

Diabetes Curriculum for Pediatric Endocrine Fellowship Utilizing Modified Team-Based Learning

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Abstract

Introduction: While type 1 diabetes is frequently encountered clinically in pediatric endocrinology fellowship training, other types of diabetes may only be encountered in educational settings. Adult learners learn best through knowledge application, but to date there are no published curricula utilizing application educational strategies for all forms of diabetes. **Methods:** We utilized a team-based learning (TBL) approach to create four modules on different types of diabetes: type 1 diabetes, type 2 diabetes, neonatal diabetes, and maturity-onset diabetes of the young. We divided our fellows (all training years, $n = 11$) into two teams and delivered four separate, 90-minute sessions. To emphasize the application of knowledge, we modified the format to combine the readiness assurance test (RAT) with application problem (APP) questions. The combined RAT/APP questions were answered by individuals and teams. We analyzed scores from individual and team tests and evaluated each module. Additionally, we acquired subjective data from the fellows regarding their experiences. **Results:** Teams outperformed individuals on the tests, as expected (94% vs. 76% correct questions, respectively). All the fellows agreed that the sessions should be included permanently. Additionally, all agreed the sessions helped them apply knowledge. Subjectively, the fellows were very engaged and lively during the sessions and felt the sessions were feasible as implemented. **Discussion:** TBL can be a valuable educational strategy to increase the application of knowledge for diabetes in pediatric endocrinology fellows. Future studies examining the use of this strategy to increase critical thinking skills and knowledge retention in the long-term would be useful.

Keywords

Team-Based Learning, Problem-Based Learning, Fellowship, Fellowship and Scholarship, Diabetes, Diabetes Mellitus

Educational Objectives

By the end of this activity, learners will be able to:

1. Alter insulin analog treatment appropriately for different clinical scenarios.
2. Utilize the mechanism of insulin action to understand diabetic ketoacidosis.
3. Compare and contrast mechanisms, consequences, and treatment of different types of diabetes.
4. Apply knowledge of insulin synthesis and secretion to create a differential diagnosis of neonatal diabetes and maturity-onset diabetes in the young.

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Introduction

Although the most common form of diabetes in pediatrics is type 1 diabetes,¹ an autoimmune condition resulting in the loss of insulin-secreting beta cells, there are multiple other causes of diabetes. Type 2 diabetes is linked to obesity and insulin resistance. Additionally, multiple genetic mutations exist which cause neonatal diabetes, and maturity-onset diabetes in the young (MODY). Since the causes of these forms of diabetes are different, the presentation, progression, and treatment also differ significantly. Understanding these differences are paramount to pediatric endocrinology education since misdiagnosing a patient as type 1 diabetes instead of MODY may be the difference between injecting insulin three to five times per day versus taking one pill once a day.²

One of the objectives of our fellowship program was to meet the objectives of the American Board of Pediatrics (ABP) endocrine outline.³ For pediatric endocrine fellow, the ABP requires that all board-certified pediatric endocrinologists be able to correctly

diagnose, treat, and counsel on all forms of diabetes. A recent study showed that despite educational curricula, pediatric endocrine fellows perceive they have suboptimal knowledge regarding insulin pumps and continuous glucose monitoring.⁴ While the number of clinical encounters in type 1 and type 2 diabetes is generally extensive, other forms of diabetes are rarer and may only be experienced in an educational session. Additionally, pediatric endocrinologists must still be able to apply the underlying physiology of the disease to a treatment even when the presentation of these diseases are not textbook. Thus, comprehensive education for pediatric endocrine fellows on all forms of diabetes is extremely important.

Fellowships present multiple dilemmas for educators. Fellowships are generally small, with only three to 12 learners in each program. Curricula must teach all learners simultaneously, accounting for those with little endocrine knowledge as well as those with more extensive experience. There is a paucity of literature regarding best practices in the education on diabetes. Learner-centered modules/curricula have been implemented to improve pediatric resident knowledge of diabetes, mainly focused on type 1 or type 2 diabetes and treatment.⁵⁻⁷ However, there is no literature regarding how to teach diabetes to endocrine fellows or how to teach the other types of diabetes.

