Received: 6 July 2020 | Revised: 16 December 2020 | Accepted: 18 December 2020

DOI: 10.1002/lim2.18

Lifestyle Medicine Open Access WILEY

ORIGINAL ARTICLE

Educational interventions to improve maternal-foetal outcomes in women with gestational diabetes

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Funding information
World Diabetes Foundation, Grant/Award Number: WDF 15-1314

Abstract

Aims: To evaluate improvement in gestational diabetes (GDM) outcomes for mothers and their offspring induced by education provided to the healthcare team (HCTM) and women with GDM, plus coordination between primary care units (PCU) and highly complex maternity (HCM) facilities.

Methods: Pregnant women with GDM completing control visits from first appointment until delivery were recruited in participating PCU-HCM, in the cities of Corrientes and Buenos Aires; 263 women recruited from 2017 to mid-2018 were assigned to the control group (CG), and 432 women recruited from mid-2018 to 2019 to the intervention group (IG). The CG received standardized care/routine management and follow-up, including basic information on blood glucose monitoring and insulin injection when necessary, whereas the IG received an educational program targeting HCTM and women with GDM. These courses included standards of diagnosis, prevention and treatment of GDM, plus systematic registry of clinical and metabolic indicators (fasting blood glucose, serum cholesterol and triglyceride). Data on obstetric history, preeclampsia, gestation-induced hypertension, delivery method and newborn's body weight were also recorded

Results: Women in the IG showed significantly ($P \leq 0.05$) lower BMI and weight gain during gestation, a trend towards lower triglyceride and caesarean sections and a significant increase in postnatal attendance for metabolic assessment. Their newborns showed significantly lower body weight and a trend towards fewer macrosomia.

Conclusions: These data suggest that our educational intervention plus management changes induced a favourable impact on GDM outcomes for both mothers and offspring.

KEYWORDS
education, gestational diabetes, newborn weight, postnatal assessment, pregnancy weight gain

1 | INTRODUCTION

The prevalence of type 2 diabetes (T2D) grows ceaselessly worldwide, mainly due to a combination of a population epidemiologic transition towards aging, a more sedentary lifestyle, and a growingly earlier age of onset.[1] Although this phenomenon occurs globally, it mainly affects developing countries.[2] Simultaneously, the prevalence of gestational diabetes (GDM), one of the most common complications of pregnancy, has increased by over 30% in recent decades in several countries,[3,4] thereby conforming an emerging worldwide epidemic.[5]

Globally, about 17% of pregnancies are affected by GDM, but its incidence ranges from 1% to over 25% depending on diagnostic criteria and maternal risk.[6–11] Its prevalence in South and Central America is estimated at 11.2% (CI, 7.1-16.6%)[9] with comparable statistics reported for Argentina.[12]

GDM is associated with a higher risk of adverse health outcomes during pregnancy and delivery for both mothers and babies. Women with GDM have a higher risk of developing complications during pregnancy such as preeclampsia, instrumental deliveries, caesarean section, postnatal DM and obesity, whereas their newborns have a higher risk of developing short-term adverse events (macrosomia, neonatal hypoglycaemia, respiratory distress syndrome and neonatal cardiac dysfunction), as well as long-term metabolic dysfunctions.[13,14]

This negative impact on the mother and offspring can be significantly reduced by early diagnosis and adequate treatment combining the adoption of a healthy lifestyle and, when needed, medication.[15,16]

Despite this heavy clinical impact, few studies have investigated its economic burden: in the United States, the estimated cost of pregnancy with GDM was double that of normal pregnancy (a difference of U$ 7803).[17] In China, considering only the cost during the last gestational trimester, the estimated difference in cost between a pregnancy with and without GDM was U$ 1008 (+95%); in 2015, its total burden was U$ 2.92 billion (¥19.36 billion).[18] Studies in different European countries reported an increase ranging from 20% to 130%, respectively.[19–21] In Mexico, the care cost of a pregnancy with GDM was 56.1% higher than that of a pregnancy without GDM.[22] Such large differences could be attributed to local healthcare systems, demography and ethnic characteristics, as well as the application of different methodologies. All of them, however, highlighted the considerable economic burden and cost differences between pregnancies with and without GDM.

