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# What if ... there were no special schools?

A spatial simulation study of inclusive school systems based on governmental data of Bavaria, Germany

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Abstract Inclusive education is a human right that involves restructuring the school system and closing special schools. However, there is uncertainty about whether all or only some students in an inclusive system should attend regular primary schools and whether all or only some special schools should be closed. This question is usually only discussed in terms of the best possible care and education and the challenge of transportation to school and travel distances is neglected. This article attempts to take both into account. The federal state of Bavaria in Germany does not yet have a fully developed inclusive school system. Using school statistics data for the entire Bavarian primary school population in 2020 (N > 445,000) and geographical data, we simulate deterministically what the Bavarian primary school system could look like with various underlying inclusion models. We analyse the resulting student numbers, support rates of primary schools and school travel distances of former special school students in an urban-rural comparison in four different simulated inclusion models. The results show that all models are potentially feasible. The student numbers at each primary school resulting from the closure of special schools would in most cases not change significantly, whereas the support rate (i.e., the percentage of students with SEN per primary school) would. Schooling close to home favours students in rural areas in particular and significantly reduces their journeys to school by up to 30km, while for students in urban areas, all inclusive models would be possible. The pedagogical and systemic consequences of the simulated inclusion models are discussed.

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# Was wäre wenn... es keine Sonderschulen gäbe?

Eine räumliche Simulationsstudie inklusiver Schulsysteme basierend auf amtlichen Schulstatistiken des deutschen Bundeslands Bayern

Zusammenfassung Inklusive Bildung ist ein Menschenrecht, das die Umstrukturierung des Schulsystems und die Schließung von Sonderschulen fordert. Es ist ein offener Streit, ob alle oder nur einige Schüler:innen in einem inklusiven Schulsystem reguläre Grundschulen besuchen sollten und ob alle oder nur einige Sonderschulen geschlossen werden sollten. Diese Frage wird in der Regel nur im Hinblick auf die bestmögliche Bildung und Betreuung diskutiert, wobei die Herausforderung des Fahrtwegs zur Schule vernachlässigt wird. Dieser Artikel versucht, beides zu berücksichtigen. Der Freistaat Bayern in Deutschland verfügt noch nicht über ein inklusives Schulsystem. Unter Verwendung von Schulstatistikdaten für die gesamte bayerische Grundschulschülerschaft im Jahr 2020 (N>445.000) und geografischen Daten simulieren wir deterministisch, wie das bayerische Grundschulsystem mit verschiedenen zugrunde liegenden Inklusionsmodellen aussehen könnte. Wir analysieren die resultierenden Schülerzahlen, Förderquoten der Grundschulen und Schulwege in einem urban-ruralen Vergleich in vier verschiedenen simulierten Inklusionsmodellen. Die Ergebnisse zeigen, dass alle Modelle grundsätzlich umsetzbar wären. Die Grundschulgrößen würden sich durch Sonderschulschließungen in den meisten Fällen nicht signifikant ändern, während die Förderquote (der prozentuale Anteil von Lernenden mit Förderbedarf pro Grundschule) dies tun würde. Wohnortnahe Inklusion kommt insbesondere Schüler:innen auf dem Land zugute und reduziert ihre Schulwege um bis zu 30km, während für Schüler:innen in der Stadt alle inklusiven Modelle möglich wären. Pädagogische und systemische Konsequenzen der simulierten Inklusionsmodelle werden diskutiert.

Full inclusion in schools is a work in progress in Germany. A recent report by the UN Committee on the Rights of Persons with Disabilities (UN CRPD 2023) criticises the lack of full implementation, prevalence of special schools, and barriers for students with disabilities in regular education. Implementation varies by region, posing challenges, especially in rural areas with accessibility, placement and resources issues (McCabe & Ruppar 2023). In order to make effective inclusion plans, it is important to consider regional structures and data, not just urban contexts. It is crucial for federal states with rural areas to understand the consequences of these transitions. Simulations provide a method for comparing scenarios before implementation. This article compares four inclusion simulations for primary schools, including full and partial closure of special schools and different degrees of schooling close to home,

demonstrating their potential consequences. We include an urban-rural comparison using Bavaria as an example.