Nine months prior to this curriculum, we conducted a needs assessment survey of our fellows through both an online, anonymous survey, and through group discussion. In the online survey, 88% stated they learned best by applying knowledge. This was consistent with literature on adult-learners. Adult learners learn best when they are involved in their education, learning through experience in relevant subjects, and learning through problem solving, not didactics.⁸ However, our prior educational offerings were mainly through traditional didactic lectures which utilized visual and auditory passive learning, not application of knowledge.

Team-based learning (TBL) is a teaching strategy which promotes learner-initiated preparation, individual assessment of knowledge, and application of knowledge in a team setting.⁹ While most extensively used in undergraduate education, TBL has been utilized in numerous postgraduate settings.^{10,11} In general, graduate medical education learners viewed TBL favorably.¹² Additionally, TBL uniquely encouraged the application of knowledge and not just overall knowledge acquisition.¹² Given that we wanted our fellows to be able to apply knowledge in order to properly diagnose and treat diabetes, we felt TBL would be an effective teaching strategy to improve our fellowship curriculum.

This resource contains a diabetes curriculum based upon ABP learning objectives and is composed of four TBL-based modules targeting pediatric endocrinology fellows of all years of learning. These modules were created as an addition to our traditional didactic lecture series and were completed in a 90-minute time frame. These modules were designed to improve the application of pathophysiology to a wide-variety of diabetes diagnoses, including type 1 diabetes, type 2 diabetes, neonatal diabetes, and MODY.

Methods

We added a TBL diabetes curriculum as four separate 90-minute sessions (i.e., neonatal diabetes, MODY, type 1 diabetes, type 2 diabetes) in addition to our traditional didactic lectures. TBL sessions occurred at least 2 weeks apart. These modules began at the end of July, which is approximately 3 weeks into fellowships for our first-year fellows. A TBL champion and coauthor of this curriculum, Dr. Stephanie Sisley, was responsible for organizing and guiding the pediatric endocrine faculty at Baylor College of Medicine/Texas Children's Hospital to create and edit the TBL sessions. Traditional TBL has multiple-choice, knowledge-based readiness assurance tests (RAT) that are taken by individuals (iRAT) and then by teams (tRAT) to ensure all learners have the same fundamental knowledge base. These are then followed by application problems (APP), which are done in groups and are designed to apply knowledge to a particular problem. Since our overall goal was to increase the application of pathophysiology with clinical phenotypes, we instructed faculty to create questions that were higher-ordered and required application of knowledge. Thus, our sessions included individual and team tests, but the tests were a combination of RAT and APP.

We relied on the diversity of knowledge within the teams and intrateam discussions to fill in any gaps regarding basic knowledge that would be addressed with typical readiness assurance questions. Additionally, we relied on the small-group dynamics to keep learners accountable for doing preparatory work. We sequenced questions to build upon knowledge throughout the session. Thus, we did not segregate readiness assurance questions and application problems into different blocks during the modules, but instead integrated them into one test. This allowed for a more natural flow of discussion regarding similar topics that would be addressed in both traditional readiness assurance and application parts. Additionally, we sequenced the sessions to start with neonatal diabetes and MODY as we felt this was the best way to fundamentally understand insulin secretion. Starting with these modules also had the added benefit of fewer objectives, which was

an easier point of entry for our fellows. Curriculum coauthors Drs. Stephanie Sisley or Ioanna Athanassaki facilitated the TBL sessions. Both of these facilitators had participated in a TBL workshop given in 2017 by Dr. Ruth Levine, a certified TBL collaborative trainer.

The TBL champion performed one 30-minute orientation about the TBL curriculum 2-3 weeks prior to the first TBL session. The orientation briefly discussed why we had chosen TBL as an educational strategy and explained the expectations and flow of the TBL sessions.

Team Division

We divided the fellows into two teams (five in one and six in another) and kept an equitable distribution of years of training among them (team 1 consisted of two third-years, one second-year, and two first-years, whereas team 2 consisted of one third-year, two second-years, and two first-years).

