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Research Article

Student Achievement in the Context of Semantic Web Application in English Education

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Abstract:

In this research, it is aimed to determine the effect of student access according to the level system consisting of Semantic web applications in the teaching of higher education program. The research was conducted in the second semester of the 2023-2024 academic year at Ondokuz Mayıs University Vezirköprü Vocational School. In this study, pretest / posttest experimental design with non-equivalent control group was used. The first-year daytime students of the Department of Computer Programming were randomly assigned to the control group. The second education of the first year of the computer programming department was determined as the experimental group. The prepared educational material was organized according to Ondokuz Mayıs University English course ydi 102 course curriculum. Both the material and the pre-test and post-test were submitted to the approval of the English field teachers. In accordance with the semantic web-based system, two level tests were prepared according to the curriculum. One of them will be administered at the beginning of the semester and the other at the end of each course. Websites were saved in the database system on the semantic web material, including the user level. When the user entered the system, the websites were shown to the user according to the user's level. The control group did not enter this semantic web system. They only worked with the classical method. The aim of this study is to develop a material suitable for the level system in English language education.

1. Introduction

Currently used web technologies are primarily based on document exchange. However, the Semantic Web focuses on the integration and consolidation of data obtained from various documents, emphasizing the necessity of shared structures [1] These structures must have the capability to retain the semantic structure of data while also providing the common framework necessary for integrating and consolidating data from multiple documents. The Semantic Web, introduced by Tim Berners-Lee in 2001, represents a shift from traditional web technologies by enabling machines to process, understand, and relate web data meaningfully. In the context of education, this technology offers immense potential to overcome information overload, streamline resource access, and support adaptive learning systems. By organizing data into structured formats, Semantic Web technology facilitates precise and efficient resource retrieval [2]. This study explores its application in English language education, focusing on student success, personalized learning, and the broader implications for modern education systems. Web-based internet pages operate within a continuously active database pool. Data on the internet is updated dynamically, sometimes within years, months, days, or even hours [3]. For instance, when a football player transfers to a new team, their updated team information will be reflected on sports-related websites. If such updates did not occur and outdated information continued to be displayed, the system would logically produce errors. Web pages are designed to present data that is interconnected through logical functions and often rely on mathematical functions to return accurate results. The semantic web aims to eliminate these issues and reduce information pollution by consolidating data on the web into a shared pool. It seeks to manage the words or resources we search for on the internet automatically [4]. For this to work, all resources and information on the web must be linked to clear descriptions, definitions, and semantically meaningful data. Metadata (descriptive data) must be created for effective data management, enabling access to complex queries and related information services, meeting rooms, amphitheaters, exhibition halls, and offices, which support various activities [5]. The same principle applies to education. There are numerous web pages dedicated to education. Producing shared instructional definitions benefits both students and teachers. Consistent search results related to web-based learning objects not only improve sharing but also reduce unnecessary duplication of work on the same subject. Learning objects prepared using the semantic web enable faster development of activities and more effective resolution of knowledge gaps by providing access to appropriate instructional materials [6]. In a study by Mohammed and Mohan (2005), they demonstrated that the effective sharing of learning objects can be achieved by enabling these objects to use linked ontologies to comment on their own context and characteristics [7]. As a result, requests for learning objects will return only those objects with the relevant features and context, effectively limiting the number of records returned by queries. The Semantic Web explores the meaning of information, enabling computers to read and understand this information in addition to humans. It is not a completely new invention, but rather an extension or add-on to the current web, where data and information are organized and programmed in a way that both computers and humans can work together [1]. The main goal of the Semantic Web is to develop standards and technologies that allow sufficiently defined and interrelated data and services to be understood easily by computers, just as humans understand them in the web environment [8]. For the Semantic Web to function properly, computers must be able to access structurally organized concepts and rules for reasoning (automatic judgment) to extract meaning.

2. Related Work

2.1 Ontology

Ontologies are key technologies used in the realization of the Semantic Web. The term ontology is defined in philosophy as the science of being [9]. In computer science, it refers to conceptualization, making something more understandable, or materializing it. In other words, it is about making something more tangible by creating a conceptual map. First, definitions, objects, and rules are determined, followed by logical and mathematical relationships to plan and reach the final outcome step by step. This is where the concept map or ontology is created. In short, it is the scenario development and virtualization of the system. This way, predicting results and errors in advance becomes possible [10].