Although it has not been clearly shown, we assume that the economic burden in Argentina is similar. Therefore, in an attempt to decrease this burden upon women with GDM and its economic impact on the healthcare system, we have developed and implemented (a) an educational approach that targets members of the healthcare team (HCTM) at the primary/high complex care level and women with GDM and (b) close contact/interaction between primary care level and maternity hospitals to ensure that every woman with GDM is seen at the appropriate high complexity level. Our study aims to assess the impact of this educational approach and management changes on outcomes for mothers and their offspring.

2 | MATERIALS AND METHODS

Pregnant women with GDM consulting for medical care were sequentially recruited between 2017 and 2019 in primary healthcare centres in combination with participating high complexity maternity (HCM) facilities. Participating HCM were one in the J. R. Vidal Hospital (Corrientes Province) and another in the Argerich Hospital (Buenos Aires City). Every pregnant woman diagnosed with GDM was immediately referred to the HCM.

During this 2-year period, we recruited women with GDM at weeks 28-30 of pregnancy in a chronological sequential order. GDM patients were diagnosed according to Latin American Diabetes Association (ALAD), which is based on glycaemia values either at fasting or after the universal oral glucose tolerance test performed on weeks 24-28 of pregnancy.[23] The recruited women attended follow-up visits from the first clinical appointment and until they delivered the baby.

As exclusion criteria, we excluded women under 18 years of age due to our law regarding underage patients,[24] those with pre-GDM, those who have previous history of serious obstetric complications as well as those who declined to sign the informed consent.

All women with GDM who met the abovementioned conditions and were recruited – in a sequential order – were as follows: Those recruited from 2017 to mid-2018 were assigned to the control group (CG), whereas those recruited from mid-2018 to 2019 were assigned to the intervention group (IG). Applying this procedure, we recruited 263 and 432 women with GDM for the control and intervention groups, respectively.

The women included in the CG received standardized care/routine management and follow-up, including basic information on blood glucose monitoring and insulin injection when necessary.

For the IG, we developed and implemented an educational programme, named EduGest, targeting different members of the HCTM and women with GDM, especially adapted to each of these audiences. Detailed descriptions of the later program have been already reported.[25] Briefly, starting at enrolment, we gave weekly small-group interactive theoretical-practical courses that included basic physiological concepts of the gestation process, foetal growth, normal vaginal delivery and caesarean section, healthy maternal meal plan, physical activities, breast-feeding and explanations of a model for insulin-self-injection practices, blood glucose self-monitoring (SMBG) and data interpretation. Participants were also given a manual summarizing all these contents. These courses were delivered by pre-trained team members – mainly nurses. It also provided educational material (Power Point material and some models such as a perineum and vaginal canal to simulate childbirth) to ensure their effectiveness.

The education program for the IG also includes physicians and nurses who attended a separate, intensive course with specific contents such as standards of diagnosis and prevention and treatment of the disease. Evaluations of their knowledge were taken before and after these courses using multiple-choice questionnaires. They also provide training to enable healthcare professionals to update the QualiDiabGest, NutriQuidGest and WHO-5 registries. The QualiDiabGest

includes clinical-metabolic and gestational events corresponding to the mother and the foetus/newborn.[25] The NutriQuidGest[26] analyses the patient's self-reported food intake and calculates the essential components and nutritional value. The WHO-5 evaluates the patient's well-being and tendency to depression.[27,28] Data were evaluated to assess the impact of the educational programme on GDM outcomes. With all these data, we addressed the evaluation of the impact of the educational program on GDM outcomes.

