/applications/Insulin_review.pdf

8. Vardi M, Jacobson E, Nini A, Bitterman H. Intermediate acting versus long acting insulin for type 1 diabetes mellitus. *The Cochrane database of systematic reviews* (3):Cd0062979 (2008)
9. Horvath K, Jeitler K, Berghold A, Ebrahim SH, Gratzer TW, Plank J, et al. Long-acting insulin analogues versus NPH insulin (human isophane insulin) for type 2 diabetes mellitus. *The Cochrane database of systematic reviews* (2):Cd005613 (2007)
10. Holden SE, Poole CD, Morgan CL, Currie CJ. Evaluation of the incremental cost to the National Health Service of prescribing analogue insulin. *BMJ Open* 1(2):e000258 (2011)
11. National Institute for Clinical Excellence (NICE). Guidance on the use of long-acting insulin analogues for the treatment of diabetes - insulin glargine (2002). Available at URL: https://www.nice.org.uk/guidance/ta53/documents/final-appraisal-determination-longacting-insulin-analogues-for-the-treatment-of-diabetes-insulin-glargine-2
12. Raskin P, Klaff L, Bergenstal R, Hallé JP, Donley D, Mecca T. A 16-week comparison of the novel insulin analog insulin glargine (HOE 901) and NPH human insulin used with insulin lispro in patients with type 1 diabetes. *Diabetes Care*. 23(11):1666–71 (2000)
13. Herwig J, Scholl-Schilling G, Bohles H. Glycaemic control and hypoglycaemia in children, adolescents and young adults with unstable type 1 diabetes mellitus treated with insulin glargine or intermediate-acting insulin. *J Pediatr Endocrinol Metab* 20(4):517–25 (2007)
14. Schreiber S a, Russmann A. Long-term efficacy of insulin glargine therapy with an educational programme in type 1 diabetes patients in clinical practice. *Curr Med Res Opin* 23(12):3131–6 (2006)
15. Salemyr J, Bang P, Örtqvist E. Lower HbA1c after 1 year, in children with type 1 diabetes treated with insulin glargine vs. NPH insulin from diagnosis: A retrospective study. *Pediatr Diabetes* 12(5):501–5 (2011)
16. MINAS GERAIS. Secretaria de Estado de Saúde de Minas Gerais. Resolução SES-MG Nº 2359 de 17 de junho de 2010 - Dispõe sobre o Protocolo Clínico e Diretrizes Terapêuticas para a utilização de análogo Glargina em portadores de Diabetes Mellitus Tipo 1 (DM1). Diário da Imprensa Oficial de Minas Gerais Poder Executivo, Belo Horizonte. 1–27 (2010)
17. Centro Colaborador do SUS para Avaliação de Tecnologias, Excelência em Saúde C. DIRETRIZES METODOLÓGICAS Detalhamento acadêmico. p. 1–47 (2015). Available from: http://www.ccates.org.br/content/_pdf/PUB_1437678333.pdf
18. American Diabetes Association. Standards of Medical Care in Diabetes - 2015. *Diabetes Care* 38(Suppl. 1):S01–98 (2015) Available from: http://care.diabetesjournals.org/content/38/Supplement_1
19. Lassere MN, Johnson KR, Boers M, Tugwell P, Brooks P, Simon L et al. Definitions and validation criteria for biomarkers and surrogate endpoints: development and testing of a quantitative hierarchical levels of evidence schema. *J Rheumatol* 34(3):607–15 (2007)
20. Canadian Agency for Drugs and Technologies in Health Care. Recommendations for the Prescribing and Use of Insulin Analogues. O*ptimal Therapy Report. COMPUS* 2(7) (2009) Available from: https://www.cadth.ca/sites/default/files/pdf/compus_IA_OT_rec_report.pdf
21. Singh SR, Ahmad F, Lal A, Yu C, Bai Z, Bennett H. Efficacy and safety of insulin analogues for the management of diabetes mellitus: a meta-analysis. *CMAJ* 180(4):385–97 (2009)
22. Mendes AB V, Fittipaldi JAS, Neves RCS, Chacra AR, Moreira ED. Prevalence and correlates of inadequate glycaemic control: Results from a nationwide survey in 6,671 adults with diabetes in Brazil. *Acta Diabetol* 47(2):137–45 (2010)
23. Garg SK, Paul JM, Karsten JI, Menditto L, Gottlieb PA. Reduced severe hypoglycemia with insulin glargine in intensively treated adults with type 1 diabetes. *Diabetes Technol Ther* 6(5):589–95 (2004)
24. Cameron CG, Bennett HA. Cost-effectiveness of insulin analogues for diabetes mellitus. C *Can Med Assoc J* 180(4):400–7 (2009)
*Good summary evaluating insulin analogues