### 1 Introduction

#### 1.1 Inclusive school systems

Article 24 § 1 of the UN CRPD promotes inclusion as a normative goal, aiming to include everyone in all aspects of life with education playing a crucial role. The UN CRPD strongly advocates for the end of segregated schooling and the closure of special schools (United Nations 2006). Accordingly, schooling close to home is particularly beneficial for students with disabilities as it enables their full inclusion in the local social environment (UN CRPD Art. 24 § 2). This is an important aspect of full inclusion, allowing students to be integrated into local social life based on the principle of normalization (Prengel 1995; Heimlich 2019; Nirje 1994). Conversely, there is the view that inclusion is primarily a school and resources issue.

Some school systems still have special schools (Buchner et al. 2021). The debate on whether to close them is ongoing (Ahrbeck et al. 2018; Mann et al. 2023; Merrigan and Senior 2023). This perspective is common in countries with minimal inclusive changes in their school systems, such as Germany (Ebenbeck et al. 2022), the Netherlands (Gubbels et al. 2018) or Australia (De Bruin 2022). In Germany, there are various types of special schools that focus on different disability types. Some of these schools primarily admit students with mild disabilities, often from families with a background of poverty or migration. Some schools focus on specific disabilities (e.g., blindness, intellectual disability). However, even in school systems with a more inclusive focus (e.g., Italy, Finland), a few special schools for specific disability types remain. This may be related to specific types of disabilities or hospital schools attached to clinics. Hospital schools continue to exist even in fully inclusive systems, and are seen as supportive of inclusion by enhancing quality, preventing dropouts, operating on a multi-professional basis, and providing guidance to local schools (Äärelä and Huusko 2023).

Maintaining a segregated school system with special schools and general schools goes against the idea of inclusive schools, where the focus is on all students learning together, even with diverse learning settings within one school. There may be class settings, group settings, and special groups that coexist and complement each other (Nes et al. 2017). Also, there are multiple approaches to inclusive school systems. Italy provides an example of how to include primary students with disabilities, as almost all students with disabilities there are taught in schools close to home. All students typically share the same class. Additionally, each student with a disability receives individual resources (Ianes et al. 2020). Austria avoids single-case inclusion. Instead, regular schools form inclusive classes with several students with disabilities. If there are five students with disabilities in a class, a full-time special education needs (SEN) teacher is present. This grouping aims to optimize educational and personnel resources (Feyerer 1998; Specht et al. 2006; Buchner and Gebhardt 2012).

Finland follows a similar approach to providing resources based on a multi-tiered system of support (Jahnukainen et al. 2023).

Overall, with regard to the school system, the question arises about whether all or only some students in an inclusive system should be admitted to regular schools and whether all or only some of the special schools should be closed. This question is usually only discussed in terms of the best possible education and care and the challenge of transportation to school is neglected. This article attempts to take both into account.

### 1.2 Consequences of inclusive primary education in Germany

The German primary school claims to be a "school for all" (Seitz and Simon 2021). It provides basic education for all students from grades 1 to 4 or 1 to 6, depending on the federal state. It is the most common type of school in Germany and conceptually the most developed in terms of heterogeneity in teaching and school life. Therefore, it also faces the challenge of developing into an inclusive primary school, which contrasts with the fact that students continue to be segregated from primary schools and instead educated in special schools (Seitz and Simon 2021).

A German inclusive primary school system would bring academic, social, and systemic consequences. Inclusive schooling has a positive effect on academic achievement of students with disabilities (Gebhardt et al. 2015a). Students with disabilities at German primary schools have significantly higher competences in cultural techniques than comparable students with disabilities at special schools (Kojac et al. 2014). On the academic performance of primary students without disabilities, inclusive education has none or positive effects (Kart and Kart 2021). Inclusion prevents social stigmatization. Attending a special school leads to social marginalization and reinforces the discrimination that often already exists, as socio-economically disadvantaged students are more likely to be in a special school (Lindsay 2004). Social stigmatization of people with disabilities is a major problem in implementing an inclusive school system, which is why it is important for legislation to provide a framework that creates inclusive environments (Muñoz 2007). On the part of students without disabilities, inclusive education leads to positive social developments as fear, hostility, prejudice and discrimination are reduced and tolerance, acceptance and understanding are increased (Kart and Kart 2021). Social integration is limited when students visit schools far from home, because they have to travel longer distances to get to school, leaving home in the morning and returning only in the afternoon or evening. 47% of regular primary school students have to travel less than one kilometer to get to school (ADFC 2023). To ensure full participation, all primary level students need to attend the nearest school, ideally within walking, cycling, or bus distance.