Preparation and Resources

Instead of creating new learning objectives, we utilized the relevant ABP pediatric endocrine content outline³ objectives as learning objectives for each session. Fellows received the objectives 1.5 weeks prior to the TBL session (Appendices A-D). Although the objectives were taken almost verbatim from the ABP endocrine content outline,³ we did modify them to eliminate duplications and combine extremely similar objectives into one single objective. In general, we did not provide advanced learning materials. However, as a part of our fellowship orientation, all fellows received copies of a review on MODY,² clinical practice consensus guidelines on diabetic ketoacidosis,¹³ and the most recent American Diabetes Association standards of care (initially created for 2018 standards but updated for the 2020 standards).¹⁴ Fellows were also provided with the most recent edition of *Pediatric Endocrinology*.¹⁵

Individual and Team Readiness Assurance Process

Learners completed a six- to eight-question individual test composed of both iRAT and iAPP problems (Appendices A-D). They completed these on their own through Blackboard Learn on the day of the session. We configured the iRAT/iAPP to be a timed, 30-minute test, even though it was designed to be completed in 20 minutes or less. Fellows were instructed and trusted to complete the iRAT test without referring to notes/resources. Fellows then came together for the tRAT/tAPP test in the afternoon. For each question, fellows discussed the answer and then one member of each team entered their team answer into the Blackboard Learn system. The facilitator of the session randomly chose who from each team would

read the answer for their team, alternating which team started and calling on all learners at least once during the session. After both teams had answered, the facilitator guided further discussion if a discrepancy existed between the teams' answers or if they were incorrect. The facilitator then provided immediate feedback by revealing the answer and giving a brief 1- to 5-minute explanation of the answer, utilizing the answer notes provided by the faculty session creators.

The group discussion was also used to determine if an alternative answer would be accepted (e.g., if question wording caused confusion) and teams used this time to appeal their answers verbally. If the facilitator could not adequately address a question from the learners, the facilitator wrote it down and gave it to a content expert within the section to address in an upcoming lecture. The TBL champion graded all the tests after the session anonymously through the learning software, and then learners were able to see their grade and score. Each question of the iRAT/iAPP and tRAT/tAPP was scored on a 2-point system: 2 points for full credit, 1 point for partial credit, and 0 points for no credit.

Team Application Activities

As stated above, each session had team application activities embedded with RAT questions. We chose to integrate these questions into the iRAT/tRAT tests because we felt it was important for our advanced learners to apply their knowledge to significant problems individually before relying on the group. These embedded questions still adhered to the four S's, a hallmark of traditional TBL: significant problem, same problem, specific choice, and simultaneous reporting. Additionally, the sessions had an additional activity done only at the end of the team test if it required drawing, since this was not a possibility on our computer systems.

Facilitation Schema

These four modules were each 90 minutes in length, although the individual tests were performed prior to the session. During the first module, team formation took 5 minutes. Otherwise, the session flow occurs as in [Figure 1](#).

Evaluation

Within the Blackboard Learn system, learners were asked to evaluate each session anonymously regarding whether the questions met the objectives, if the questions stimulated them to apply knowledge, and if the session should be included permanently (Appendix E). Additionally, at the start of each session, learners were asked as a group if they were able to finish the iRAT/iAPP in the time allotted. We also held feedback

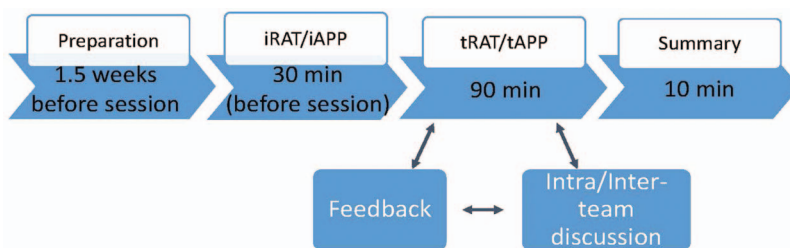


Figure 1. Facilitation Schema. Abbreviations: RAT = readiness assessment test, APP = application problems, i = individual, t = team.

sessions with the fellows as a group to provide input on how the curriculum was meeting their needs.

Results

Between nine and 11 pediatric endocrine fellows participated in each TBL session. Of the individual fellows, four were first-year, four were second-year, and three were third-year. Subjectively, the learners were very engaged and interactive during the sessions. Facilitators observed equal participation among the team members, including all years of training. Both first-year and upper-level fellows contributed toward the teaching of others in their group.

Initially we had placed a time limit of 20 minutes for the completion of the iRAT/iAPP. However, after the first session, fellows stated that 20 minutes was not enough time for all of them. After changing the time limit to 30 minutes, all of the learners were able to complete the remaining iRAT/iAPP in the time allotted.