In both CG and IG groups, each woman's clinical and metabolic data were registered using the QualiGest form, designed and validated especially for the EduGest study.[25] This form includes personal data and obstetric history, body mass index (BMI), blood pressure, cardiovascular risk factors, fasting blood glucose (FBG), serum total cholesterol and triglycerides. It also includes data on the woman's obstetric history, characteristics of delivery, preeclampsia, gestation-induced hypertension and newborn's body weight, as well as the characteristics of the delivery method employed.

Blood glucose and triglyceride assays were done following instructions of commercial kits. The total data recorded were loaded into a single database for further statistical analyses.

2.1 | Statistical analyses

Statistical analyses were done using the Statistical Package for Social Sciences version 15 (SPSS Inc, Chicago, IL, USA). Descriptive statistics are presented as percentages and mean ± standard deviation (SD). Group comparisons for continuous variables were determined by Student t-test and Mann-Whitney U test according to the data distribution profile. We used two-way ANOVA to assess differences between groups in increments in weight, BMI and serum triglyceride of the pregnant women (CG vs IG) and differences between moments of measurement (baseline data vs the one collected at the end of pregnancy). The Chi-squared statistic was used to evaluate differences between proportions. Significance was established at $P \leq 0.05$.

2.2 | Ethical considerations

All study procedures were complied with the ethical standards of the institutional research committee, the Helsinki Declaration of 1964 and its subsequent modifications, or comparable ethical standards. The study protocol was analyzed and approved by the Ethics Committee of the Universidad Nacional del Nordeste (UNNE) (IRB Number: 27/16-10819). All participants included in the study signed their corresponding informed consent.

3 | RESULTS

At the time of the first clinical appointment, clinical and obstetric pregestational background information from the recruited women was recorded as shown in Table 1. It shows that although women included in the CG have a background of lower percentage of obesity, they had a larger percentage of previous macrosomic newborns. No other significant difference was found comparing the other background factors.

When analysing clinical and metabolic variables recorded at the first pregnancy consultation (Table 2), we saw that although we recruited them only by a sequential chronological order, the only significant difference between CG and IG was gestational age (30.2 vs 28.9 weeks; $P \leq 0.002$) and FBG levels (100.6 ± 31.6 vs 92.2 ± 28.9 mg/dL; $P \leq 0.000$), respectively. These two values, however, indicate a GDM diagnosis according to ADA criteria.[27] In both groups, the diagnosis of GDM was confirmed by Oral Glucose Tolerance Test (OGTT).

As an important detail, the QualiGest form records only the woman's body weight and height from these two measurements and the software automatically calculated the BMI. Therefore, due to the availability of these two basic measurements required by the system to determine that parameter, we had BMI data only for 76% and 98% of women from the CG and IG, respectively. These results might suggest that even when data registry was not ideal, it improved in the IG.

At the end of the gestational/delivery period, women in the IG had significantly lower BMI (33.5 ± 5.7 vs 35.8 ± 6.2 Kg/m^2; $P \leq 0.003$) and significantly less weight gain compared to the weight recorded at the first clinical appointment (Table 3 and Figure 1). Concurrently, the newborns in the IG showed significantly lower body weight (3.377.9 ± 591.8 vs 3.484.1 ± 538.3 g; $P \leq 0.0021$), a trend to a lower percentage of macrosomia (12.0% vs 14.8%), a non-significant but lower number of caesarean sections (56.0% vs 60.1%) and a trend to lower serum triglyceride levels (250.1 ± 92.6 vs 285.3 ± 98.2 mg/dL). Also, newborn weight was significantly associated with the mother's weight gain in both the CG and the IG ($r = 0.12$, $P < 0.025$) (Figure 1).

The BMI calculated was 29% (CG) and 69% (IG), whereas triglyceride levels were 3% (CG) and 41% (IG). These differences were considered at the time of statistical evaluation, thereby suggesting a registry improvement associated with the education process.