A state's special education system is less inclusive when it is more differentiated and better developed (Entrich, 2021). To develop an inclusive school system, it is necessary to minimize the proportion of special schools and close them accordingly. Maintaining a segregated special education system in Germany leads to distortions in identifying SEN at the systemic level. Consultations and placements are influenced by SEN teachers for the segregated system, resulting in spillover effects. In Bavaria, the number of a region's special schools and their proximity to primary schools directly correlates with the percentage of students with SEN identified and segregated in special schools (Ebenbeck et al., 2022). In rural areas, where the density of special schools is lower, more students are educated inclusively (McCabe & Ruppar, 2023). Therefore, it is necessary to consider the structural and spatial characteristics of educational institutions, forming the basis for educational processes and being crucial for the quality development of institutions. Goldan and Grosche (2021), Müller (2020), Raggl (2020), Parade and Heinzel (2020), and Stirner et al. (2019) demonstrated related findings.

Empirical evidence supports the implementation of an inclusive school system, but it is often argued in political debates that major changes in the school system, like closing special schools, are not possible and too costly. Countries with inclusive systems have shown the opposite. An inclusive school system is often not as expensive as a segregated school system (Porter 2001). Education spending has no impact on the success of inclusion (Entrich 2021). Closing special schools is an important factor here, as resources would otherwise be used for support in special schools, which at the same time affect the inclusive system, e.g., through diagnosis and identification. In an inclusive school system, the resources used to maintain special schools. Having enough resources is crucial for successful inclusion implementation, as well as teachers' perception of the availability of human resources (Bennemann 2019; Oetjen et al. 2021; Goldan and Schwab 2019; Goldan et al. 2021) and the school culture (Kefallinou et al. 2020).

#### 1.3 Models and research questions

We analyse the effects of four inclusion models on the primary school system in Bavaria and compare their impact on student numbers, support rates, and student travel times, focusing on potential disparities between rural and urban areas. All models are simulated based on school data and on the following assumptions:

- 1. In an inclusive system, all students are educated together in one school building.
- 2. Inclusion requires the closure of special schools.
- 3. Special schools enroll students from the special school's district.
- 4. The size of a school is measured by the number of students.
- 5. Large schools tend to be located in more populated areas or serve a larger catchment area than small schools.
- 6. Large schools have greater resources in terms of space, finances, personnel and materials than small schools.
- 7. Hospital schools ("Schule für Kranke", KraSO 1999) continue to exist.

Model 1a represents the inclusion of all students with SEN close to home (Ianes et al. 2020). Special schools, except for hospital schools, are closed. Their resources and students are distributed to primary schools in the district. Depending on their size, primary schools take on more or fewer students.

Model 1b focuses on inclusion in selected inclusive primary schools. All special schools are closed, but students and resources are not spread across all primary

schools, but selected primary schools are developed into dedicated inclusive primary schools. Inclusive elementary schools admit a maximum of 20% of students with SEN and receive resources accordingly (Specht et al. 2006; Buchner & Gebhardt 2012). Primary schools are selected as inclusive primary schools according to their size, with a support rate of 20%, until all former special school students in a district have been distributed.

Models 2a/b are structured in the same way as models 1a/b, with the difference that only combined special schools for high-incidence disabilities (learning disabilities, behavioral disorders and speech and language disorders), and so-called "Sonderpädagogische Förderzentren" (SFZ, these combine all high-incidence disabilities in one school), are dissolved. Instead, special schools for intellectual and physical disabilities, visual and hearing impairments were maintained.

## 2 Materials and methods

### 2.1 Database

RStudio with the sf package is used for spatial data analysis (Pebesma 2018). For simulations, we combine open and closed data for the German state of Bavaria (Table 1). Baseline are Bavaria's school statistics, which provide a list of all primary school (n=420032) and special school students (n=55055), their school affiliations in 2020, and their SEN status. The data does not provide information about class or grade level. To simulate the primary school system, 50% of the students in each special school (n=27,527.5) are selected, which corresponds to the number of special education students at the primary level. We expand the data with schools' addresses, coordinates, and funding. We use geodata on administrative districts and their settlement structure to compare rural and urban areas.

