Interventions to foster academic aspirations adjustment among disadvantaged and female students - A PRISMA systematic review of literature

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Interventions to foster academic aspirations adjustment among disadvantaged and female students - A PRISMA systematic review of literature[1]

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Abstract

Occupational aspirations significantly contribute to educational inequalities according to family background and gender. Little is known, from a policy perspective, about the impact of educational interventions aimed to foster aspirations among low-SES students and female students. We attempt to fill this gap through a PRISMA systematic review of interventions assessed using counterfactual designs. A total of 11 articles encompassing 13 interventions, published between 2003 and 2020, are included in the study. Hence, only a limited number of impact assessment studies have been carried out so far, and these are mostly concentrated in the US and track only short-term impacts. These studies are classified according to the kind of levers they use: *role modeling*; *encouragement* (emotional support); *practice* (meeting with professionals of a given field); *learning component* and/or *information*. The review describes how each intervention combines multiple levers. A majority of these studies reported either null effects or even negative effects on the aspirations of disadvantaged students, especially among low-achieving ones. We identify two main reasons for these discouraging results. First, most of these interventions concerned high school students who had been often already formally or informally tracked. It may be important to start earlier to intervene on the aspirations and skill development processes of disadvantaged pupils. Second, most of these interventions targeting disadvantaged students rely on role models, while our results suggest that role models may be double-edged. If they appear to be effective in increasing girls' STEM aspirations, particularly when they emphasize a positive image of science careers, role models may end up discouraging low-performing or disadvantaged students, if they are perceived as too far from the students' situation, and therefore out of reach. However, some interventions do yield encouraging results for the latter population and we discuss which characteristics may have contributed to their positive impacts.

Keywords: academic aspirations; interventions; inequalities; gender gap; STEM; censorship; academic achievement

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1.Introduction

Inequalities in educational attainment by family background and gender have been traced back to a variety of factors, such as differential academic performance, economic resources and educational and occupational aspirations. This latter factor constitutes the main focus of this work.

The scientific literature shows that educational and occupational aspirations are unequally distributed according to the gender and the Socio-Economic Status (SES) of students and that they are predictive of academic performance as well as of track choice and college enrolment even among students with prior comparable performance (Jackson 2013). Hence, self-censorship and the resulting social gaps in student aspirations can be regarded as an important source of educational inequality.

An extensive literature on aspirations has identified and empirically tested several potential mechanisms driving inequalities in student aspirations, including gender identities and roles (Correll 2007), status maintenance motives (Breen, Goldthorpe 1997), biased knowledge of the costs and the economic pay-offs of college degrees (Morgan 2005), low self-confidence and biased perceptions of the selectivity of academic tracks and university programs (Booth, Gerard 2013), adaptive preferences, peer mechanisms and social networks (Manzo 2015), fatalism, achievement orientations and other socially-biased cultural attitudes (Willis 1977).

Unfortunately, much less is known, from a policy perspective, about the impact of educational interventions to foster aspirations adjustment among low-SES students and their parents as well as among female students. This is an important research gap, given the above-mentioned evidence on the important role of aspirations for educational success and the related social inequalities.

This work presents a systematic review of evaluation studies assessing the causal impact of interventions to foster student aspirations, with a particular focus on disadvantaged students. We focus on studies using randomized controlled trials and other counterfactual methods, discuss their substantive findings, as well as their limitations and the related avenues for future research, with the objective of providing some ideas and inputs to the members of the LIEPP for future evaluation projects in this domain.

2. Search strategy

2.1 Eligibility criteria

The following criteria were used to identify eligible studies:

1) A research publication providing an empirical assessment of a specific intervention to raise student aspirations among students in primary or secondary education;
2) Students aspirations (or alike, including track choice and student ambition) had to be one of the reported outcomes of these studies;
3) Results for the treatment group had to be compared to those of an equivalent control group (counterfactual methodology);
4) The study had to be published from 1990 onwards
5) The study was a research publication written in English or French and published in a peer-reviewed journal (e.g. Ph.D. dissertations were excluded).

Hence, studies focused on students' aspirations are the main target of this review. This means that studies in which the main intervention focus was to improve school performance and academic achievement were excluded. Additionally, we excluded evaluation studies of college guidance programs providing information about college costs and pay-offs to senior high school or university students, for two reasons. First, a number of recent reviews on this topic is available, including a recent review focusing on disadvantaged students (Herbaut, Geven 2019). Second, social inequalities in aspirations emerge early in the educational career and have long-lasting consequences for student educational opportunities. In particular, in several European countries, students are tracked into lower or upper secondary education in different curricular programs that strongly differ in their academic opportunities and the quality of training for higher education that they provide. Hence, it is particularly important to intervene on aspirations *before* the last year of high school. The literature on college-guidance programs is dominated by American studies paying limited attention to high school tracking, not the least because between-schools tracking is absent in the US and only informal mechanisms of within-school tracking (e.g. ability grouping or elective subject choice) are at work.

Moreover, we focus on counterfactual studies to have reliable estimates of the causal impacts of educational interventions, thus avoiding biases relating to self-selection into the treatment and, more generally, to the lack of equivalence between treated students and the comparison group. Under some conditions, RCTs and other counterfactual methods ensure that treated and control groups are on average equivalent ex-ante or, more precisely, that any difference is due to random fluctuations and is thus not driven by any systematic bias. That said, some assessments that we review integrate quantitative impact evaluations with qualitative analyses of the treatment implementation and of participants' perceptions of these programs: whenever possible, we will also comment on the important feedbacks these mix-method studies provide.

Finally, we focus on journal articles published over the past three decades because the results of unpublished work would be less reliable and because earlier studies would be less informative for the present context.

2.2 Search strategy

The following search strategy based on the PRISMA framework was adopted (Moher et al., 2009). First, we used an initial list of eligible publications and we carried out some exploratory searches to identify a robust and comprehensive search algorithm, which was implemented in English and French. Based on this exploratory analysis, we identified the following search algorithm: (("educational" OR "orientation" OR "raising" OR "tutoring" OR "students" OR "high school" OR "STEM") AND ("aspirations" OR "ambition")) OR (("college" OR "post-secondary") & ("expectation OR "desire" OR "plans")) OR ("mentoring" OR "tutoring" OR "college STEM")) & ((("randomized" OR "randomized") AND "controlled trial" OR "RCT" OR "intervention program" OR "intervention" OR "program" OR "programme")).

Then, we conducted a systematic search through a search engine (Google Scholar) and two scientific databases (PROSPERO; PsycInfo). Next, we exploited citations and bibliography of eligible articles to identify any other potentially relevant publication.

At this point, we started the screening process, which involved 838 titles initially selected for inclusion. Among these articles, 788 were excluded based on their titles and/or abstracts, and 50 articles were selected to be fully skimmed in the eligibility phase. A total of only 11 articles encompassing 13 interventions, published between 2003 and 2020, was included in our systematic review based on the above-mentioned criteria. The PRISMA flow diagram summarizing this selection process can be found in Appendix 1. This is a first, important result of the review: **only a small number of impact evaluation studies of interventions to foster student academic aspirations are available in the scientific literature**.

Consistently with the reproducibility framework, the output of our search algorithm was compiled in an online open-access database. It gives access to all the abstracts read, the keywords used, and the reasons for exclusion. The combination of keywords used has also been reported in the keywords sheet of our open-access database.

3. Results

3. 1 Overview of the results

The table below presents an overview of the selected studies. Seven of these eleven studies have been carried out in the US, and eight out of eleven targeted underprivileged students. As the American context and educational system are very different from those of most European countries, the results of these studies can be extended to other countries only with great caution, as discussed below in more detail.

These interventions take several forms: three of them are mentoring programs (Behagel et al., 2013; Ly et al., 2020; Merrill et al., 2017); five of them consist in enriching the high school environment with college preparation activities and career counseling, mainly targeting low-SES students (Kemple & Willner, 2008; J. Moore & Dunworth, 2011; Stillisano et al., 2013; Wang et al., 2018; Watt et al., 2007); and three of them are interventions specifically aiming to increase women's participation in Science, Technology, Engineering, and Mathematics (STEM hereafter) (Breda et al., 2018; Hughes et al., 2013; Jayaratne et al., 2003).

Each intervention relies on multiple levers to foster students' aspirations. For the sake of clarity, we will group these mechanisms into five different categories:

- **Role modeling**: providing identification figures and examples of career success to emulate.
- **Encouragement**: providing students with emotional support so that they can gain confidence in their ability to succeed (e.g. "you (your kids) can make it!").
- **Practice**: introducing students to one discipline, field, or career by providing them the opportunity to meet and work with professionals of this track (e.g. in summer camps; networking/apprenticeships with employers, etc.)
- **Learning component**: improving academic readiness through regular exercises and extra training to develop student academic skills.
- **Information** on curricula and related academic requirements as well as on their employment opportunities.

Each intervention involves a varying mix of levers to reach its goal. For instance, mentoring interventions rely on role modeling through contact with an emulating figure, but during

meetings with their mentor, mentees usually receive encouragement and/or discuss and get information about tracks and career opportunities and/or discover the professional world through visits, or do homework and additional exercises. The summary table below reports the specific mechanisms mobilized in each intervention.