The overall mean score on the iRAT/iAPP was 76% (Figure 2a), although this varied from 60% to 89%, depending on the difficulty level of the session (Figure 2b). Based on a *t*-test, the teams performed better on the tRAT/tAPP ($M = 94\%$; range 83% to 100%; $p < .05$) compared to iRAT/iAPP (Figure 2a). Based on a one-way ANOVA, the mean score on the iRAT/iAPP was statistically different ($p < .05$) by year of training (Figure 2c).

A total of 35 session evaluations were obtained. Learners were asked to rate their agreement with a statement based on a 5-point Likert scale (1 = *strongly disagree*, 5 = *strongly agree*). All learners agreed all four sessions should be included permanently in our curriculum, with 65% strongly agreeing. Respondents agreed/strongly agreed 93% of the time that the sessions appropriately tested their knowledge of the content objectives, and 100% of the time that the session helped them apply knowledge. As seen in Figure 3, the evaluations were similar across the sessions, with the lowest scores being in the type 2 diabetes session.

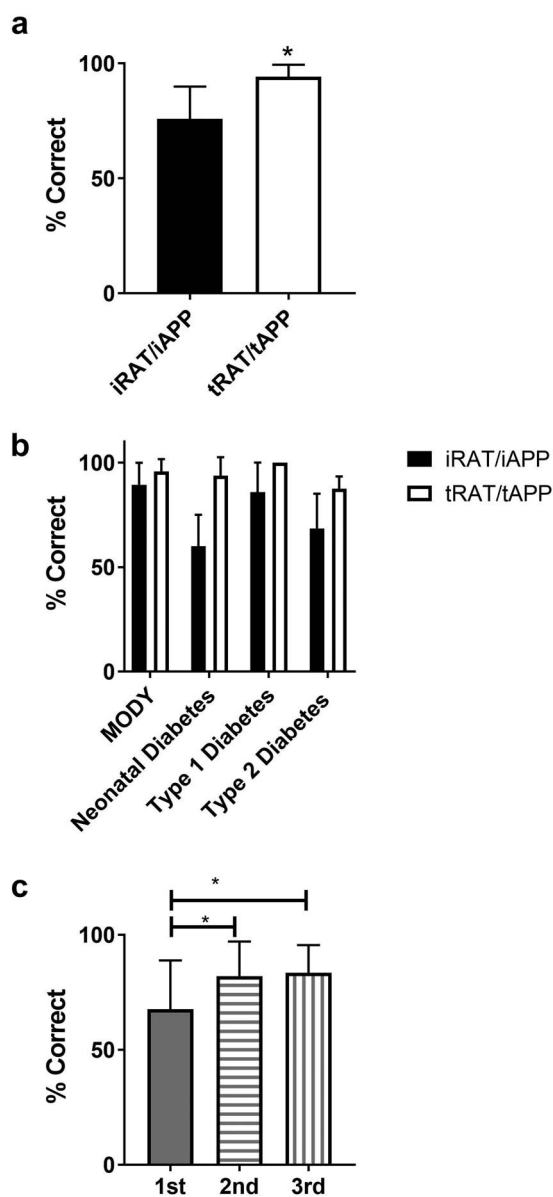


Figure 2. iRAT/tRAT Scores. a. Percent of answers correct on iRAT/iAPP versus tRAT/tAPP tests averaged over the four modules. b. Percent of answers correct on iRAT/iAPP versus tRAT/tAPP tests for each of the four modules. c. iRAT/iAPP scores according to year of fellowship training. * $p < .05$.

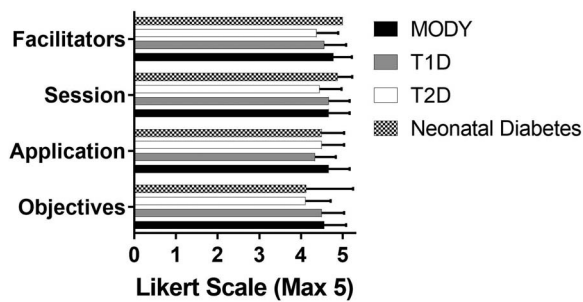


Figure 3. Session Evaluations. Fellows were asked to evaluate each session separately based on a 5-point Likert scale (1 = *strongly disagree*, 5 = *strongly agree*). The statements were as follows: (1) The facilitators balanced guiding the group and allowing the learning to occur within the group setting. (2) This session should be included as a permanent session in the curriculum. (3) The group questions/tests stimulated application of my knowledge. (4) The iRAT adequately assessed my knowledge of the learning objectives. Abbreviations: MODY = maturity-onset diabetes of the young, T1D = type 1 diabetes, T2D = type 2 diabetes.