Bavaria has, as one of 16 federal states in Germany, its own school system with a three-tiered structure consisting of primary, secondary, and tertiary education.

Data	Source
List of all special school students at all special schools in Bavaria in 2020	Bavarian State Statistical Office (2021) (closed data)
List of all primary school students at all primary schools in Bavaria in 2020	Bavarian State Statistical Office (2021) (closed data)
Addresses of all Bavarian elementary and special schools	Bavarian State Ministry of Education (2022) (open data)
Financial basis of all Bavarian elementary and special schools	Bavarian State Ministry of Education (2023) (open data)
Coordinates of all Bavarian elementary and special schools	Own data based on Openstreetmap (Ebenbeck et al. 2022)
Geolocated data on administrative districts including boundaries, keys, names, <i>etc</i>	Federal Agency for Cartography and Geodesy (open data)

Table 1 Overview of used datasets and their sources

Table 2       Description of the current school system in comparison between urban and rural areas		Urban districts	Rural districts
	N schools	966	1615
	N primary school	814	1417
	N special school	152	198
	N students	207,648	239,911.5
	N primary school	194,304	225,728
	N special school	13,344	14,183.5

Primary education usually lasts four years. There is a separate special education system that covers all three levels. Bavaria is divided into 96 districts (68 rural, 28 urban). Most schools are located in rural areas. In cities, special schools make up a larger proportion of the primary school system than in rural areas (Table 2). About half of primary and special school students attend rural schools.

### 2.2 Modelling assumptions

We simulate inclusive school systems deterministically. Depending on the simulation's underlying inclusive model, we remove certain special schools from the data to represent their closure. We then distribute the former students of these closed special schools among the primary schools in the district. Different assumptions are made for this distribution of students, depending on the model, and implemented in the simulations (Table 3). **Model 0** serves as the baseline for comparative analyses and describes the current situation in Bavaria. It includes all primary and special schools that existed in 2021 and all students attending these schools at that time. **Models 1a** and **1b** simulate a school system without special schools (except hospital schools). In model 1a former special school students are educated in primary schools near their homes and special schools are closed. At district level, the students are distributed proportionally to the primary schools based on their size. The primary school's size is determined by the population of its catchment area. In **model 1b**, the former special school students are not distributed across all primary schools in the district, but specific inclusive primary schools are simulated, each of which accepts

Model	Special schools	Distribution of stu- dents with SEN	Simulation method
0	Current Situation		_
1a	No Special Schools	Every Primary School	Proportional distribution across all primary schools in the district
1b	No Special Schools	Inclusive Primary Schools	Allocation to inclusive primary schools in the district with 20% SEN share
2a	No SFZs	Every Primary School	Proportional distribution across all primary schools in the district
2b	No SFZs	Inclusive Primary Schools	Allocation to inclusive primary schools in the district with 20% SEN share

Table 3 Overview of school system models and simulations

up to 20% of students with SEN. Inclusive primary schools receive more places for students with SEN and can therefore expand by up to 20%. The previous proportion of students with SEN in a primary school is taken into account. Primary schools are selected for inclusion based on their size, as larger schools are assumed to have more resources to support inclusion. Schools are converted to inclusive schools until all former special school students in the district have been accommodated. **Models 2a** and **2b** simulate school systems without SFZs (special schools with focus on learning, behaviour, speech or combine those focus areas). Other special schools remain. Compared to models 1a and 1b, only SFZs are removed from the data set and fewer students have to be distributed to the primary schools. The same distribution assumptions are used for models 2a and 2b as for models 1a and 1b.

### 2.3 Analysis of the simulations

We analyse three variables for each simulation: the resulting primary school size ("school size", i.e. the number of students per primary school resulting from the special school closures), the support rate per primary school ("support rate", i.e. the percentage of students with SEN per primary school), and the average distance travelled by each former special school student ("distance").