For heuristic purposes, we cluster the selected intervention into two *dominant* mechanisms: **role modeling** (Behagel et al., 2013; Breda et al., 2018; Ly et al., 2020; Merrill et al., 2017; J. Moore & Dunworth, 2011; Stillisano et al., 2013) and **practice** (Hughes et al., 2013; Jayaratne et al., 2003; Kemple & Willner, 2008; Wang et al., 2018; Watt et al., 2007). On the one hand, interventions that have been grouped in the role modeling category all have in common that they appeal mainly to a privileged relationship with one or more inspiring figure(s) to foster an adjustment of student aspirations. The other mechanisms stem from this privileged relationship. On the other hand, interventions that have been grouped in the category 'practice' put the exposition to the professional world at the core of their intervention. For instance, the intervention evaluated by Wang et al. (2018) focuses on internships with local employers within students' regular school weeks.

Effect sizes[2] have been computed with R software when data were available to do so. Hedges' g was used as a common metric to compare results across studies.

[2] Effect sizes are a metric that allows to estimate how much one group differs from another one within one study (usually the intervention group vs. a control group). The fact that it is a common metric for each reviewed article enables to compare the relative magnitude of impacts of different interventions. Hedges' g is one of the possible metrics to report effect sizes. It refers to the difference between the two compared means divided by a pooled standard deviation (Aromataris & Munn, 2017).

	Description of the intervention						Main results Impact: Positive / Neutral / Mitigated		
Reference:	Program	Age range (y)	Mainly for low SES?	Country	Additional mechanisms	Brief description	Impact on students' aspirations	Other results	Cost (per student per year)
Interventions whose main mechanism is: ROLE MODELING									
Behagel et al. (2013)	Actenses	15-18	Yes	France	Information; encouragement	**Mentoring program** for disadvantaged children. Mentors follow students from grade 10 to 12	Mid-term		Medium (300€)
Ly et al. (2020)	Talens	16-18	Yes	France	Information; practice; encouragement	**Monthly mentoring program** for disadvantaged children from grade 11 to 12	Different effects depending on performance and SES (high = positive effect / mid = negative effect)	Impact on students' exit score: high-achieving ones g=0.69 mid-achieving g=-0.44	High (1500€)
Merrill (2017)	iMentor	14-18	Yes	United States	Information; practice; encouragement	Partially online and **weekly mentoring program** from grade 9 to 12 (only assessing here the effect on grade 10)	Only one dimension of aspiration is significant, neutral otherwise		High (more than $900)
Stillisano (2013)	Enhanced Go centers	15-18	Yes	United States	Information	Enhanced college access centres from students from grade 9 to 12 with **mentoring** and **career counsellors**		Perceived barriers (Hedges'g= 0.07, CI 95% = [0.014;0.14]).	Medium
Moore & Dunworth (2011)	Aimhigher	12-18	Yes	England	Information; encouragement; practice	British program to improve college enrolment through several **outreach activities** (e.g. mentoring; summer classes; talks or presentations) for grade 7-12 students of deprived areas	Aimhigher students are more likely to want to go to college and to be admitted to it; or to form more accurate aspirations.		High
Breda et al. (2018)	Pour les filles et la science	15-16 & 17-18	No	France	Information; encouragement	**Role modelling one-shot intervention** by a woman scientist to increase the participation of girls in STEM for grades 10 and 12	For girls in science related careers: g=2.6, CI 95% [2.54; 2.74]	Perception of science-related career; track choice; male-dominated tracks	Very low
Interventions whose main mechanism is: PRACTICE									
Kemple et al. (2018)	Career Academies	15-18	Yes	United States	Information; encouragement; role modelling	**Career counselling program** with a strong work-based learning dimension though partnerships with local employers for grades 9 to 10 students	Children often take more suitable courses in high school but no effect on post-secondary educational enrolment	Males' earnings & employment stability; social adjustment outcomes	NA (Probably medium-to-high)
Wang et al. (2018)	IHSH	15-18	Yes	United States	Information; role modelling	**Inclusive STEM High Schools** (IHSH): can include mentoring, internships, project-based learning or opportunities to take college-level course, for grades 9 to 10 students	G = 0.24-0.32	More likely to persist through grade 12 (0.45) and to get a diploma (0.35)	NA (Probably medium-to-high)
Watt et al. (2007)	AVID / GEAR UP	15-16	Yes	United States	Learning; encouragement; Role modelling	Multicomponent **college preparation programs** that relies on an extensive training, from grade 7 to grade 12	GEAR UP AVID	AVID: positive effect on college knowledge preparation. No difference for the rest.	GEAR UP: High ($2,071) AVID: Medium ($330)
Hughes et al. (2013)	GIRLS / COED	11-13	No	United States	Encouragement; Role modelling	**STEM summer camp**s to increase a STEM self-concept and interest in girls, from grade 7 to 9	(STEM self-concept) g=0.55	STEM interest: g=0.8	NA (Probably medium-to-high)
Jayaratne et al. (2003)	Summerscience for Girls	13-14	No (50%)	United States	Learning; information; Role modelling; encouragement	2 weeks-long **STEM summer camp** to enhance STEM interest of high-achieving 8th-grade girls	Positive for nonminority girls but negative on girls from ethnic minorities	Globally positive for nonminority girls but negative on girls from ethnic minorities	NA (Probably medium-to-high)

Mechanisms: **Role-modelling**: good example / **Encouragement**: "you (your kids) can make it" Impact: Positive / Neutral / Mitigated | NA : Not available
Practice: e.g. in summer camp, networking/apprenticeship with employers
Learning component: improving academic readiness / **Information** on curricula & related academic requirements and employment opportunities

Figure 1 - Overview of the included studies, grouped by their main mechanism

3.3 Limitations

Regarding our sample of articles, some limitations must be pointed out. Although all studies used random sampling methods, sample size varies a lot across studies. To illustrate, Wang et al. (2018) rely on a sample of 38,756 students, while the sample of Hughes et al. (2013) is composed of 59 students and is thus most likely underpowered.

This is why, to estimate the overall risk of bias of eligible studies, we used the Robvis-2 tool (McGuinness & Higgins, 2020). This tool relies on several criteria to estimate the overall risk of bias in a sample of articles. For one study, this bias is said to be low, medium, or high according to the several features. Our evaluation is based on the following criteria:

- **Bias arising from the methodology or the sampling process:** this refers to efforts made when implementing the study to limit the risk of sampling bias (e.g. using random sampling; quality of the control condition; if respondents are aware of whether they are in the control group or the intervention group, etc.). In our sample, this bias is acceptable for all studies, except for two (J. Moore & Dunworth, 2011; Stillisano et al., 2013) where the modalities of implementation were unclear, although not necessarily incorrect.

- **Bias arising from attrition in the sample**: to which extent individual observations from the initial sample have dropped out from the study over time. If too many subjects drop out of the intervention or the control group, groups become dissimilar and thus potentially less comparable. Thus, a strong attrition rate is likely to induce bias in the results. In our sample, the attrition rate was deemed to be acceptable, except for two studies (Behagel et al., 2013; Kemple & Willner, 2008), where it exceeded current standards (What Works Clearing House, 2020).
- **Bias arising from the measurement:** this refers to the extent to which the measurement of the outcome variables is reliable (e.g. to rely only on one type of outcome/indicator instead of crossing several ones). As all studies cross several measures and nearly all of them use a pre-test/post-test design, the risk of bias arising from the measurement was deemed acceptable.
- **External validity and replicability of the results** refers to the extent to which the results of a study can be applied outside of the context of that study (e.g. if done on a very specific population; if it requires a large amount of money per student, etc.). In our sample, as there were some concerns about too expensive studies and as most of them came from a very underprivileged American context, the general risk of bias emerging from the external validity has been estimated as medium.
- **Feasibility in the French (or European) context:** to which extent the intervention could be applicable outside the borders of its original country, and particularly in France. In our sample, I rated as intermediate the overall feasibility of the selected studies.

Of course, this kind of evaluation always involves some degree of arbitrariness, but the detailed criteria for the assessment on a study-by-study level are illustrated in Appendix 2, Figure 2 compiles the results of all studies for a given criterion, thus allowing us to estimate the overall risk of bias in our sample, which appears to be moderate to low in most studies. When discussing each study, I will provide more details and discussion on its specific limitations.