The number of women who attended reclassification 6 months after delivery was significantly greater in the IG (38% vs 2.7%; $P \leq 0.000$) (Table 3). In the former group, 76.8% had a normal OGTT, 19.5% had prediabetes and 3.7% had already developed T2D. Due to the low percentage of cases in the CG (only seven women attended), no consistent statistical analysis could be done, but the values suggest that the group had a poorer profile (57.1% normal OGTT and 42.9% T2D).

4 | DISCUSSION

Our current IG results show the combination of several favourable outcomes for both mothers and their offspring: a significantly lower BMI and weight gain during the gestational period, a trend towards a lower percentage of serum triglyceride and caesarean sections as well as a significant increase in postnatal attendance to the medical appointment for metabolic assessment/reclassification.

The newborns had a significantly lower body weight associated with a trend to a lower percentage of macrosomia. All together, these

TABLE 1 Pregestational, clinical and obstetric background of the recruited pregnant women

	Control group		Intervention group		
Data recorded	Value	N	Value	N	*P*-value (between groups)
CVRF					
Hypertension (%)	4.9	263	3.0	432	0.193
Obesity (%)	15.6	263	25.0	432	0.003
Smoking (%)	2.7	263	3.0	432	0.790
Dyslipidaemia (%)	0.4	263	0.0	432	0.199
Obstetric history					
Number of previous pregnancies (mean ± SD)	2.3 ± 2.0	258	2.0 ± 1.8	420	0.081
GDM in previous gestations (%)	10.5	209	13.5	347	0.296
Premature newborns (%)	8.5	235	6.8	426	0.424
Preeclampsia (%)	3.0	231	4.5	425	0.366
Family DM background (%)	46.6	251	52.9	423	0.176
Newborn with >4 kg (%)	19.6	240	13.4	426	0.034
HIG in previous gestations (%)	7.2	236	5.2	425	0.289
Eclampsia (%)	0.4	231	0.7	426	0.669

Abbreviations: CVRF, cardiovascular risk factors; GDM, gestational diabetes; HIG, hypertension induced by gestation; DM, diabetes mellitus.

TABLE 2 Characteristics of pregnant women at the time of the first clinical appointment

	Control group		Intervention group		
Parameter	Mean ± SD	N	Mean ± SD	N	*P*-value (between groups)
Mother's age at pregnancy outset (years)	30.8 ± 6.3	259	30.7 ± 6.5	427	0.819
Gestational age at the first consultation (weeks)	30.2 ± 5.1	237	28.9 ± 4.8	396	0.002
Height (cm)	158.9 ± 6.5	221	158.0 ± 6.0	426	0.055
Weight (kg)	75.7 ± 17.4	229	74.6 ± 16.9	424	0.445
BMI (kg/m^2)	29.9 ± 6.1	201	29.8 ± 6.2	423	0.908
SBP (mmHg)	107.5 ± 13.8	240	109.0 ± 13.2	419	0.184
DBP (mmHg)	67.5 ± 9.3	240	68.5 ± 9.6	419	0.160
FBG (mg/dL)	100.6 ± 31.6	220	92.2 ± 16.5	419	0.000
Triglyceride (mg/dL)	225.1 ± 91.8	46	236.2 ± 81.4	296	0.399
Total cholesterol (mg/dL)	229.2 ± 61.6	71	233.8 ± 48.0	368	0.481

Abbreviations: BMI, body mass index; SBP, systolic blood pressure; DBP, diastolic blood pressure; FBG, fasting blood glucose.

results suggest that our educational intervention combined with management changes (active interaction between primary care and special maternity care) induced a favourable impact on several risk factors and consequently on GDM outcomes related to both the mothers and their offspring.