To simulate distances to school, all inhabited areas in Bavaria are divided into a  $100 \times 100$  m grid. Uninhabited areas (e.g., agricultural land) are excluded. The land cover classes are taken from the ESA's Corine Land Cover Classification and have a minimum mapping unit of 5 hectares. Starting from each grid point, the distance to the nearest possible school location of a special school student is calculated. In model 0, this corresponds to the distance to the nearest special school, in model 1a the distance to the nearest primary school, in model 1b the distance to the nearest inclusive primary school, in model 2a the distance to the nearest primary school or the nearest remaining special school and in model 2b the distance to the nearest inclusive primary school or the nearest remaining special school. The variables are analysed as a whole and by settlement structure. Differences in the variables between the simulations and settlement structures are tested for significance. Simulated school systems are visualised with maps for the whole of Bavaria and exemplified for the urban district Munich (1,488,202 residents, 310.7 km<sup>2</sup>) and the rural district Regen (78,035 residents, 975 km<sup>2</sup>) in comparison.

### **3** Results

### 3.1 Systemic changes

Closing all special schools results in a reduction up to 15% of primary level schools and up to 95% of special schools. The current primary level school system (model 0) consists of 2231 primary schools and 350 special schools (16 hospital schools). In contrast, models 1a/b would result in the closure of all special schools, leaving a total of 2247 schools. The primary level school system in Bavaria reduces in the



Fig. 1 Composition of the school system at primary school level in the simulated inclusion models

number of schools under inclusion models 2a/b, with an 8% decrease overall and a 44% decrease in the number of special schools.

Although half as many schools are closed in model 2b as in model 1b, only a slightly smaller number of inclusive primary schools are needed to accommodate all students. The number of inclusive primary schools needed to replace closed special schools is determined by the number of closures (see Fig. 1). Closing all special schools (1b) requires 471 inclusive primary schools with a target support rate of up to 20% to educate all students in the districts. This converts 21% of primary schools into inclusive primary schools. 80% of these schools reaches their capacity of 20% support rate, while the rest has support rates between 2 and 19.8%. Closing only the SFZs requires 315 inclusive primary schools. This is 33% fewer inclusive primary students than in model 1b, although 50% fewer special schools were closed.



**Fig. 2** Special schools and in the course of the simulations new transformed inclusive primary schools in Bavaria based on the inclusive models. Note: For reasons of presentability, regular primary schools are not included in this figure

As a result, 14% of primary schools become inclusive primary schools. 70% of these schools reach their target capacity, while the remaining 30% have a support rate between 2 and 19.8%. Both cases have a maximum of 20% of students with SEN per class. In a class of 20, this means up to 4 students may have SEN. Models 1b/2b also show that 13 primary schools in Bavaria would have a support rate higher than 20%. However, these primary schools already have a support rate of more than 20% in the current system, making them inclusive primary schools. However, as they already exceed the 20% limit, they would not receive any new students, and their school size would not change.

Figure 2 shows the distribution of schools per model. In urban areas, there are higher numbers of special schools. Model 1a displays the distribution of the remaining hospital schools. Model 1b supplements these with inclusive primary schools as the main place of schooling for students with SEN. In contrast, model 2a displays all other special schools that are not SFZs and are therefore not closed. These schools are also oriented towards urban areas and are sparser in rural areas. In model 2b, they are again supplemented by inclusive primary schools. Regular primary schools are more prevalent in urban areas than in rural areas.

The distribution density of local schools is determined by the population density of the districts (see Fig. 2). Special schools are more prevalent in cities, despite their smaller size compared to rural districts. As a result, the simulated inclusion models would eliminate more schools in cities than in rural regions. Schools in cities are closer together, resulting in shorter distances to travel compared to rural areas. A visual comparison of the example regions shows that the inclusive primary schools have a similar spatial distribution and possibly the same number as the current special schools per district (Fig. 3).



Fig. 3 Special, primary and inclusive primary schools in urban and rural districts in simulated school systems in models 0, 1a and 1b (i.e., models without special schools)



Fig. 4 Distribution of primary school size (i.e., number of students per school) and percentual increase in student numbers per school in comparison for the simulated inclusion models

#### 3.2 Primary school size and support rate

Depending on the inclusion model, a primary school enrolls between 8 and 12 more students on average, resulting in a mean growth of between 2.3 and 6.4% (Fig. 4). Post hoc comparisons of average school size show that primary schools only in models 1a/1b become significantly larger (model  $0 \sim$  model 1a: p < 0.005, model  $0 \sim$  model 1b: p < 0.01). The number of students determines the size of the school. The current system shows that primary schools have a student population ranging from 18 to 699 (M=188.3, Md=165, SD=108.2). Urban primary schools are significantly larger than rural primary schools (p < 0.001, as shown in Fig. 4).