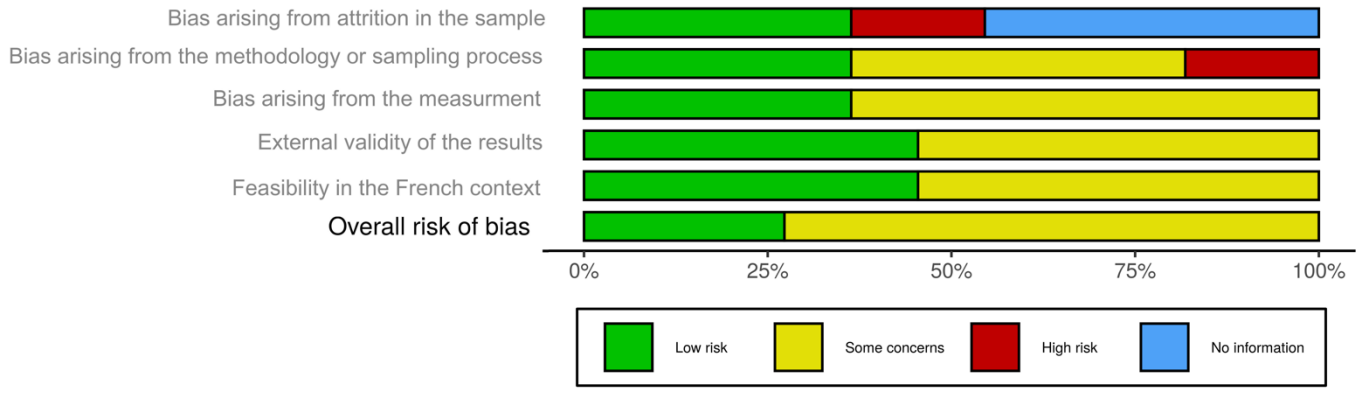

Figure 2 - General risk of bias in the total sample, assessed with Robvis-2 (McGuiness & Higgins, 2020)

The next section presents the results of the selected studies article-by-article, reporting systematically a description of the contents and methodology of the intervention, of the evaluation design, and then illustrating the results, their limitations, and implications for

policy-oriented research. As mentioned above, studies are grouped according to their dominating mechanism, namely **role modeling** or **practice**.

4. Detailed results

4.1 Role modeling

A mentoring program: The *Actenses* program (Behagel et al., 2013)

Methodology of the intervention and its evaluation design

Behagel et al. (2013) analyze the effectiveness of the *Actenses* program, which is a targeted mentoring program that was implemented in France between 2008 and 2010 for high school students (15-18 years old) from socio-economically disadvantaged areas. The main objective of this program is to guide high school students on their college choice and employment paths.

The program lasts three years from grade 10 to grade 12, and the average cost per student per year is estimated to be around 300€. It relies on several components:

a) A mentor/mentee relationship with an individual unpaid mentor, chosen by the student. This mentor is a senior professional (e.g., lawyers, entrepreneurs) and is in charge of discussing with and advising the mentee, first about her high school track choice and then about her future career choice, and of introducing her to the professional world. The pair is supposed to frequently communicate by email, meeting, or phone call (the choice of the exact frequency of the meetings is left to the pair). Mentors receive no initial training, but rather an ongoing coaching and several support resources to help them in the process (Actenses, 2006). The overall expected investment on the mentor's side corresponds to 2 to 3 days per year.
b) Every month, outings are organized by Actenses for mentees with a mentor (and only for them). It can be cultural moments, company visits, employment or education fairs, etc.
c) Every student is also invited to four different meetings/ talks per class. Each year is about a different topic. The first year is about the mentor/mentee relationship; the second is about an introduction to the business world, and the last one is about getting teenagers ready for student life.

While it mainly relies on role modeling, this mentoring relationship also aims to provide **information** about possible (and feasible) curricula and related employment opportunities, as well as providing **encouragement** and support through this personal relationship.

The authors assessed the impact of this program through a Randomised Controlled Trial (RCT) implemented in 22 high schools of deprived areas in France. Data were collected on around 2500 students, among which 630 students were in the intervention group. Unfortunately, due to severe attrition issues, data at grade 12 could not be analyzed. Moreover, initially, the randomization was supposed to be at the level of classes (i.e. all students in one class were supposed to have a mentor, while control students in another class were supposed not to have any mentor). However, due to the lack of mentors, not all students of the selected test class could have a mentor in the end[3], but still, they attended the four meetings for mentored

[3] Within each test class, who would have a mentor and who would not have one has been randomly chosen.

students. Outcomes on students are assessed by paper-and-pencil questionnaires and administrative data.

The main outcomes of the intervention were the intended track and career choice, the level of education that the student regards as feasible and accessible, her professional project, students' knowledge about the academic and professional world, the school track plans of the students, as well as the school results and absenteeism for the first and second year of high school. Data were collected via questionnaires and administrative data mainly at three-time points: at the beginning of grade 10, and the end of grade 10 and 11.

Results & implications

On the whole, the study reported mixed results on short-term (i.e. track choice and student aspirations at the end of grade 10) and mid-term outcomes (i.e. career knowledge and choice at the end of grade 11). Contrary to the expectations, **on average, treated students scaled their aspirations down**. They were less likely to consider the most ambitious educational options, that is, a prep school [4], a BTS[5] , or a DUT[6] than students in the control group. They also reported lower self-esteem and were less likely to know what they wanted to do after graduation from high school. No difference was found between the two groups in terms of work plans, or of knowledge of the possible pathways in the labor market. Concerning school track plans at the end of grade 10, in terms of choice between vocational and academic tracks, the only significant value involves academic tracks: mentees were more likely to intend to choose an ES[7] track, but they were less likely to want to do both L and S tracks. This could be understood as adapting to more realistic choices in the intervention group. However, compared to their actual choices in grade 11, no value reaches statistical significance compared to the control group.

The interpretation and policy implications of these results are unclear. Exposition to a mentor with a good professional position could negatively impact student aspirations in the short-term because it allows students to realize what it means to pursue higher education and to have a successful professional career. In other words, mentors could have inadvertently deflated students' aspirations by showing the efforts and challenges to pursue the career paths to the best-rewarded occupations.

Of course, this intervention might still have a positive impact in the long run, if students manage to identify with and are inspired by their mentor and make more ambitious track choices, but there is little evidence going in that direction. Indeed, this evaluation study has

[4] A very selective and competitive two years-long type of post-secondary curriculum, which consists of intensive preparatory courses training students for enrolment in one of the French *Grandes écoles* (prestigious and elitist higher education institutions).

[5] *Brevet de Technicien Supérieur*: it is a national diploma of higher education in France. This vocationally orientated diploma usually requires two years to be obtained, after graduating from high school.

[6] More generalist than the BTS (see footnote above), the Diplôme Universitaire de Technologie is also a two-years long tertiary-level diploma. However, students can easily access an academic program (level V of the ISCED classification) after having obtained it.

[7] ES stands for Economic and Social, L for Literary and S for Scientific, they are the three different types of French academic tracks. The scientific baccalaureate is commonly regarded as the most prestigious and elitist type of academic high school track. The choice between the different tracks has to be done by students at the end of grade 10.

two main limitations. First, no long-term evaluation of the program was carried out, since it was interrupted due to the high attrition rate. Second, due to the nature of mentoring programs, students were aware of the aim of the intervention. Even though some outcomes were measured with administrative data, this evaluation was mainly based on students' reports.

A mentoring program: the *Talens program* (Ly et al., 2020)

Methodology of the intervention and its evaluation design

The Talens program is another French, two-years long mentoring and tutoring program for disadvantaged students in grades 11 and 12, quite similar to the *Actenses* program. The main objective of this program is to create **role-models** through mentors, but compared to the previous program it has also a strong **learning component**. The program is implemented in the last two years of high school and the cost per student per year is estimated to be around 1500€. Hence, this is quite an expensive program.

Mentors are volunteers from one of the most prestigious *Grande Écoles* in France, the École normale supérieure (ENS hereafter), and they mainly come from privileged family backgrounds. Meetings between the mentor and a group of mentees (4 to 7 people per group) usually occur once or twice a month (around 12 per year, plus 2 additional guidance activities). During these meetings, mentors are supposed to learn and sustain the aspirations of their mentees, either working on school topics or helping them thinking about their post-secondary education. Participants are also invited to a one-week introductory meeting at the beginning of the program, which is a preparation for grades 11 and 12. Mentors also benefit from a two-day training.

Ly et al. (2020) assess the impact of this program through an RCT evaluation design, implemented at the level of each 12 high schools of deprived areas in the Paris region. This evaluation is based on a sample of 556 students (305 in the intervention group and 251 in the control group), with good to excellent academic performance. Each year, the headmaster of these high schools submits a list of students deemed to have the ability to succeed in high school and to pursue college education. Participants are randomly selected on each list and then attributed by groups to one mentor.

Several outcomes are measured on each student at the end of each year: grades 11 and 12 average, whether students graduated or not on grade 12, their college aspirations, and actual career choices after grade 12 (whether they accessed selective undergraduate programs or not), as well as their perceptions of the chosen program.

Results & implications

On the whole, this intervention seems to have benefitted only to high-performing students: it contributed to an increase in high school final examination scores for this group, but also to a severe decrease of the same variable among students with lower performance (effect on grade 12 average score: Hedges'g= -0.44 for mid-abilities students compared to Hedges'g = 0.69 on high-abilities students). There was a similar pattern of (smaller) effects on students' aspirations and whether they pursued (and maintained) post-secondary selective programs. This means that, instead of filling the gap between the two groups of students, it actually increased inequalities.