The lower BMI and weight gain during the gestational period recorded for IG women have been associated with different decreased risk ranges of adverse outcomes depending on pregestational weight.[29] This range went from 14.0 kg (underweight women) to less than 6.0 kg for obesity grade 3 (BMI ≥ 40 kg/m^2).[29] Gestational weight gained outside this range was associated with low and moderate adverse outcomes.[30] A population-based study in the United States of pregnant women with singleton hospital births between 2004 and 2013 found that both low and excess weight gain were associated with severe adverse birth outcomes.[31] In our case, newborn weight was significantly associated with the mother's weight gain ($r = 0.12$, $P < 0.025$).

The combination of maternal BMI, excess gestational weight gain and hyperglycaemia operates as a set of independent factors promoting neonatal adiposity.[32] This evidence supports the favourable

TABLE 3 Outcomes at the end of the gestational/delivery period

Data recorded	Control group Value	N	Intervention group Value	N	*P*-value (between groups)
Delivery by caesarean (%)	60.1	238	56.0	423	0.311
Newborn (number)	1.2 ± 0.7	219	1.0 ± 0.1	421	0.001
Newborn					
Capurro index (weeks)	38.6 ± 1.4	192	38.4 ± 1.9	422	0.214
Weight (g)	3.484.1 ± 538.3	243	3.377.9 ± 591.8	432	0.021
Macrosomia (%)	14.8	243	12.0	432	0.304
Other complications (%)	7.2	263	8.8	432	0.464
Maternal					
Weight (kg)	88.7 ± 18.4	95	83.8 ± 15.4	304	0.011
BMI (kg/m^2)	35.8 ± 6.2	77	33.5 ± 5.7	300	0.003
Triglyceride (mg/dL)	285.3 ± 98.2	7	250.1 ± 92.6	175	0.361
Complications (%)	8.7	263	7.9	432	0.684
Postpartum reclassification (%)	2.7	263	38.0	432	0.000

Abbreviation: BMI, body mass index.

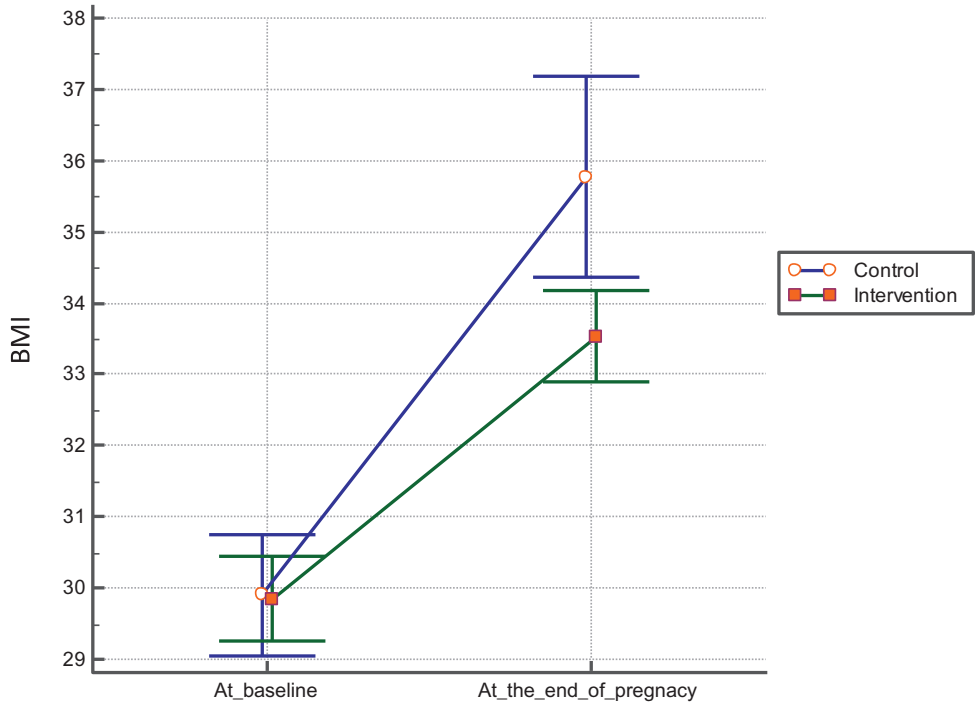

Figure 1 Increase in BMI (baseline vs at the end of pregnancy)