In the inclusion models with schooling close to home, all primary schools would increase in size, but in most cases only by small percentages: In model 1a, schools enroll between 0.35 and 90 more students (M=12.34, Md=8.84, SD=10.66), leading to a percentage increase of between 1.34 and 30.02% (M=6.37%, Md=5.93%, SD=3.44%). The increase in the number of students is significantly greater in cities than in rural areas (t (1713.2)=4.26, p<0.001). The overall school size ranges from 18.76 to 747.66 students (M=200.61, Md=175.21, SD=115.94).

In comparison, inclusion models that rely on inclusive schools have the consequence that most primary schools do not increase in size at all. Model 1b leaves the number of students in most primary schools unchanged and makes large primary schools even larger. The selected inclusive primary schools, on the other hand, increase significantly in size, resulting in a percentage increase between 0 and 25% (M=3.7%, Md=0%, SD=7.77%). In absolute numbers, this corresponds to an increase between 0 and 171 students (M=12.04, Md=0, SD=27.52). The overall size of the school would be between 18 and 870 students (M=200.3, Md=167, SD=129.09).

Closing only the SFZs does not lead to a significant increase in the average number of students. Like model 1a, model 2a increases the size of all primary schools, leading to a percentage increase in the number of students between 1.34 and 12.14% (M=4.35%, Md=4.17%, SD=1.65%). In absolute numbers, this corresponds to an increase between 0.35 and 38.83 students (M=8.18, Md=6.47, SD=5.78). The overall school size was between 18.76 and 728.11 students (M=196.45, Md=171.75,



Fig. 5 Distribution of support rate and percentage increase in student numbers per school in comparison for the simulated inclusion models

SD=112.86). Like model 1b, model 2b leaves the number of students in most primary schools unchanged, resulting in a percentage increase between 0 and 25% (M= 2.32%, Md=0%, SD=6.32%). In absolute numbers, this corresponds to an increase between 0 and 171 students (M=8.18, Md=0, SD=23.87). The total size of the school would be between 18 and 870 students (M=196.4, Md=166, SD=124.52).

A similar picture emerges for support rates in primary schools (Fig. 5). All inclusion models lead to a significant increase in the support rate (p < 0.001), with no significant differences between urban and rural areas. In model 0, support rates range from 0 to 31.43% (M=3.41%, Md=2.2%, SD=3.97%). In inclusion models with schooling close to home, support rates increase in all primary schools. The support rates range from 1.33 to 39.22% (M=9.1%, Md=8.05%, SD=4.87%) in model 1a and from 1.33 to 35.98% (M=7.41%, Md=6.36%, SD=4.21%) in model 2a. In the inclusion models with inclusive schools, the support rates of most primary schools remain the same, but increase more in the inclusive primary schools. In model 1b the support rate would be between 0 and 31.43% (M=6.4%, Md=3.15%, SD=7.33%) and in model 2b also between 0 and 31.43% (M=5.3%, Md=2.7%, SD=6.43%).



Fig. 6 Distribution of travel distances between possible homes and schools of students with SEN in the different inclusion models in comparison for urban and rural areas

### 3.3 Comparison of travel distance

In the current school system, the potential residence of special school students is between 0.002 and 43.014 km (M=6.635 km, Md=4.767 km, SD=6.19 km) away from the nearest special school, with special school students in urban areas living a maximum of 33.063 km away and special school students in rural areas living a maximum of 43.014 km away (Fig. 6). All distances are as the crow flies, so the actual travel distance by car or bus may be even greater.

In a school system based on schooling close to home (models 1a and 2a), the distances between home and school are greatly reduced. In both models 1a and 2a, the homes of former special school students would be between 0.002 and 13.708 km away (model 1a: M = 1.215 km, Md = 0.744 km, SD = 1.264 km; Model 2a: M = 1.198 km, Md = 0.727 km, SD = 1.261 km). In both models, former special school students in the city would travel a maximum of 10.49 km, while in the countryside they would travel a maximum of 13.708 km to the nearest primary school.