The main interpretation of these results is that, as the program is a relatively high-intensity one[8], it replaces other extra-curricular activities (such as school homework). While this substitution has no impact on top students, it has a negative impact on students with more difficulties. An additional interpretation of these results, which echoes the one for the previous study, is that, as there were only elite tutors, this had a discouraging effect on students, leading them to think that higher education is only for privileged people. However, mentors who came from the most advantaged social backgrounds had a more positive impact on students' grades. This might be because they were less close to their students and thus more eager to act as teachers. Furthermore, most students reported that they persisted in the program even though they were aware of its negative effect on their academic achievement because they wanted to keep in touch with their new friends (i.e. other students in the groups). In this respect, a one-to-one relationship between mentor and mentee would seem to be more favorable for academic achievement, but it would further enhance the costs of this already highly expensive program. Overall, the results imply that this program can have positive impacts only if it is more carefully targeted on academic performance.

A mentoring program: the *iMentor* program (Merrill et al., 2017)

Methodology of the intervention and its evaluation design

Like Talens, iMentor is another mentoring program that matches low-income students with college-educated mentors. The matching is here based on gender and shared interests, and the program is four-years long (from grade 9 to grade 12). Through weekly online classes and a close relationship between the two, it aims at developing non-cognitive skills and college knowledge to improve college readiness. It is both online and in-person, and the cost of this intervention is assumed to be around 900$ per student and per year.

Before beginning their relationship with their trainee, mentors have to attend a two-hour training in which "they are introduced to the program's model and learn about expectations for mentors (e.g. emailing their mentee weekly, attending events monthly, etc.) (Merrill et al., 2016). The online meetings are programmed within the students' school schedules and done through a dedicated website. The intervention relies on a **role modeling** mechanism (through identification with and emulation of the mentor), as well as on **information** delivery, **practice,** and **encouragement** through the weekly meetings. During each of them, the first fifteen minutes consist of a standardized course done by the mentor. In 10th grade, these courses focus on fostering aspirations for college-level careers, and the development of non-cognitive skills (goal setting to identify careers; self-promotion; building excitement about college; developing critical thinking skills). For the rest of the session, the mentor and mentees are then invited to discuss the content of the lesson and to discuss mentees' questions about post-secondary education. IMentor staff can use data from the platform to monitor and support these pairs (Merrill et al., 2016). As in *Actenses*, mentors and mentees are also invited to four additional thematic events every year.

Implemented in the United States, the evaluation of (Merrill et al., 2017) is based on a mixed-method methodology[9] and focuses on grade 10 outcomes' evaluation over 1711

[8] It has been identified by mentees as so.

[9] A methodology that relies on both quantitative and qualitative assessments. Mixed methodologies are particularly relevant to evaluate the impact of an intervention as they allow to both evaluate causal impact and

underprivileged treated students compared to a random control group (i.e. students with a similar profile and from the same schools but a year before who thus could not access the program). Their evaluation is based on data from two different cohorts across eight different schools. For each student, data from a survey at baseline (in the fall of grade 9) and at the end of grades 9 and 10[10] are crossed with data extracted from administrative records (demographics, 8th-grade test scores, high school GPA in 10th grade, absenteeism, on-track graduation rates). Hence, the following outcomes are investigated: college and career activities; college and career aspirations, and an assessment of students' socio-emotional skills and attitudes (internal resilience, school efficacy, perseverance, self-advocacy, critical thinking, confidence about success in college, goal-setting attitudes].

Results & implications

On average, iMentor had a **significant positive impact** (p>0.05) on some dimensions of student's **non-cognitive skills** (critical thinking; internal resilience) and on **aspirations**[11] (p>0.05), but **no impact either on school attendance or performance**. This is quite discouraging, not the least because the effects on non-cognitive skills and aspirations depend on student self-reports which could be biased by the awareness to be involved in this program.

It has to be pointed out that, as the outcomes are evaluated midway through the program in Merrill et al.'s study (2017)[12], it could be the case that effects on students' aspirations appear only at the end of the program when students are more directly confronted with making choices for their future education. Some recently published results indicate that, at the end of the program, the college enrollment variable is positive but fails to reach significance. There is also some evidence that iMentor had a significant, positive impact[9] (p>0.05) on graduation rates (i.e. it helped students that otherwise would not graduate to earn a diploma).

There is some evidence that the **positive effects on non-cognitive skills** might be **mediated by mentor-mentee closeness** (the closer they are, the better the outcomes), but there is no evidence that this mechanism applies to students' aspiration. The outcomes in this latter dimension were neither mediated by student closeness with her mentor, nor by the intensity of participation. Moreover, program compliance is low: only 37% of students assisted regularly to the session with their mentor, and only 28% of students assisted in at least 75% of the collective meetings. This could suggest that these very high-intensity requirements may be detrimental to treatment compliance. While the evidence for this intervention is more

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understand with qualitative methods the context of implementation of this intervention. The qualitative component thus enables to understand under which condition the intervention is well received by the targeted audience in order to promote its dissemination.

[10] From Merrill et al. (2017) "*The student survey contains over 100 items, including measures of non-cognitive outcomes, as well as details about their background that cannot be obtained through administrative records. Mentors also take a baseline survey when they are matched with a mentee and then another survey every subsequent year. The mentor survey has over 60 items, including questions about mentors' relationships with their mentee, as well as demographic information, details about their career, and their satisfaction with iMentor.* »

[11] As standards for treatment impacts were not reported, it was not possible to calculate standardized effect sizes.

[12] No report has been found for the grade 10- grade 12 time-lapse.

encouraging when compared to the previous two, we are still faced with a costly program with strong problems of compliance and modest treatment impacts.

A mentoring program within counseling centers: *Enhanced Go Centers* (Stillisano et al., 2013)

Methodology of the intervention and its evaluation design

Go Centers are career awareness centers that aim at helping students from grade 9 to grade 12 to be prepared for and recruited in post-secondary colleges. These centers aim to create a college-going culture within high-schools to attract students from low socio-economic backgrounds into college (Stillisano et al., 2013). To this end, Go Centers are located within high schools of deprived areas. In these centers, internet-ready computers, and physical documentation about college access are available to students (Committee for Education and Labour, 2007). Compared to traditional Go Centers, academic advisors, a mentoring service with college students, and helping volunteers are also available in *Enhanced Go Centers* (EGC hereafter). Thus, the main mechanisms through which Enhanced go centers aim to raise students' aspirations are **role modeling** and **information**, the latter component being more central for this program relative to the above-described mentoring programs.

Using a mixed-method methodology and a quasi-experimental design, Stillisano et al. (2013) assess the effectiveness of Enhanced Go Centers high schools compared to traditional GO Centers in 8 highly disadvantaged schools. This study thus measures the additional impact of advisors and mentors on improving students' perception of and aspiration for college. The control group consists of eight control schools that had to match with the intervention schools in term of total enrollment rates, ethnic distribution, percentage of underprivileged students, assessment scores (Texas Assessment of Knowledge Skills), percentage of students taking the recommended high school plan, number of graduates, students-teacher ratio, student mobility rate and percentage of students at-risk. The estimated cost per student per year was not available.

Since the experimentation is at the high school level, the exact number of students who have been exposed to the centers is hard to assess. It is however reported in the article that "student populations for both intervention and comparison sites ranged in size from a low of 593 to a high of 2,770". Stillisano et al., (2013)'s evaluation measures outcomes through a two-year-long experimentation. These outcomes are based both on a Teacher self-reporting Survey (59 items) to assess if the centers succeeded in creating a college-going culture, and on a student survey. The student survey was administered to students at four-time points: before they entered grade 11 and after finished it, and before they entered grade 12 and after they finished it. The teacher survey was administered only once, at the end of the second year. Quantitative and qualitative data from Go Centers were also collected (sign-in sheets and interviews with the staff).

Results & implications

Enhanced GO centers have been found to have very small but significantly negative effects on students' aspirations, compared to traditional GO centers (Hedges'g= -0.061, CI 95% [-0.0004; 0.12]). Hence, adding mentors and advisors to the existing setting does not seem to have any additional, positive impact. Moreover, treated students seemed to perceive on average *more* barriers to college than students in the control group (Hedges'g= 0.08, CI 95%

= [0.014;0.14]). The qualitative study suggests that this might be due to increased knowledge of the different steps and processes to go to college. This could also partly explain the decrease in students' aspirations in the treatment group (i.e. due to an increased awareness of access barriers). Unfortunately, once more long-term outcomes are not available. Additionally, it would have been interesting to directly measure students' outcomes in high schools without GO center and to compare them with those of schools with EGC and Go Centers to estimate more precisely the effect of these centers on students' aspirations.

Summary on mentoring programs

Altogether, the results for Actenses, Imentor, Talens, and Enhanced GO centers suggest that **the positive impacts of mentoring programs are extremely uncertain and that negative impacts are a concrete possibility**. Moreover, these interventions are rather costly compared to other studies in our sample (e.g. 300€ for Actenses per student per year, and 1500€ per student per year for Talens). However, if they seem to be ineffective or to have negative effect on low-achieving disadvantaged students, they still could be beneficial for high-achieving ones.