pathogenic role of lower weight gain observed in our IG women. With the same reasoning, a recent report strongly suggests that early GDM screening and diagnosis may be beneficial for tempering gestational weight gain by prescribing and monitoring treatment early in the pregnancy: this program includes the adoption of a healthy lifestyle (meal planning and weight management), as first-line treatment for GDM together with initiating SMBG.[33,34]

A trend of decreased triglyceride was another risk factor ascribed to our educational intervention: though during pregnancy an increase of serum triglyceride occurs normally as a compensatory mechanism to cope with increased demand for metabolic substrates,[35] it has been proposed that impairment of lipid metabolism rather than solely hyperglycaemia is the factor that increases the risk for macrosomia in GDM.[36] Our recent publication which studied the frequency

and pathogenesis of macrosomia in mothers with GDM supports this hypothesis.[37] Although no clear normal cut-off values for serum triglyceride are available for our local population, the lower values recorded in our IG women suggest that they may favour the significantly lower body weight and the lower trend to macrosomia of the offspring currently reported. We are at the moment trying to settle the triglyceride cut-off value for each gestation trimester to overcome such lack of information.

Despite the large pathogenic role of triglyceride in undesirable GDM outcomes, our data show that their measurement is neither systematically prescribed nor fully and systematically recorded. How to change this behaviour may be an excellent area for further research.

Outcomes improvement in our IG could be partly ascribed to the women's adherence to the prescription of a healthy life style; its efficacy concords with previous reports establishing that prevention/treatment of GDM must start with dietary and lifestyle advice, associated with metformin or insulin when the former strategy fails to reach glucose target values. Diabetes education provided to IG might be a prime factor in the induction of this healthy behaviour and the consequent reduction of the risk of having big babies.[38]

The efficiency of the education strategy currently implemented is further supported by the conclusions of the Cochrane meta-analysis, which assures that lifestyle interventions are the primary therapeutic strategy as well as self-monitoring of blood glucose levels.[39] Its success, however, requires trained personnel to provide optimal education and management support such as we implemented in our EduGest study.

Low-quality evidence suggests that women receiving these educational interventions may have more probability of achieving weight goals than those receiving the customary care or only dietary advice. For the infant, moderate-quality evidence shows that lifestyle interventions yield a reduced risk of births with large-for-gestational-age babies and reduced adiposity compared to usual-care or dietary-advice-only babies. On another front, little is known about the cost-effectiveness of these interventions on GDM outcomes for mothers and/or their offspring.[40] This point merits further studies for its assessment and to get stronger evidence of its efficacy.

Postpartum attendance for metabolic reclassification was another successful goal of our intervention: 164 versus seven cases in the IG and CG, respectively. The low attendance observed in the CG was not completely unexpected, because it has been reported that after delivery, women who have had a GDM face difficulties for attending glucose testing postpartum and long-term control visits. These difficulties include fears concerning the risk of developing diabetes and other factors as well. Previous reports have shown that education regarding the risk of developing T2D after having GDM, provided during and after pregnancy, would lower the barriers against testing, thereby enabling earlier diagnosis/treatment management of diabetes and improving long-term outcomes.[40,41] These findings consequently lend further support to our current improvement of postpartum consultations in the IG.

Although we have too few cases to reach a sustainable conclusion, the large difference in percentage of Normal Glucose Tolerance (NGT) (78.6% vs 57.1%) and of T2D (3.7% vs 42.6%) in the IG and CG, respectively, would suggest a favourable impact of our intervention on these results. This suggestion merits further studies to prove the real value of this assumption.