The ontology is qualified and fixed as a finite number. This includes understanding the meaning of data, relationships between data, similarities and differences between data, and sequential relationships such as order. For a concept set in the Semantic Web to be considered an ontology, it must meet certain criteria. These include:

The data set must have a boundary, and from there, data should be meaningfully connected from part to whole.

The logical and mathematical operations between data sets and meaningful data must be atomic, meaning they should have only one answer.

According to Maedche and Staab (2001), for an ontology to be more understandable and user-friendly, it should:

- Contain an easily understandable, simple example,
- Have class attributes found in object-oriented programming,
- Include criteria for comparing mathematical functions,
- Include criteria for comparing logical functions.

Maedche and Staab addressed ontology as a web ontology . Each data point has a descriptor, and the data in the ontology is characterized and finitely fixed. This includes the meanings of the data, the relationships between the data, the similarities and differences among the data, and their sequential and ordering relationships. If we examine the layered structure of the Linked data, as seen in Figure 1, the bot-tom layer contains XML (Extensible Markup Language). XML, developed after HTML, is a language used for data storage and data exchange between web pages and other software. Following XML is RDF (Resource Description Framework), which forms the data model of the Linked data, essentially establishing the rules of the database. The next layer contains Ontology, which represents the entity-relationship system within the database and is written in OWL (Web Ontology Language). The logic layer consists of standards used to strengthen the ontology language, creating a more stable and

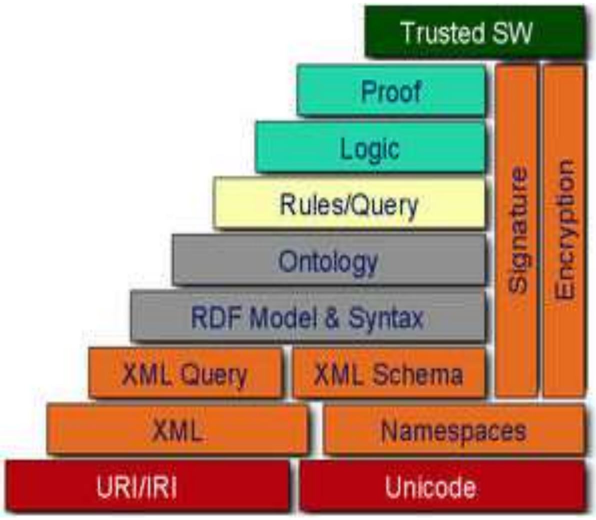

Figure 1. *The structure of semantic web*

robust structure. The proof layer enables the interaction of the linked data structure with other web languages and facilitates the transition from the whole to the particular. The trust layer is the final and most crucial feature, encompassing the security aspects.

2.2. XML (Extensible Mark up Language)

XML is a highly flexible and simple text format derived from the standard established for markup languages, specifically SGML (Standard Generalized Markup Language). Originally designed to address large-scale electronic publishing issues, XML has also become increasingly important in the exchange of various types of data both on the web and in other environments (http://www.w3.org/XML). Before XML, transferring data from one system to another web-based platform was difficult, often leading to compatibility issues between systems. To address this problem, a standardized approach was necessary, which XML successfully provided.
XML has a flexible structure.

Table 1. *Comparison of HTML and XML*

HTML	XML
<html> <head> <title>My Page</title> </head> <body> Welcome This is an HTML page. </body> </html>	<bookstore> <book> <title>XML Guide</title> <author>John Doe</author> <price>29.99</price> </book> </bookstore>

It can be programmed based on its own entities without relying on any specific language. Today, XML is frequently encountered in various areas related to data transfer and usage. Table 1 shows some popular ontology creation tools:

2.3. Resource Description Framework (RDF)

RDF (Resource Description Framework) is used to present information and facilitate its sharing on the web. The RDF format is based on XML technology. In RDF structure, meanings are expressed using RDF triples. Each triple consists of a subject, predicate, and object (subject-verb-object). As mentioned earlier, these triples can be created using XML tags and structure.
In an RDF document, certain things (subjects such as people, web pages, etc.) and some of their properties (e.g., "-s sister", "-s author", etc.) with specific values (such as another person, web page, etc.) can be expressed. This structure is actually the natural way of representing most of the data processed in computers. Both subjects and objects are defined by URIs (Universal Resource Identifiers), just like the links used on a web page. These links are called URLs (Uniform Resource Locators), and they are the most common form of URIs. Actions are also defined through URIs. This way, anyone can define a concept or action on the web with a URI, allowing them to create it [1]. URI references are used to define connections. As a result, the RDF graph in Figure 2, using URI references, defines:

- Individuals (e.g., "Eric Miller" is defined by http://www.w3.org/People/EM/contact#me),

Figure 2. *RDF example*

- Types of objects (e.g., Person is defined by http://www.w3.org/2000/10/swap/pim/contact#Person),
- The values of these properties (e.g., the email value is "mailto:em@w3.org").
- RDF also supports defining character strings such as "Eric Miller" and other data types such as integers and dates [11].

RDF provides an XML-based syntax for recording and exchanging these graphs. Below is the RDF/XML syntax corresponding to part of the graph shown in Figure 3.

```
<?xmlversion="1.0"?>
<rdf:RDFxmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
xmlns:contact="http://www.w3.org/2000/10/swap/pim/contact#">
<contact:Personrdf:about="http://www.w3.org/People/EM/contact#me">
<contact:fullName>Eric Miller</contact:fullName>
<contact:mailboxrdf:resource="mailto:em@w3.org"/>
<contact:personalTitle>Dr.</contact:personalTitle>
</contact:Person>
</rdf:RDF>
```

Figure 3. *The XML of the RDF*

The Web Ontology Language(OWL)

The Web Ontology Language (OWL) is a language used to define semantic web ontologies [8]. With OWL, information is designed not only to be understood by users but also to be processed and modified by computers through semantic interpretation. OWL allows for the transformation of web content and web pages, created by XML and RDF, into the semantic web, which is essentially the process of semantic web indexing [12]. Semantic web indexing refers to organizing web pages according to the semantic web structure using languages such as XML, OWL, and RDF.

There are several editor programs for creating OWL. Among them, Protege is the most preferred [8]. Protege is an open-source system used in many fields to create ontologies for the semantic web and to build knowledge-based solutions. It is supported by academic and governmental institutions (www.protege.stanford.edu).

3. Material and Methods

3.1. Research Design

In the study, a pretest-posttest control group quasi-experimental design was used. The experimental design is a research method used to explore cause-and-effect relationships between variables [13]. The purpose of the quasi-experimental design is the same as that of the experimental design. The most notable difference between the two methods is that, in quasi-experimental design, the control and experimental groups are not randomly assigned but are selected based on measurements [14]. In this study, random assignment was not applied in selecting the experimental and control groups, and it was ensured that the pretests of the groups were equal in terms of academic achievement, which is the dependent variable of the study. The lessons in both the experimental and control groups were conducted by the researcher.

3.2. Participants

The study was conducted with 40 participants at Ondokuz Mayis University Vezirköprü Vocational School. The sample for the research was selected using the purposive sampling method, one of the probability sampling techniques. Probability sampling involves selecting units from the population with an equal chance each time. Its distinctive feature is the random selection of elements from the population. In such selections, the groups being studied are divided into homogeneous groups, provided they share similar characteristics [15].Through random assignment, the first-year daytime class of the Computer Programming department was designated as the control group, while the first-year evening class of the same department was designated as the experimental group. In certain special research situations, purposive sampling becomes inevitable [16].

3.3. Data Collection Tools

The prepared educational material and system were organized according to the curriculum of the YDI 102 English course for associate degree students at Ondokuz Mayıs University and were submitted for approval by English instructors.The ontology of the study was created using the Protege 4.2 ontology development program and the Graphviz graph program. Accordingly, two objects were created: user and site. In Figure4, the user object includes sub-values such as the user's name and the level determined based on the result of a proficiency test. For the site object, sub-values include the addresses of formal sites pre-determined by expert instructors and their difficulty levels. As a result of these Semantic Web processes, the sites suitable for the user's name and level are automatically displayed. Specifically, the user object has subclasses for name and level. Under the level subclass, there are further subclasses: beginner, intermediate, and advanced.