When following students closely and interacting with them, positive role models might induce a **discouragement effect**, at least in the short and medium-term. If negative effects on students' aspirations partially come from an increased awareness of the possible hurdles to college graduation, **more work on long-term outcomes is needed** to evaluate whether these negative effects persist in the long run, or turn out to be positive in terms of college enrolment and /or graduation, due to increased knowledge of the procedures and career tracks that would be more appropriate for them. For example, in the latter case, we could expect less drop-out in post-secondary education. Mentoring programs can sometimes be also **time-consuming** if their intensity is too high and impinge on students' work time and thus on their academic achievement, as well as on program compliance. This could be especially detrimental for low or middle achieving students, as in Actenses, which required around 12 meetings with mentors per year. Intensity must thus be carefully evaluated at the stage of intervention design, depending on the characteristics of the targeted population.

A mixed role modeling intervention: the *Aimhigher* partnership (Moore & Dunworth, 2011)

Methodology of the intervention and its evaluation design

Aimhigher is a British program that aims to improve college enrolment through outreach activities with an explicit targeting on promising students that are not likely to pursue post-secondary education due to adverse socio-economic conditions[13]. The program follows students from the beginning of middle school (grade 6) to the end of secondary education (grade 12). Its main objective is to increase students' academic aspirations. This program relies on several components that all serve this common goal. These components range from individual contact and tightly targeted, resource-intensive support with priority groups through group mentoring and one-to-one activities, to more diffuse information and awareness-raising collective events such as campus visits, or presentations for instance. From

[13] Mainly first generation students; deprived areas or areas where the participation in post-secondary education is low; students in vocational tracks; white working class males and students from ethnic minorities (Aimhigherlondon.org, 2020).

grade 6 to grade 8, the goal of each component is to help students exploring possible career paths and inspire them; grades 9 and 10 are about helping them to understand and decide which curriculum would be the most appropriate. The last two years (grades 11 and 12) prepare students for this goal and help them progressing and developing their skills. Aimhigher also provides support for parents, teachers, and a strong continuing professional development for staff to improve its academic involvement and support to students. Hence, Aimhigher integrates all the above-listed mechanisms: **role-modeling**, **encouragement, and educational support** to students, as well as **practice** to be better trained for higher education and provision of **information** about existing and more appropriate career tracks.

Moore & Dunworth (2011) review studies that assessed the impact of Aimhigher on students. The report includes both quantitative and qualitative studies. Papers that are reported here are cohort studies with counterfactuals that assess Aimhigher impacts via student questionnaires and/or administrative data (e.g. application statistics). Control groups are made of similar students with a similar socio-economic status from other schools that are not involved in the Aimhigher partnership. The main outcome is whether Aimhigher students are more likely to first consider and then actually apply for post-secondary education. No estimate of the costs per student per year is available for this program, but costs are assumed to be high, as this is a long, comprehensive program.

Results & implications

The results of this program, which mixes several approaches to raise students' aspirations, are encouraging. A study led on 950 students between years 10 and 11 revealed that Aimhigher participants were 1.5 times more likely than those in the control group to demonstrate a good understanding of higher education on year 11 and 1.4 times more likely to say that they were considering it (Moore & Dunworth, 2011). This program seems to help students refine their preferences and, in the end, feel better equipped to enter post-secondary education. Crucially, **Aimhigher has significantly and substantially increased the share of students from the most disadvantaged areas[14] entering higher education** from one third to a half, compared to control students (Moore & Dunworth, 2011). Moreover, Aimhigher students from ethnic minorities are 10% even more likely to consider going to university in the future compared to control students from the same background (Aimhigher, 2019). Finally, this program seemed **not only to have raised students' aspirations, but also to have adjusted them towards realistic goals**. Indeed, 84% of participating students appeared to be more likely to choose courses or universities that were most appropriate for them, although it is worth underlining that there is no longitudinal measure of university drop-out in these studies. Thus, it is impossible to say if enrolled students succeeded to complete their post-secondary degree or not.

High-intensity activities, such as mentoring, summer schools, and master classes were reported to have a greater impact than any other low-intensity activity, such as presentations and talks. However, even though the heterogeneity of the intervention enables a comparison of the relative impact of each type of activity, it also makes the results hard to interpret in the light of a common frame.

[14] To be understood as the first quintile of disadvantage here.

A role modeling intervention: *Pour Les Filles et la science* (Breda et al., 2018)

Methodology of the intervention and its evaluation design

Pour Les Filles et la Science (for women in science) is another **role-modeling program** that aims to foster the participation of women in STEM tracks, both in high school and post-secondary education, through a one-hour in-class intervention of a women scientist (56 women in the whole sample). More precisely, the role model shares her experience and career path with students. By its content, this intervention aims thus at **encouraging** young girls' participation in these tracks, as well as providing **information** about the related educational opportunities.

Before any intervention, role-models must attend a full-day training to help them share their experience. This also includes a workshop about the underrepresentation of women in science as well as sessions to help speakers enhance their communication skills.
Each intervention is divided into four main sequences. The presentation begins with a set of slides that highlight two facts: (1) the labor market is marked by high demand for STEM[15] skills, and there is a shortage of graduates in the relevant fields of study, and (2) women are underrepresented in STEM careers.

The second sequence consists of the diffusion of two three-minute videos to illustrate and deconstruct stereotypes and myths about science-related careers and gender roles in science. Besides its informational content, the goal of this sequence is also to stimulate class discussions, based on students' reactions to the videos.

The third sequence centers on the female role model's own experience as a woman with a background in science. It is the longest and most important part of the intervention, done in an interactive format of questions and answers with the students. Topics addressed during this discussion include the role model's typical day at work, her everyday interactions with co-workers, how much she earns, and work-family balance issues. The intervention concludes with an overview of the diversity of STEM studies and careers, illustrated by concrete examples, such as jobs in graphic design, environmental engineering, and computer science. The cost of the program is not reported but is assumed to be very low.

The evaluation by Breda et al. (2018) consists of a between-class RCT among 19451 female and male high school students attending the academic track in France, aged 15-16 (grade 10) and 17-18 (grade 12). As mentioned earlier, at the end of grade 10, French students have to choose between three tracks[16], and boys are often overrepresented in the scientific track, which is considered as the most prestigious one. The end of grade 12 marks the end of secondary education, when students have to choose the kind of post-secondary education they want to pursue. This evaluation relies on three main data sources "*(i) a post-intervention survey of role models; (ii) a post-intervention survey of students; and (iii) student-level administrative data*". (i) is completed just after each intervention and collects the speaker's impression and eventual problems for each session, while (ii) is filled by students one to six months after the classroom visit and collects information on students' plans, personality

[15] Science, Technology, Engineering, and Mathematics
[16] See footnote page 6 for more details.

traits, actual choices, and stereotypes about science-related careers. Students' administrative data consists of demographics, grades at the end of middle school, track chosen by grade 10 students at the end of the year, and grades obtained by grade 12 students in French and Math at the end exam marking the end of secondary education, as well as their college enrollment outcomes.

Results & implications

This intervention had a **significant, persisting, and positive impact on gender stereotypes and STEM aspirations**, especially among girls. Girls in the intervention group report stronger aspirations for science careers in grade 12 (Hedges'g=2.6, CI 95% [2.54; 2.74] and a positive perception of science-related careers (Hedges'g=2.0 in both grades). This translates successfully into their actual educational choices at grade 12 (increased enrolments in STEM fields (Hedges'g= 2.6; CI 95% [2.47; 2.67], and in male-dominated fields of study (Hedges'g= 2.57, CI 95% [2.48; 2.68]), with a related decreased enrolment rate in female-typed fields. Interestingly, **this effect was mediated by measures of identification with the female model**. Further analysis suggests that this positive impact is driven by **female students in the top quintile achieving students[17] of the sample**. For these students, the probability of enrolling in a selective STEM program after high school increases by 16.3 percentage points, which corresponds to a 57 percent increase from the baseline of 28.5 percent. The classroom interventions not only were effective in debiasing students' beliefs about gender differences in math attitude, but they also **raised awareness about the underrepresentation of women in science**. Overall, the intervention seemed to be **more effective in grade 12 than 10**, in which the classroom visits had no detectable impact on boys' and girls' probability of enrolling in the science track in Grade 11. No effect was found neither for taste for science nor for academic performance. This is compatible with the hypothesis that differences in track choices are not rooted in differences of taste, but on self-censorship and stereotypes.

Importantly, **the timing mattered a lot**: visits that took place in November increased female enrolment in selective or male-dominated STEM programs by 7 to 9 percentage points, compared with 3 to 6 points for visits in December-January and non-significant effects for visits in February-March. Thus, the **sooner during grade 12 the better**.

However, the results among the different role-models are quite heterogeneous. The ones who seemed to have the strongest impacts on girls' choices were those whose main emphasis was to project a positive image of science-related careers and stimulate students' aspirations for them, while putting less emphasis on the underrepresentation of women in science. Hence, **gender-related messages seem to be the least effective messages**. The authors suggest that this may be because such messages reinforce the stereotype according to which *women dislike science careers and face discrimination in them*.