Although Figure 3 shows the learners felt the material addressed the ABP content specifications objectives within each module, this supports learners achieving the overall educational objectives for the session. The overall educational objectives are supported in the following way: objective 1 is covered in Appendix C and D; objective 2 is covered in Appendix A and C; objective 3 is addressed in Appendices A-D; and objective 4 is covered in Appendix A and B. In addition, the ability of learners to answer the iRAT questions and the increase in scores from iRAT to tRAT showed that learners were able to meet all four educational objectives.

From a qualitative standpoint, learners were very enthusiastic regarding the sessions. The facilitators noticed significant energy and discussion from everyone present. While there were a few questions that needed editing/clarification during the sessions, there were several comments from participants that the best part of the session was “the interactive questions” or “great questions.” Surprisingly, the fellows asked for even harder questions on some of the evaluations and during feedback sessions. Some fellows noted that the sessions forced them to study because they did not want to “let their team down.” Several comments from the evaluations pointed toward the team learning as the most enjoyable part of the sessions. Although preparing well for the session required a significant amount of time, fellows who had not been able to devote significant time to preparation still stated they got a significant amount of learning from their teammates and enjoyed the sessions.

Discussion

This diabetes curriculum provided a comprehensive overview of different types of diabetes utilizing an interactive, TBL-based

style. We demonstrated the feasibility and use of this curriculum in a pediatric endocrine fellowship containing mixed levels of learners. While the creation of these sessions took a significant amount of time for our faculty and TBL champions, the publication of this curriculum will allow other programs to use this format with much less effort. From our perspective, the greatest value in this curriculum was the interactive nature of the format, allowing for significant participation by all fellows. Additionally, this curriculum was implemented in a 90-minute time frame which is less than the 120+ minutes reported by many other TBL curriculums.^{11,16-18}

Our overall goal for this curriculum was to stimulate the application of pathophysiology to clinical care. Both in quantitative measurements and from a qualitative standpoint, we were able to achieve both of these objectives. The fellows who requested even harder questions for subsequent sessions underscored this. Although we were somewhat surprised by this, it is likely that their ability to learn from each other negated any frustration over answering questions incorrectly.

While the vast majority of our fellows felt the sessions appropriately tested their knowledge, there were one to two learners in some of the sessions who were neutral or felt the session did not appropriately test their knowledge. Given that the objectives from the ABP pediatric endocrine content outline³ were too numerous to cover entirely by the RAT/APP tests, it is possible that these learners either: (1) had a mismatch with what they studied and what was tested, or (2) felt that their knowledge base was not tested completely. Since our evaluations were anonymous, we were not able to ascertain whether there was any association between the level of learner and their response to this question. Regardless of their feelings on the scope of knowledge testing, the learners all agreed that the sessions should be continued and were pleased with the sessions overall.

Based on the success of these modules, we have continued to create modules for additional topics of pediatric endocrinology, including growth, thyroid, and puberty. We hope to publish these in the future. Additionally, we are currently assessing how to implement the curriculum repeatedly in subsequent years.

We acknowledge some important limitations to this curriculum. We were able to implement this curriculum in 90 minutes by having learners complete the iRAT/iAPP prior to the official TBL session. To achieve this, we placed faith in the integrity of our learners that they would not utilize outside resources to answer the questions. Given the iRAT/iAPP scores, it does not appear that outside resources were utilized. However, it is possible that

the fellows did utilize outside resources. The ultimate goal of our curriculum was to improve knowledge and critical thinking skills of our fellows and not to ascertain their knowledge or grade/rank them. Thus, for our program, we deemed using the entire 90 minutes of the TBL session for group discussion a much greater priority over guaranteeing that outside resources were not used during the iRAT/iAPP. Other programs implementing this curriculum may have different priorities and might want to modify this part.