Similarly, the site object includes subclasses for site address and difficulty level, where the difficulty level also has shared values such as beginner, intermediate, and advanced, as in the user object's level subclass. The user and site objects are processed by finding their mathematical intersection sets based on the level. For instance, if the user's level is beginner, they are directed to sites labeled as beginner level.

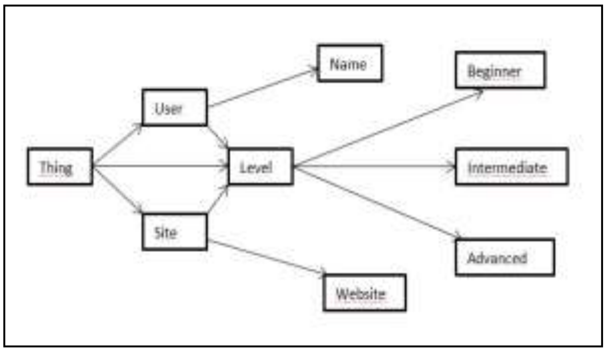

Figure 4. *The Ontology*

The material prepared has been developed using PHP, an internet-based programming language, and the PHP V 0.9.6 semantic web library. RAP, RDF API for PHP, is a Semantic Web tool for developers. RAP provides two different programming interfaces to process RDF graphs: the Statement-centric model to handle an RDF graph as a set of tables, and the Resource-centric model to handle an RDF graph as a set of resources [8]. In the Statement-centric model, a model is first created, and then new statements are added to this model in the form of triples (subject-predicate-object). In the Resource-centric model, RDF is structured more deeply according to its sub-properties, listing the sub-resources, what they contain, and what has been added. In the study, the Statement-centric model was used to prepare the material, as this model is most suitable for the triple structure and works efficiently. As shown in Figure 5, XML is a hierarchical markup language similar to HTML. However, unlike HTML, XML allows users to define their own tags freely.

In Figure 6, a multiple-choice level determination exam consisting of 40 questions, previously used in the university's English exemption exams, is administered to the candidate. The levels determined by the experts are: up to 20 correct answers is beginner, between 20 and 40 correct answers is intermediate, and 40 or more correct answers is advanced. Incorrect answers do not deduct from correct answers. After logging into the system with the student's name and ID, the student's level is determined based on the number of correct answers. The material prepared will not simply list sources that have received hits in semantic web searches, but

```
<rdf:RDF xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#">

  <!-- Beginner Level -->
  <rdf:Description rdf:about="Beginner Level">
    <hasLevelDescription>A1-A2</hasLevelDescription>
    <canUnderstand>Basic expressions, simple phrases</canUnderstand>
    <canDo>Introduce themselves, ask and answer questions</canDo>
  </rdf:Description>

  <!-- Intermediate Level -->
  <rdf:Description rdf:about="Intermediate Level">
    <hasLevelDescription>B1-B2</hasLevelDescription>
    <canUnderstand>Routine tasks, familiar topics</canUnderstand>
    <canDo>Describe experiences, handle simple conversations</canDo>
  </rdf:Description>

  <!-- Upper Intermediate / Advanced Level -->
  <rdf:Description rdf:about="Upper Intermediate Level">
    <hasLevelDescription>C1-C2</hasLevelDescription>
    <canUnderstand>Complex subjects, nuanced language</canUnderstand>
    <canDo>Express fluently, interact spontaneously</canDo>
  </rdf:Description>

</rdf:RDF>
```