Some limitations of this study are worth noticing. The first one is the absence of a pretest, that would have been interesting to formally assess ex-ante equivalence on a stronger basis. More importantly, a long-term evaluation to assess to what extent these impacts are long-lasting is missing, in particular, with regard to potentially negative outcomes on dropout rates.

[17] Top quintile of the distribution of math performance at the *Baccalauréat* in the end of grade 12

That said the study provides **strong evidence of a cost-effective intervention to reduce gender segregation in higher education enrolments**.

4.2 Practice

A career counseling program*: Career Academies* (Kemple & Willner, 2008)

Methodology of the intervention and its evaluation design

Career Academies is an American program that aims to prepare students for post-secondary education and employment, through several **information** sessions around a career theme as well as **practice**, through work-based learning opportunities *via* partnerships with local employers. The goal is to increase students' awareness and knowledge about career opportunities while encouraging them to complete high school and enroll in post-secondary education (Algan et al., 2018; Kemple & Willner, 2008).

Typically, 150 to 200 students per location (30 to 60 students per grade) attend Career Academics, when they are around grade 9 or 10 until grade 12. Within this program, students:

1) Are separated in small learning and training communities for a more supportive and personalized learning environment;
2) Attend a combination of academic and vocational curricula around a career theme (e.g. health sciences, law, business and finance, and engineering;
3) Attend career awareness sessions and work-based learning opportunities with local employers. This means that they are offered the opportunity to discover the professional world through concrete practice, by having a "first job".

Implementing these different dimensions requires enough administrative flexibility from the high school involved to allow students to take a few hours on their school time scheduled to take part in the apprenticeships.

Kemple & Willne (2008) conducted a long-term evaluation (12 years after students began) of this program, with a RCT design (students were randomly assigned to the intervention group or the control group). They used data from 1428 students (55% in the intervention group and 45% in the control condition, that is, regular high school attendance), who mostly come from low socio-economic backgrounds.

Data in this evaluation were gathered from high school transcripts, and surveys administered to students in high school and at three time points, during the eight years following their graduation. These surveys collected information on (i) whether students graduated from high school, whether they enrolled in post-secondary education programs (if so, program's characteristics were also surveyed), and whether they completed them (ii) information about their work experiences (duration, number of hours worked per week, and number of weeks per month, hourly wages). (iii) information on the sectors of employment, job tasks, and whether their job was connected to their educational background.

Results & implications

At post-test, Career Academics has **increased the probability of staying in school until graduation, as well as attendance of and number of credits earned in both academic and technical courses, for students at high risk of academic failure**. For the other students involved in this program, it has increased their participation in career and technical courses

and participation in career development activities, without reducing academic course-taking and standardized test scores.

Eight years after they graduated, Career Academies produced long-lasting earning gains (11% or $2088 per year[18] in terms of wages) for students who had had access to the program compared to the control group. This trend is stronger for high-risk students (17%) than for other participants (around 10%). These effects are concentrated on young men. The program has benefited not only their salary, but also the number of hours worked, wages, and employment stability. Taking these last dimensions into account would lead to a total **increase of 17% in earning gains ($3731 per year) for this population**. This intervention also seems to have had a positive socio-behavioral impact on students, with a higher percentage of young people living independently with a partner. However, the program had a globally positive but non-significant impacts on girls. These differences between men and women are attributed to gender differences in employment patterns (men are on average better paid, work for longer hours, and their earnings increase more steeply).

Unfortunately, this program had **no impact on average postsecondary education enrollment** and educational attainment rates. This means that the program managed to increase earnings without having any impact on higher education enrolment. This intervention shows that investments in career-related experiences during high-school can produce substantial and long-lasting improvements on labor market prospects, especially on earnings as well as on global adulthood-life stability of men not pursuing higher education. However, although Career Academics is efficient to improve the labor market prospects of young men at risk, **it could be challenging to scale it up while maintaining high levels of fidelity**. In this respect, as impacts are higher for high-risk students, it might be useful to target it only to this population. Finally, even though it was its initial goal, it is unclear whether this program has been successful in raising students' academic aspirations, given the null results on college enrollment and attainment rates. Another limitation is the high attrition rate in the initial sample (45% between randomization and post-test) that could lead to overestimating the real impact of this program.

A high-school level program: *Inclusive Stem High Schools* (IHSH) (Wang et al., 2007)

Methodology of the intervention and its evaluation design

Inclusive Stem High Schools (IHSH hereafter) are specific **American high schools** that aim to attract, support, and sustain the participation of students from all backgrounds in STEM tracks. To meet this goal, these high schools combine rich STEM course offerings and experiences. There is an explicit targeting of students from under-represented groups in STEM, with the view of developing their aspirations and interest for STEM and related educational paths. The program lasts three years from grade 10 to grade 12. Unfortunately, no information is available on its cost per student.

Based on data collected from 2012 to 2013 on over 38756 12thgrade students, Wang et al. (2018)'s evaluation covers different types of ISHS. Some are occupation-oriented with the

[18] A $16,704 boost in total earnings at follow-up eight years after the end of the program.

provision of **extensive mentoring** and **internship opportunities**. Others are **learning-oriented**, either by stressing the integration of STEM subjects and project-based learning or by the provision of more traditional school courses but with the opportunity to take college-level courses. Hence, rather than a standardized program, IHSH may be rather regarded as a broad set of interventions with a shared focus on fostering STEM aspirations.

For their evaluation, the authors use two types of comparison groups, one within the same district to control for local context, and one composed of comparable high schools from other districts where there are no IHSH to prevent from self-selection bias in ISHS (i.e. for example ISHS could gather better students in the district and thus bias the comparison with other schools from the same district). Their analysis is based on longitudinal student data: for each student, they collect "*high school outcome indicators, including a college aspiration indicator from a statewide survey, student demographics, 8th-grade achievement data, and academic experience indicators*".

Results & implications

This high-school level intervention gives rise to **positive effects on students' outcomes**. When tested on grade 12, IHSH have a positive impact on students' aspirations to go to college either for a long period (4 years or more, Hedges' g=0.24, IC 95% [0.05; 0.42][19]) or a shorter one (less than 4 years, g=0.32 , IC 95% [0.13; 0.50]). IHSH has also helped students to persist through grade 12 (g= 0.45, IC 95% [0.17; 0.51]) and to earn a high school diploma (g=0.35, IC 95% [0.18; 0.52]). However, there is no evidence on college enrolment and graduation. Moreover, as we have seen, the settings and intervention types vary a lot across the different IHSH. This is why, despite these encouraging results, a more fine-grained evaluation would be necessary to disentangle the components that are the most effective to raise students' aspirations. Once more, we are confronted with a program failing to raise college enrolments, including enrolments in STEM fields.

A college preparation program: AVID/GEAR UP (Watt et al., 2007)

Methodology of the intervention and its evaluation design

Advancement Via Individual Determination (AVID) and *Gaining Awareness and Readiness for Undergraduate Programs* (GEAR UP) are two **college preparatory programs** that aim to raise students' aspirations and skills to get them ready for college. Both programs target low-income students, and both are comprehensive, which means that they involve not only students, but also parents and teachers. Each of them primarily relies on **information** and **practice**, but they also use some elements of **role modeling** through available tutoring.

GEAR UP offers comprehensive services to all students from mostly disadvantaged high schools from grade 7 until grade 12 (Watt et al., 2007). Although the precise details of the contents are left to the free evaluation of each high school, this program is mostly based on tutoring and **preparation for the admission tests, dissemination of information concerning application procedures, financial aid counseling,** and **parental coaching** to help parents support the students in their preparation for college. Some scholarships may also be offered to students most in need (*ibid*).

[19] Based on the most conservative estimates.

AVID are elective classes, within the regular school day in high school (Watt et al., 2007). It relies on a **college entrance exam preparation, a strong writing and reading curriculum, activities to develop critical thinking skills** through collaborative teaching[20] and other **socio-behavioral skills** (e.g. study management). Besides classes, tutoring with trained tutors is also available to students, and students are exposed to college-level classes, and other collective activities are developed to increase students' and parents' involvement in the college preparation process. Overall, compared to the previous programs, the core of these programs involves **educational activities and information provision**. While the cost per student per year for AVID is $330, it is much higher for GEAR UP ($2071).

Using a quasi-experimental design with randomly assigned subjects and a mixed-method methodology, Watt et al. (2007) assess the effect of both programs on 142 grade 10 students. Among these 142 10thgraders, 40 were AVID students, 40 were GEAR UP students, 22 participated in both programs, and 40 were assigned to the control group. In each of these four groups, eight students were randomly selected to participate in discussion groups where qualitative data were collected. Qualitative evaluations allowed here to evaluate attitudes towards and perceptions of the intervention that could not have been captured through quantitative methods. Quantitative data were collected through school records and a 25-item student survey. In quantitative data, the following dimensions were assessed: "*academic achievement, educational aspirations, educational expectations and anticipations, college knowledge, participation in college activities, college requirements information, and financial aid information*".