All our results could be ascribed to the educative strategy employed, thereby confirming its effectiveness. In this regard, we initially assume that GDM results from β-cell failure to cope with gestational insulin resistance and that its treatment attempts to prevent/decrease adverse pregnancy outcomes. Consequently, we share and support other authors' conclusion that education is the cornerstone of GDM management, and that well-trained members of the HCTM are the most effective personnel for its implementation.[42]

They also support the hypothesis that this type of intervention implemented at the primary care level closely associated with HCM facilities at an early stage, that is before the pregnancy develops GDM, would enhance the chances for both effective gestation control and post-delivery surveillance to implement preventive care, thereby reducing the risk of undetected early-onset T2D.[43] Furthermore, education given and supported by diabetes peers is associated with many benefits in relation to clinical, behavioural, and psychosocial outcomes. Consequently, when feasible, peer support could be included in order to reap its many potential benefits and cost-effectiveness.[44]

Regarding the future, we might consider that all the above education-induced beneficial effects were obtained by initiating its implementation around the 29-30 gestational weeks; therefore, the results could presumably be significantly improved when education is applied at an earlier stage: ideally, in the first trimester of gestation.

Although our results provide evidence of the improvement of GDM outcomes ascribed to educational intervention, they should be considered with caution due to several weaknesses, namely (a) BMI differences at the end of the gestational period were not obtained/recorded for all the participants, (b) serum triglyceride levels were measured/recorded at that period only for less than 50% of the participants, (c) many of our improvements showed a trend to rather than a significant difference in favour of the IG and (d) our physicians do not spend much time or dedicate careful attention to completely fill out the patient's records; we might reinforce recommendations in our educational program to cope with this problem as suggested by other authors.[45] Implementation of electronic clinical records might also help to overcome this deficiency.[46]

As an aditional limitation, although we have explored food intake (NutriGest) and psychological impact (WHO-5) of GDM, we have presently not described/analysed these results. They merit, however, a deep analysis to their respective role within the education process for a further proximal publication.

Notwithstanding, the consistency of the current data suggests the favourable impact of the integral educational process implemented for the HCTM members and the women with GDM diabetes.

In conclusion, our results suggest that education provided to all the actors involved in the gestation process (women with GDM, members of the HCTM and a well-trained education team), in an integrated combination of primary care level and HCM facilities, is an effective

approach to cope with the socioeconomic burden of the disease both at present and in the long term.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

ACKNOWLEDGEMENTS

This study was partially funded by the World Diabetes Foundation (WDF 15-1314) granted to Silvia Gorbán de Lapertosa. The authors are grateful for the efficient and generous cooperation of all the staff of the Facultad de Medicina of the UNNE and the Municipality of the City of Corrientes. Also to the Dean of the Faculty of Medicine UNNE, Professor Mag. Omar Larroza and Accountants Dana Zimmerman and Analía Falcón of the same Faculty for their kind cooperation. We appreciate the valuable contribution of Dr Enzo Rucci for the development of the software that manages the loading and analysis of the database as well as Mrs Susan Rogers for the manuscript edition. JFE and JJG are members of the CONICET Research Career. The authors also gratefully acknowledge the active participation of EduGest Group: Lic. Arias V, Lic. Costa D, Dres. Aquino C, Saucedo J and Rovira M; Ludman V, Gutierrez JP, Veglia V, de Sagastizabal T, Cardozo A and Bordon G; Barrios E; Burgos G; Bustos MV; Del Campo MJ; Dominik E; Hidalgo GE; Maldonado G; Nasello M; Pla MF and Zafrán E.

CONFLICTS OF INTEREST

The authors declare no conflicts of interest.

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How to cite this article: Gorbán de Lapertosa S, Elgart JF, González CD, et al. Educational interventions to improve maternal-foetal outcomes in women with gestational diabetes. *Lifestyle Med*. 2021;2:e18. https://doi.org/10.1002/lim2.18