Figure 5. *The RDF of the material*

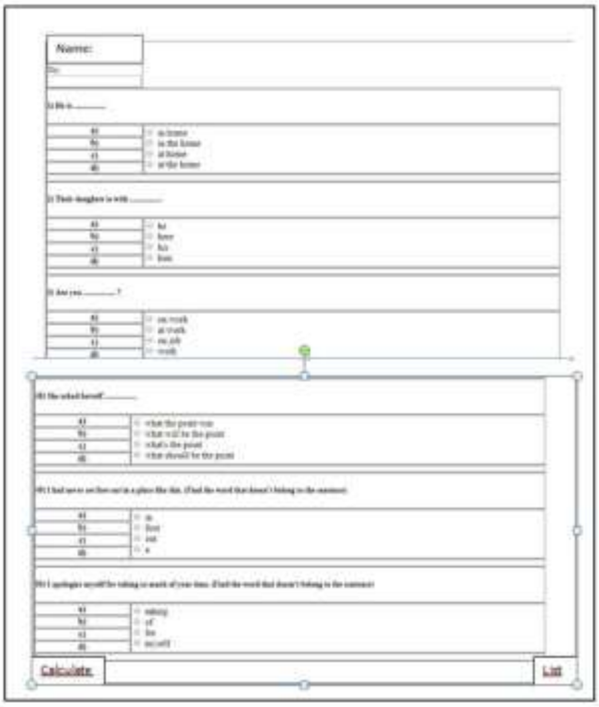

Figure 6. *The material*

will include a multimedia report in the background containing meaningful sources related to the topic. These sources will consist of web pages, blog dialogues, articles, book chapters, YouTube videos, information stored on mobile phones, and similar content [12]. Desired information is being built on solid foundations, which helps prevent time loss, allowing the individual to internalize knowledge in the targeted field and dedicate more time to thinking [17]. Since sources will be listed according to the user's level, the system will function like a personalized learning network. It will even guide the user like a personal education module.

Two level determination exams, designed according to the curriculum, have been created using the PHP RDF-API library for the semantic web system on the internet. These tests, similar to pre-tests and post-tests, were prepared by field experts in accordance with the requirements of the level determination exams. One test was administered at the beginning of the term, and the other tests were conducted after the completion of each topic. Websites containing content appropriate to the user's level and the relevant topic were pre-stored in the data pool. When the user logs into the system, these websites are easily accessible based on their level.

4. Results and Discussion

The user's level is determined according to the results of the level determination exam. English websites previously stored in the system were listed by topic and level, based on the curriculum of English 101 and 102 courses. The control group continued their education using traditional methods. They took the practice exams in the system but could not directly access the specific websites and resources through the system. These users attempted to access sources on their own according to their level. On the other hand, the experimental group, in addition to their normal education, could check their level after completing the practice exams at regular intervals, and they were able to quickly access websites and resources automatically recommended according to their level. Thus, they were able to both track their level progress and quickly, easily, and accurately access additional resources when needed based on their level. In the study, the data obtained from the pre-test and post-test conducted with students in English education, using materials prepared in accordance with the semantic web, were analyzed through frequency and percentage using the SPSS 18 statistical package at a significance level of 0.05. In Table 2, the skewness values for the pre-test, post-test, and total focus values were found to be between -1 and +1. The Independent Sample T-test was used to test whether there was a significant difference between the two-variable groups in the pre-test. Figure 7 shows the result of the application.

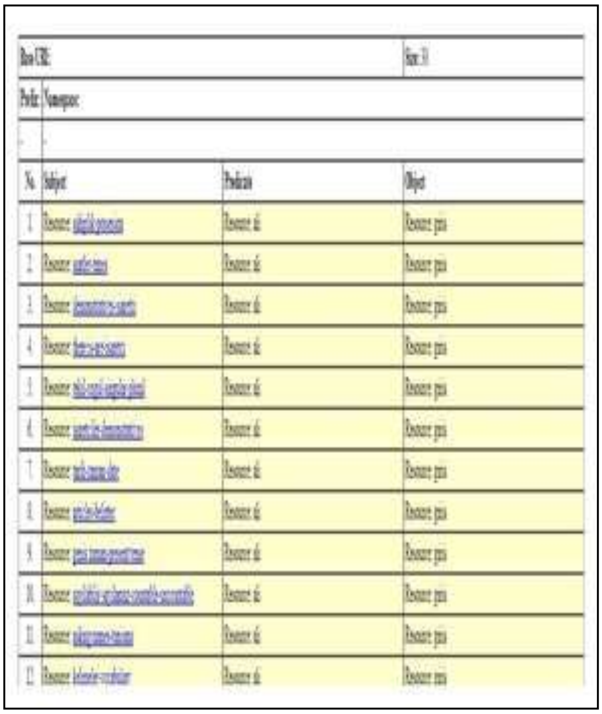

Figure 7. *The result of the application*

Table 2. *Results of the Normal Distribution Test for Pre-Test, Post-Test, and Scale*