Results & implications

According to the evaluation of Watt et al. (2007), no significant effect has been found between GEAR UP students and control students in grade 10 in terms of educational aspirations, college knowledge, or academic achievement. The only **significant** and **positive** impacts are on **AVID students' aspirations** (g= 0.94, CI 95% [0.47; 1.41] and **college knowledge** (g=0.47, CI 95% [0.01;0.9]). AVID is very similar to GEAR UP but unlike the latter, it also includes some socio-behavioral training components. Thus, the results suggest that fostering **socio-behavioral skills** is of critical importance.

However, due to the small sample size, these results must be interpreted with caution. Moreover, it would have been interesting to compare these results to similar measures taken in grade 12, as the effects on students' aspirations might only show up when career choices become a more concrete and pressing issue, as in Breda et al. (2018). Furthermore, other studies examining different outcomes for the same programs revealed mitigated results. While some studies found evidence of positive outcomes for AVID students (e.g. (Marchand et al., 2007)), a report of the What Works Clearinghouse among 66 studies on AVID concluded for a null effect on the reading and writing skills (reading fluency or general literacy skills) (WWC, 2010).

[20] Teachers working in tandem

A STEM summer camp program: *Summerscience for Girls* (Jayaratne et al., 2003)

Methodology of the intervention and its evaluation design

Summerscience for Girls is a **summer program targeting high-achieving 8thgrade girls** that aims to enhance science interest, aspirations, and persistence of girls in science. It relies on **practice**, **encouragement**, **information** provision, and **role modeling** as it consists of a two-week-long science immersion on the campus of the University of Michigan. During these weeks, girls are exposed to hands-on laboratory experiences or field experiences, to female role models, to informational sessions on careers and requisite training, and to other activities that are aimed at dispelling stereotypes about women doing science. Some of the staff are from minority ethnicities to increase role model identification of girls from ethnic minorities. Application to this program is on a voluntary basis and it requires a recommendation from a science teacher.

Jayaratne et al. (2003) realized an evaluation of this program through a four-year longitudinal study. The 38 girls that were enrolled in the program have been compared to 173 applicants that did not access the program, as a control group. Surveys have been filled by all students at three time-points: right before the start of the program, one year after the end of the program, and four years after. The surveys aimed at measuring the following dimensions: "*self-concept and interest* [in science], *persistence and aspirations in science, science activities, science course-taking in high school, and plans for a science college major*".

Results & implications

The program appears to have benefitted **only nonminority girls** and to have had **an overall negative effect on girls from ethnic minorities**. In fact, three years later, the program appears to have positively impacted science self-concept, enjoyment and aspirations for science of non-minority girls at 12thgrade (science self-concept (g= 0.38; CI 95% [0.09; 0.67]); enjoyment and interest for science (g=-0.29; CI 95%[0.005; 0.6]), science aspirations (g=0.32; CI 95% [0.03; 0.62]) and science course-taking (g=0.44, CI 95% [0.006;0.87]). On the other hand, it has globally negatively impacted girls from ethnic minorities on the same dimensions (science self-concept (g= -0.76; CI 95% [-1.50; -0.03]); enjoyment and interest for science (g=-0.46; CI 95%[-1.18; 0.25]), science aspirations (g=-0.56; CI 95% [-1.3; 0.16]), and science course-taking (g=-0.39; CI 95% [-1.10; 0.32]). These effects are non-significant for the enjoyment and interest of science, science aspirations, and science course-taking due to the small sample size of this group. No simple explanation was found for these differentiated impacts. Participants' perception and satisfaction of the program may partially account for these differences of behaviors and attitudes, as minority girls tended to report lower satisfaction on average. It is likely that some selection effect arose in the process, as a quota of half participants from minority groups had been fixed upstream so that possibly minority girls were not as motivated to participate as other girls. Finally, the program may have served as "*a dose of reality*" for some participants, underprivileged students being more susceptible to have an idealized vision of research in science.

A STEM summer camp program: GIRLS / COED (Hughes et al., 2013)

Methodology of the intervention and its evaluation design

Getting Involved in Research and Learning Science (GIRLS hereafter) and *Cultivating Opportunities in Engineering Disciplines* (COED hereafter) are both **summer camps** to improve

middle school[21] **girls' interest in STEM** fields and create a STEM identity by exposing them to careers in STEM.

Both camps rely mainly on **practice**, **encouragement,** and **role modeling**. In each of them, students are exposed to STEM research, STEM content, and STEM professionals who could serve as possible role models, for example through STEM places visits. A typical day in COED would be composed of one or two visits to local STEM places in the morning and a daily challenge competition about a STEM theme during the afternoon. A typical day in GIRLS would consist of one visit of a STEM place with most of the time a female scientist, and a STEM activity such as building a water filtration system. While students in COED are faced with a daily challenge about a STEM theme, girls in GIRLS have to build their scientific posters at the end of the camp in STEM.

While their organization is very similar, COED is a one-week-long mixed-sex STEM camp, while GIRLS is a two-weeks long girls-only camp. While no information was available on the implementation costs of these camps, they are assumed to be moderately low as the student groups are not small.

Hughes et al. (2013) used a mixed-method methodology to assess the efficacy of these programs. To do so, they carried out some pre- and post- surveys among students assessing STEM interest and STEM self-concept, they did post-interviews with teachers and students, carried out some participant observations, and used student application responses. The COED group was composed of 27 students, while the GIRLS group consisted of 32 girls. Given the fact duration of both camps is quite short, pre-intervention surveys of the same students have been taken as control responses to estimate the effect of the interventions[22].. Plus, as COED intervention is a mixed-sex program while GIRLS targets only girls, COED has been used as a control intervention to estimate the additional impact of girls-only camps in raising girls' aspirations for science tracks. This estimation is however not perfect, as the two summer camps also differ according to their duration.

Results & implications

While both programs had no significant impact on boy's STEM self-concept[23] and STEM interest, girls in both groups showed a significant pre/post difference in STEM self-concept (g=0.55, CI 95% [0.03; 1.07]) and STEM interest (g=0.8, CI 95% [0.26; 1.32]). This **could suggest that both camps were successful to initiate a STEM identity transformation in girls**. In these camps, the setting (girls-only or not) thus seems less important than the content of the camps. Given their small sample sizes, these programs could be regarded as pilot studies that show some promising outcomes. They thereby complement the promising results of the RCT by Breda et al. (2018), where the information component was stronger, by suggesting the potential of practice-based mechanisms.

[21] Grades 6 to 8 for COED and 5 to 9 for GIRLS.

[22] It must be pointed out that this study does not use counterfactuals methods. We decided to include it in our final sample because of the paucity of available studies on the same topic (three studies in our final sample, this one included) and because this study collects detailed information on the treatment group before the intervention. Given the short duration of the intervention, it seems unlikely that some concomitant intervention or preexisting trend biased the results.

[23] Perception of one's own efficacity and abilities in STEM fields.

However, the outcomes were only measured in the very short-term and it is possible that student answers were biased by their recent participation in the program and awareness of its goals; or that the camps fostered some genuine, initial interest for STEM careers, but that their effects faded out. Finally, the programs targeted already motivated students, the results should not be generalized to the overall student population. Taking into account the small sample sizes of this study and the absence of passive control group, the evidence base for the efficacy of these summer camps is quite uncertain.

Discussion

- A preliminary, important result of this review is that there is only a **limited number of impact evaluation studies targeting the aspirations of students since the early stages of secondary education**, **even more so in the European context**. Hence, there is a strong potential to develop and rigorously test new programs as well as to adapt and replicate in the European context some programs that were developed in the US. Indeed, several components of the methodology of most of the US programs seem reasonably transposable to the French context. The small number of studies reviewed in this report prevents any strong conclusion on the efficacy of this type of programs.
- The rare existing studies face some important limitations: self-reported measures, which are susceptible to the social desirability bias, are most often used. When behavioral outcomes are included, they are most often measured short after the end of the program. Hence, it **is unclear whether these interventions have long-lasting impacts on student enrolment and persistence in higher education**. Hence, **there is room to considerably improve the research designs** of existing impact evaluations in this domain. Additional limitations for some evaluation studies involve the small sample sizes and excessive treatment heterogeneity.
- **The interventions under examination use a varying mix of five distinct mechanisms:** role modeling, encouragement, practice, learning components, information provision. Among these components, **role modeling** is extensively used, as it is present in some form in virtually every intervention we presented. However, altogether our results suggest that **multi-component interventions** combining different mechanisms are **more likely to increase students' aspirations** than interventions relying predominantly on role modeling alone, such as the 'pure' mentoring programs, for which mostly null effects are reported (Hughes et al., 2013; J. Moore & Dunworth, 2011; Wang et al., 2018; Watt et al., 2007). Successful examples of such multi-focused interventions include Aimhigher, inclusive STEM high schools, and college preparation programs. At the same time, multicomponent and multi-target interventions are often heavy and costly to implement, which could limit their applicability. Furthermore, while most of the interventions that we have examined targeted students only, **involving parents in programs**, as in Aimhigher and AVID, could be a go, as parental aspirations for their child are regarded as important in the scientific literature, particularly in the early stages of educational careers (Barone et al. 2018). On the same vein, **involving teachers** might also be a powerful lever as they play an important role in students' track choices and self-confidence (Papageorge et al., 2018). Recent studies have shown that teachers often have differentiated expectations for their students according to their gender and ethnicity, with consequences for the performance of the students concerned (Carlana, 2019; Lavy & Sand, 2015; Papageorge et al., 2018). This perspective opens up new avenues for interventions: awareness-raising intervention or even behavioral interventions directed to teachers could be a go.
- While no restriction on students' age range has been established in our systematic search, most of the eligible interventions involve high school students, in some cases students who have been already formally or informally tracked. **Starting earlier might be important**, especially to intervene on the aspirations and skill development processes of underprivileged students. In this view the relatively small effects

observed in this review are no surprise given the fact that these interventions arrive relatively late in students' educational career, while social inequalities in academic achievement are a complex and multifactorial process that is likely to be constructed well upstream secondary education.