25. Sanchesa ACC, Correrb CJ, Venson R, Pontarolo R. Revisiting the efficacy of long-acting insulin analogues on adults with type 1 diabetes using mixed-treatment comparisons. *Diabetes Res Clin Pract* 94(3):333–9 (2011)
*Good summary re-evaluating insulin analogues
26. Tricco AC, Ashoor HM, Antony J, Beyene J, Veroniki AA, Isaranuwatchai W, et al. Safety, effectiveness, and cost effectiveness of long acting versus intermediate acting insulin for patients with type 1 diabetes: systematic review and network meta-analysis. *BMJ* 349:1–13 (2014)
*Good summary re-evaluating insulin analogues vs NPH insulin
27. Laranjeira FO, Silva EN, Pereira MG. Budget Impact of Long-Acting Insulin Analogues: The Case in Brazil. PloS One. 11(12):e0167039 (2016)
*Good paper evaluating the budget impact of long acting insulin analogues
28. National Institute for Health and Care Excellence (NICE). Diabetes mellitus type 1 and type 2: insulin glargine biosimilar (Abasaglar). NICE Guidance (2015) ESNM64. Available from URL: https://www.nice.org.uk/advice/esnm64/chapter/key-points-from-the-evidence
29. US Food & Drug Administration. FDA approves Basaglar, the first "follow-on" insulin glargine product to treat diabetes (2015). Available from URL: http://www.fda.gov/NewsEvents/Newsroom/PressAnnouncements/ucm477734.htm
30. Yamamoto C, Miyoshi H, Fujiwara Y, Kameda R, Ichiyama M, Nomoto H et al. Degludec is superior to glargine in terms of daily glycemic variability in people with type 1 diabetes mellitus. *Endocrine journal* 63(1):53-60 (2016)
31. Evans M, Chubb B, Gundgaard J. Cost-effectiveness of Insulin Degludec Versus Insulin Glargine in Adults with Type 1 and Type 2 Diabetes Mellitus. *Diabetes Therapy* 8(2):275-91 (2017)

Electronic supplementary material

Figure 1 - Glycemic control after 6 months using glargine analog, by age group.