	Group	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
		Statistics	N	p	Statistics	N	p.
Pre test	Control	.12	20	.20	.96	20	.56
	Experimental	.16	20	.15	.94	20	.30
Post test	Control	.12	20	.20*	.92	20	.13
	Experimental	.14	20	.20	.96	20	.53

In the study, reliability was examined by looking at the Cronbach's alpha value. Then, the relationship between the post-test results and each factor, as well as the overall factor results, was analyzed through correlation. The first research question of the study, "Is there a significant difference between the pre-test mean scores of the experimental group, which was taught using the Semantic Web Application, and the control group, which was taught using traditional methods?" is addressed in Table 3. As shown in the table, when examining the pre-test averages of the experimental and control groups, the control group's average is 16.05, while the experimental group's average is 15.60.

Table 3. *Statistics for Pre-Test and Post-Test Results by Group*

	Group	N	$\bar{x}$	SS
Pre test	Control	20	16.05	4.39
	Experimental	20	15.60	3.63
Post test	Control	20	16.85	4.30
	Experimental	20	21.15	4.51

The pre-test and post-test consist of 40 questions, each worth 2.5 points, and the pre-test averages are very close to each other. According to Table 3, the post-test average of the control group is 16.85, while the post-test average of the experimental group is 21.15.

Table 4. *Statistics for Pre-Test and Post-Test Results by Group*

	Group	N	$\bar{x}$	SS sd	t p
Post test	Control	20	16.85	4.30 38	0.69 0.04
	Experimental	20	21.15	4.51	

p<.05

The presence of a significant difference between the experimental and control groups can be assessed from the significance value in Table 4. The significance value for the independent samples t-test for the post-test is .04, indicating a statistically significant difference between the experimental and control groups ($t(40) = .69$, $p < .05$). Semantic web applications in education have mostly been conducted as ontology-based predictive studies. In other words, instead of being directly applied in education, they have been used for planning and guidance. In an analysis conducted in 2008, Ohler stated that the semantic web would bring innovations to education in terms of knowledge construction, personal learning networks, and personal education management. In this study, semantic web-supported instruction was applied in the field of English language teaching, and its effects on student achievement were examined. For this purpose, an experimental and a control group were formed, and the impact of semantic web-supported instruction on student success in English education was investigated by comparing it with traditional teaching methods. When analyzing the pre-test scores of the achievement test for both the experimental and control groups, it was observed that the class averages were very close to each other. This indicates that the English proficiency levels of the control and experimental group students were similar. This could be attributed to the negative attitudes of associate degree students toward general ability courses and the fact that, according to the curriculum, general ability courses are given less priority compared to field-specific courses.

5. Conclusion

In this study, which compares the effect of semantic web-supported English teaching and traditional teaching methods on student success, the impact of the semantic web application on student performance was investigated. It was found that semantic web-supported English teaching is more effective than traditional teaching methods. This conclusion was demonstrated through comparative independent samples t-test analyses of the pre-test and post-test scores administered to the experimental and control groups at the beginning and end of the program. The post-test average of the experimental group showed a greater increase compared to the post-test average of the control group. Accordingly, semantic web-supported English teaching creates a more beneficial and effective learning environment for students, leading to more successful and advantageous outcomes for students using this method. Through the semantic web application and the materials prepared for English education, students were able to share and reuse the produced learning objects, allowing them to reach the most accurate results in the shortest time, both within the system and on the internet regarding the topics they searched for. As a result, students were able to track their English proficiency levels and, by quickly accessing resources suited to their needs, they were able to increase their success. All these research findings are consistent with the results obtained in this study and support each other. Based on all the findings, semantic web-assisted English language teaching is considered to be a highly effective approach both in enhancing student motivation and, consequently, in improving student achievement. The semantic web system should not be designed solely based on ontology. Additionally, to leverage the semantic web's power in providing fast and accurate access to desired resources, semantic web applications in education should be further developed.

Author Statements:

- **Ethical approval:** The conducted research is not related to either human or animal use.
- **Conflict of interest:** The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper
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- **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.

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