However, in a school system with certain inclusive primary schools (models 1b and 2b), the distance to school for former special school students does not change much compared to the current system. In both models, the homes of former special school students would be between 0.002 and 41.679 km away from the nearest school (model 1b: M=5.626 km, Md=3.347 km, SD=5.96 km; model 2b: M=5.787 km, Md=3.813 km, SD=5.853 km). In both models, former special school students in the city would travel a maximum of 28.81 km, while in the countryside they would travel a maximum of 41.679 km to the nearest primary school. The distances are therefore only slightly shorter than under the current system.

Overall, there are significant reductions in the distances traveled by students in the models that implement schooling close to home in the local primary school. The difference in distances to school is particularly large in rural areas. The presence of some special schools in models 2a and 2b, on the other hand, has no effect on the distance students have to travel to school, as there is often also a primary school in the towns where a special school is located.

# 4 Discussion

It is possible to transform Bavaria's school system into an inclusive one. The simulation-based approach allows for accurate predictions that would otherwise be difficult to make. It enables estimation of the consequences of changes in the school system for each school and also predicts the travel distance that has hardly been mentioned in the discussion about school inclusion so far.

Schooling in a regular school alone does not constitute inclusion, but it is an important foundation (Gebhardt 2022). There are different ways to implement an inclusive school system and both schooling close to home and schooling in specific inclusive schools is feasible. A fully inclusive school system would have only a minor impact on the school system itself and would not disrupt it in the long run. Special schools make up only about 15% of the primary school system. Maintaining them does not benefit the density of the school system or the coverage of school locations,

as special schools are mostly located in the same areas as primary schools and as there is hardly any difference in the distances covered by students if only some or all special schools are closed. It also can be assumed that the additional students with SEN would not create space problems for the schools, as the size of primary schools would also not change significantly in most cases. Furthermore, in an inclusive school system, resources would not be used to maintain special schools, but rather to educate and support students in regular schools. Resources of special schools, such as funding, equipment, and staff, could therefore be transferred to primary schools, creating synergy effects in solving educational challenges.

### 4.1 Realisability of the inclusion models

We consider a model to be feasible if inclusion can be provided with short travel distances and if schools can cope with the number of new students with their resources. An approach of 20% students with SEN per class or school provides us with orientation. Model 1a is the maximum form of inclusion, where all special schools are closed, and there is no systemic segregation of students. Instead, all students attend the primary school closest to their home (Ianes et al. 2020). In this way, students travel the shortest distance possible to school and former special school students' school routes are just as long as those of regular primary school students (ADFC 2023). Therefore, they do not leave the local community for several hours each day and have better opportunities for daily social inclusion for example, through clubs or friendships (Prengel 1995; Heimlich 2019; Nirje 1994). Model 1a also has the highest average support rate at 9.1%, so about 2 out of 20 students in a class have SEN. To realize this model, it is necessary to consider whether there are enough students with SEN in a school or class to fund and justify local special education, how many students a SEN teacher can support, the specific nature of that support, as well as when a permanent SEN teacher can be on site, or how many mobile special education teachers are required, particularly in rural areas (McCabe & Ruppar 2023).

Model 2a is kind of "inclusion light" as only some of the special schools are closed. It still prioritises schooling close to home, but may segregate students, probably those with severe disabilities (Buchner and Gebhardt 2012, McCabe & Ruppar 2023; Ianes et al. 2020; Jahnukainen et al. 2023; Äärelä and Huusko 2023). Therefore, parents may choose special schools for their range of therapies, all-day programs, associated residential facilities, and educational services for severe disabilities. The UN rejects the maintenance of two separate systems, as 56% of special schools would remain, and the majority of resources would still be allocated to the special school system. Therefore, the question of whether to close these schools is more political and normative.