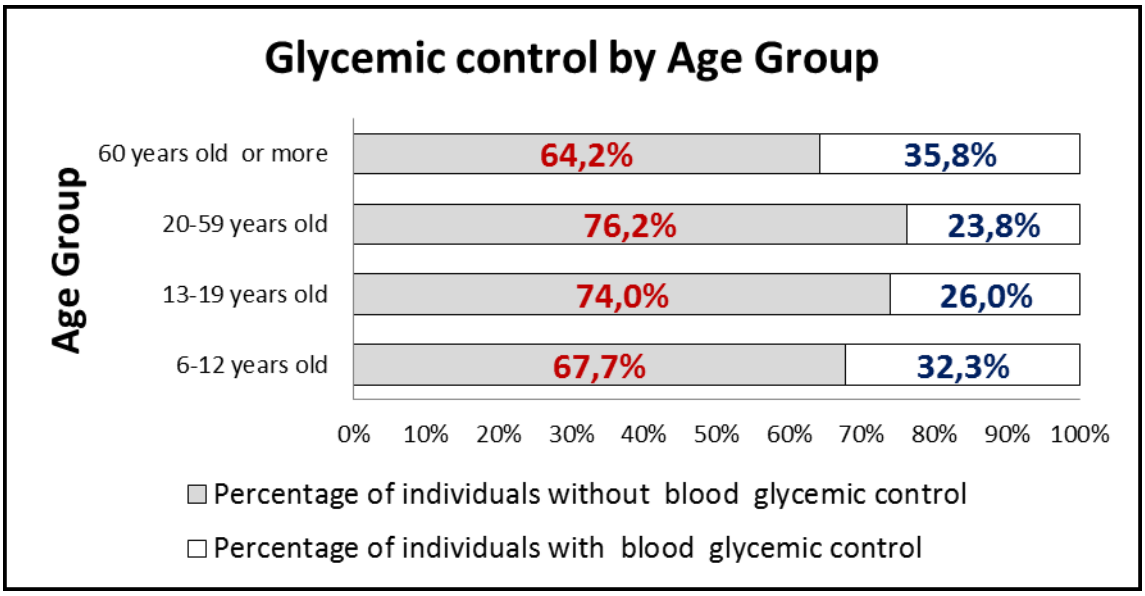


Table 1 – Inclusion criteria to dispensing program of glargine analog in Clinical Protocol and Therapeutic Guidelines (1).

1. The diagnosis of diabetes mellitus type 1 and LADA should be proven through detailed medical reports and supplementary examinations: fasting glucose and / or random, confirmed by a second dose and glycated hemoglobin. Other examinations may be required where there continue to be doubts as to the correct classification applicable to the patient.
2. It is necessary to document the persistence of poor glycemic control and the incidence of severe hypoglycemia without warning signs. The evidence of poor glycemic control will be made by the demonstration of laboratory tests (glycated hemoglobin and blood glucose levels) recorded 2 times at intervals of four months between tests. For the purposes specified in this protocol, it is understood that poor glycemic control is the persistence of glycohemoglobin with more than 2 percentage points above the normal test upper limit.
3. Patients who suffer from severe hypoglycemia (less than 50 mg / dl) for 2 or 3 proven episodes by laboratory examination and / or hospital care report this condition in at least two separate occasions in the past six months, they may be included in the same program without the confirmation of the occurrence of persistent hyperglycemia, as defined in item 2.
4. Be older than 6 years.
5. Patients who have been administered glargine analog for more than a year, which have not yet been included in the glargine dispensing program, and to monitor glycemic control - should have record of severe hypoglycemic episodes as described in items 2 and 3.

Table 2 - Patients characteristics (N = 580). Minas Gerais, Brazil

Variable		N	(%)
Sex	Male	290	50
	Female	290	50
Ethnicity	White	196	33.8
	Black	15	2.6
	Brown	66	11.4
	Uninformed	303	52.2
Age	06-12	65	11.2
	13-19	96	16.6
	20-59	366	63.1
	>=60	53	9.1
Report of comorbidities	Yes	122	21
	No	458	79.0

Table 3 - Descriptive statistics of patients included in the study.

Variable	Average	Standard Deviation	Median	Minimum	Maximum
Age (years)	33.04	17.357	31.00	6	75
Age at diagnosis (years)	17.50	13.185	13.50	0	65
Diagnosis time (years)	14.80	12.776	12.00	1	57

Table 4 - Characteristics of the treatment used (N = 580). Minas Gerais, Brazil.

Variável		N	(%)
Type of Treatment	Conventional	150	25.9
	Intensive	287	49.5
	Uninformed	143	24.7
Carbohydrates Counting	Yes	144	24.8
	No	177	30.5
	Uninformed	259	44.7
Insulin type of fast/ultrafast acting	Regular	180	31.0
	Short-acting analog	144	24.8
	Uninformed	256	44.1
	Total	580	100.0
Frequency	once a day	537	92.6
	twice a day	43	7.4
	3 times a day	580	100.0

Table 5 - Dose Analysis of analog glargine in different age groups.

Variable	N	Average	Standard Deviation	Minimum	Maximum	p-Value
Dosage (UI)						
6 a 12	65	19.18	10.927	6	58	
13 a 19	96	33.53	13.643	2	60	0,000*
20 a 59	366	37.24	14.925	6	120	
≥60	53	35.53	13.584	10	80	

Note: * Statistically significant difference. Post hoc analysis was performed using the Tukey test.

REFERENCES

1. MINAS GERAIS. Secretaria de Estado de Saúde de Minas Gerais. Resolução SES-MG Nº 2359 de 17 de junho de 2010 - Dispõe sobre o Protocolo Clínico e Diretrizes Terapêuticas para a utilização de análogo Glargina em portadores de Diabetes Mellitus Tipo 1 (DM1). Diário da Imprensa Oficial de Minas Gerais Poder Executivo, Belo Horizonte. 2010;1–27.