We did not create new objectives for each module but instead utilized the existing ABP pediatric endocrine content outline³ objectives. This decreased the workload on our faculty to create new objectives. However, we acknowledge that the number of objectives given to the fellows was much greater than other published TBL curricula. Additionally, the objectives themselves are largely lower-order objectives. We were initially worried that perhaps the sheer number of objectives were too many and we asked the fellows if they would prefer broader, higher-order objectives where the number of objectives could be reduced. However, the fellows chose to have the longer list of objectives. Informal conversations about this seemed to indicate that they found it easier to determine what to study with the longer list of lower-order questions than a shorter list of higher-level, broad objectives.

For the questions themselves, we realized a few were too simplistic or caused the fellows to go in an unintended direction and we have modified the appendices to reflect how we intend to deliver these modules in the future. These questions used several different styles of questions: (1) multiple-choice with elaboration on why answers are correct/not correct, (2) matching, and (3) free-text. In our opinion, the most discussion came from the single choice, free-text answers where they also had to justify why they chose that answer. We did not directly measure how question format (e.g., open-ended vs. multiple-choice) impacted the time to answer. Our impression is that response time for questions did not depend on the format but rather the difficulty of the question itself. We have unpublished, pilot data which demonstrated that the fellows agreed open-ended questions were better for testing true understanding of a topic. However, many of the questions could be altered into different styles to aid with grading. The open-ended nature of the questions likely allowed the test itself to be a learning tool within the framework of desirable difficulties.¹⁹ Thus, adapting the questions to a different format would likely necessitate structuring them in a way to provide competitive incorrect alternatives which would invoke the retrieval processes to select the right answer.¹⁹

Additionally, we were not able to assess long-term knowledge retention or changes in problem-solving skills. The assessment of both of these skills in the long-term was difficult in a clinical program since changes over time may be reflective of differences in clinical experiences and not necessarily the mode of instruction. We do intend to analyze results from our intraining scores as possible measures of retention of material, although this also falls subject to the confounders mentioned above. However, future studies comparing traditional didactic versus TBL-based delivered information in both long-term retention and improvement in critical thinking skills would be beneficial.

This curriculum was facilitated by faculty who had done extensive self-education in adult learning theory and TBL. Additionally, they were significantly involved in the creation of the TBL sessions. However, since the initial implementation of these modules, we have had one faculty member facilitate a session in which she did not play a role in the TBL session creation; her estimated preparation time was 1-2 hours. This preparation time is in line with what we would estimate for other facilitators, although it may increase for facilitators who are not familiar with the subject material.

Lastly, we acknowledge that use of this curriculum in other settings may require adaptations. We have a large fellowship for the pediatric endocrine program which allowed us to create two teams of at least four learners each. In our experience, teams of three learners would be adequate for these sessions. Programs with less than six fellows may have difficulty implementing this curriculum. Using faculty as team members, either integrated on fellow teams or as a separate team (e.g., fellows vs. faculty) may be feasible and perhaps a fun alternative for smaller programs. Programs might also be able to compete virtually with other programs. Additionally, we feel this curriculum is likely applicable to other pediatric learners, such as residents or nurse practitioners, with minor modifications. Less advanced learners, such as residents, would likely need to be provided with guided reading material such as a review on neonatal diabetes,²⁰ MODY,²¹ and the pediatric standards of medical care in diabetes.¹⁴ We also feel residents would likely benefit from the objectives being shortened to only those applicable to the questions in the module. However, we have not tested this and further feasibility studies utilizing residents would be useful.

In summary, this diabetes curriculum consisting of four different TBL-based modules was designed to increase the application of knowledge to clinical concepts in diabetes. These modules utilized both traditional knowledge-based questions as well as application-based questions in our individual and group

assessment tests. Groups outperformed individuals and the learners were highly satisfied with the curriculum. We feel this is a valuable educational strategy to enhance the application of knowledge in diabetes.

Appendices

- A. Neonatal Diabetes TBL Module.docx
- B. MODY TBL Module.docx
- C. Type 1 Diabetes TBL Module.docx
- D. Type 2 Diabetes TBL Module.docx
- E. Session Evaluation.docx

All appendices are peer reviewed as integral parts of the Original Publication.

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Ethical Approval

Reported as not applicable.

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