Models 1b and 2b add inclusive primary schools alongside regular primary schools, but only model 1b adds value to inclusive school systems. Inclusive schools could be centers of excellence and expertise, better equipped to cater to certain disabilities and with knowledge in the area of diagnostics. This distribution of tasks only makes sense if the special schools are closed. In the current system and in model 2b, the expertise and resources for special education are (also) in the special

schools. The school types would therefore overlap in this respect, leading to potential conflicts and disturbing effects in the school system (Ebenbeck et al. 2022). Also, as the difference in the number of inclusive schools required between closing all and only some special schools is not large, maintaining both systems alongside the overall expansion of inclusive schools is therefore hardly worthwhile. By comparison, only 30% fewer inclusive primary schools are needed if special schools were closed proportionately. However, model 1b places a heavy burden on individual schools and increases their size, while other schools would see little to no change. Implementing these models in rural and urban areas may not be equally effective and would be of limited use in rural areas, because inclusive schools would be mostly located in cities. Similar to the current special school system, students with SEN would have to travel up to 42 km to reach the nearest inclusive primary school, which would contradict the thought of social inclusion and normalization (Prengel 1995; Heimlich 2019; Nirje 1994). Spreading inclusive primary schools evenly throughout the district could mitigate this effect. However, it raises the question of how resources are allocated and how many and where inclusive primary schools are needed in rural areas. In urban areas, this model is easier to implement due to shorter distances.

# 4.2 Limitations

Our study is based on simulations and compares various inclusion models in a conservative school system, using Bavaria as an example. As a federal state, Bavaria has a school system that has special features compared to the rest of Germany, such as the existence of the SFZs. These combined schools for SEN in learning, language and behaviour do not exist in other German federal states. In order to transfer our methodology to other school systems, the special schools for these SEN would have to be used instead. Simulations have inherent limitations and can only depict certain aspects of real scenarios. However, social reality is complex and requires simplification. We have decided to distribute the special school students within a district to its primary schools, as the special schools themselves do not have a single district. The administration of special schools is subject to the district, allowing students from the district to attend. However, some students commute across district borders. We chose schools based on administrative districts, instead of fixed school districts. The selection of inclusive primary schools was based solely on school size, without considering social index variables (e.g., household income, immigration) which are especially relevant for learning disabilities and behavioural disorders. In addition, the simulations consider a school only if it has an independent school number, meaning that external buildings are not taken into account. Boarding schools and their students are also not considered in the distribution of students and travel distances. Also, it was not possible to include information about the specific SEN in the simulations. To be able to incorporate local characteristics, boarding schools and catchment areas more precisely into calculations, it would be necessary to make considerations and decisions at a local level, e.g., in contact with the respective schools. In this way, outbuildings and individual cases can also be considered.

### 4.3 Consequences of inclusive education for the primary school system

In discussions about inclusive education so far, the focus has mainly been on teachers and how to facilitate special educational approaches in the best possible way. Too little attention has been paid to the individual student's travel, and decentralized educational inclusive solutions have hardly been developed at local primary schools. However, true inclusive participation requires attendance at the local school (Nirje 1994; Prengel 2018) and the development of inclusive structures in rural areas (McCabe & Ruppar 2023) to comply with the UN Convention. This means that the structures and resources of the special schools will be transformed into new structures.

Therefore, the question is which educational offerings can be provided locally and decentrally, and which must actually take place centrally (Gebhardt 2022). The discussion may include, for example, support through digital media, assistive technologies, and specialized professionals on site, as it seems essential to provide primary schools with local special education expertise. Additionally, regional consultation services can empower primary school teachers to handle pedagogical challenges (Oetjen et al. 2021), for instance, through quick and straightforward consulting on site, over the phone, or digitally, or through further training in inclusive education at the class and school level. The difference of urban and rural schools needs to be acknowledged, as rural schools may have fewer resources and support services available in their immediate surroundings (McCabe & Ruppar 2023).

An inclusive school system and education policy ensures that primary schools can function as inclusive, successful places of learning close to home, without the need for special schools. Schooling in the same building is not the goal of inclusive education, but it is the starting point from which new approaches and didactic methods must be developed for inclusive primary schools. In order to successfully progress towards inclusion, primary schools may need to develop an inclusive mindset in the first step and see themselves as inclusive primary schools. The next step would be to adapt their programs and teaching methods towards an inclusive teamteaching approach (Gebhardt et al. 2015b). This raises the question of how teachers can collaborate concretely in primary school classes and when it is worthwhile to have a second special education teacher in the classroom compared to having special education experts available at the school in general. However, some of these topics could also be simulated using the appropriate teacher data to make further and more accurate predictions.

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