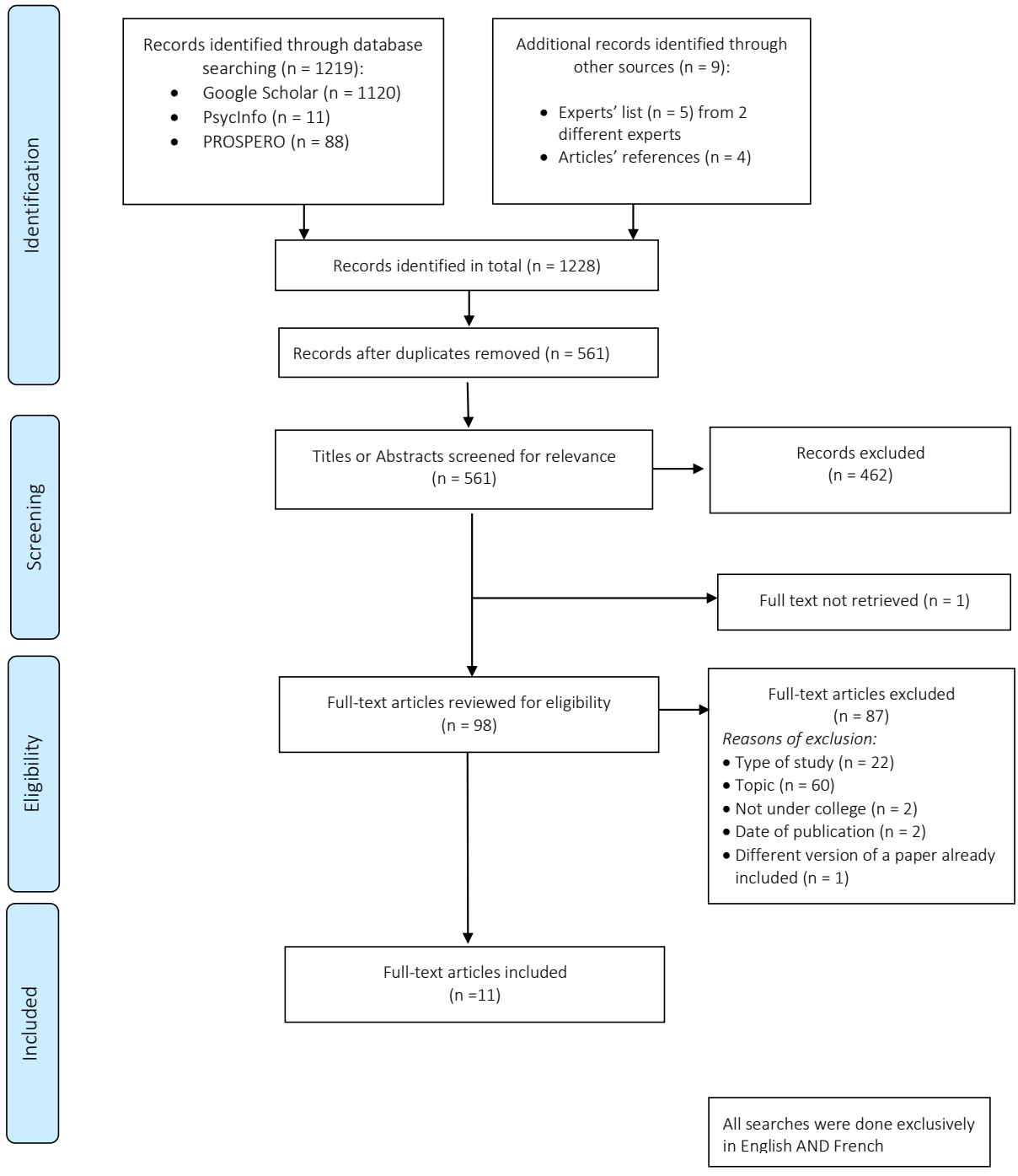
- On the whole, the risk that these interventions result in **Matthew effects**[24] is quite concrete. Most of the interventions reviewed here seem to **benefit more or only high-achieving** (Bakermans-Kranenburg et al., 2005; Behagel et al., 2013; Jayaratne et al., 2003; Ly et al., 2020) or **socially advantaged students**. The lack of (or negative) effects on minority students is discouraging and needs to be further investigated (Behagel et al., 2013; Jayaratne et al., 2003; Kemple & Willner, 2008; Ly et al., 2020; Stillisano et al., 2013; Watt et al., 2007). For example, mentoring programs seem to boost the aspirations of high-achieving students, but not those of less performing students. As academic performance correlates with family background, these interventions may thus reinforce inequalities between high- and low-SES students. Three main explanations have been proposed for these Matthew effects in this review. First, especially for mid-achieving and low-achieving students, these interventions may impinge on the time devoted to schoolwork, if they are too intensive. Second, if mentors are academically or socially too 'distant' from treated students, they may paradoxically induce a discouragement effect. Further investigations are yet to be done, as some programs that include mentoring among other dimensions, display encouraging results (Kemple & Willner, 2008; J. Moore & Dunworth, 2011; Wang et al., 2018). Finally, it could be the case that the information provided by the intervention make low-achieving students realize that their aspirations were unrealistic and lead them to drastically lower them down. More work is needed with more fine-grained measures of students' initial abilities to disentangle between the three hypotheses. Overall, however, in the stage of treatment design, it seems important to identify interventions that are **not time-consuming for students and that involve mentors that are not perceived as too distant by socially disadvantaged students**. Additionally, for ethical reasons, potentially negative effects on low-achieving students need to be carefully considered before implementing these programs, a concern that should also lead to a cautious targeting of the intervention population.
- Given the previous points, it is perhaps unsurprising that, among the programs to foster the academic aspirations of low-SES students, **Aimhigher had the most promising results: it starts in middle school and lasts for six years throughout high school, it involves also parents and teachers, it combines group activities with individual support to single students, integrating an initial focus on mentoring and aspiration boosting with information provision on feasible academic paths, and later on with academic support to students**. Its comprehensive, long-term, processual approach resulted in positive, long-lasting impacts on students' aspirations, knowledge of higher education, and actual enrolments. At the same time, since costs and feasibility are important issues with Aimhigher, it would be important to consider whether some simplification of this heavy intervention design could still result in positive outcomes. Moreover, the encouraging results for both Aimhigher and AVID

[24] The ones who need the most are the ones who benefit the less, or conversely, those who already have, even though they are not the main target, are the ones who receive the most. As a consequence, this effect strengthens inequalities instead of reducing them.

may suggest that, while fostering student aspirations is essential, **a focus on academic readiness is important to motivate students to realize their aspirations and succeed in higher education**.

- Regarding interventions to raise girls' STEM aspirations, **a short, one-shot intervention complementing role modeling with information provision** by an inspiring figure, such as *Pour Les Filles et la Science* seems to be effective and efficient, given its low costs (Breda et al., 2018). This kind of result is consistent with other studies on a similar theme. For example, a large RCT in Italy providing information on occupational and economic returns to high school seniors resulted in a substantial reduction of gender segregation across fields of university enrolment (Barone et al. 2019). (Beaman et al., 2012) carried out a natural experiment in India that quantifies the impact of the arrival of female leaders in village councils on 11 to 15 years-old girls' aspirations. In these villages, the gender gap in educational attainment was erased and girls spent less time in domestic chores. This suggests that role **modeling figures** in the early years of life can have an impact on students' stereotype formation (Beaman et al., 2012; Breda et al., 2018; Hughes et al., 2013; W. Moore, 2010). In this process, Breda et al. (2018) suggest that **emphasizing a positive image of science-related careers could be more effective** to stimulate students' aspirations than emphasizing the underrepresentation of women in science. Thus, gender-related messages seem to be the least effective messages to convey, while identification seems to be a key element to raise girls' aspirations, particularly when matched with information provision in simple formats on opportunities associated with STEM careers.

Appendix 1 – PRISMA flow diagram



From: Moher D, Liberati A, Tetzlaff J, Altman DG, The PRISMA Group (2009). *P*referred *R*eporting *I*tems for *S*ystematic Reviews and *M*eta-*A*nalyses: The PRISMA Statement. PLoS Med 6(7): e1000097. doi:10.1371/journal.pmed1000097

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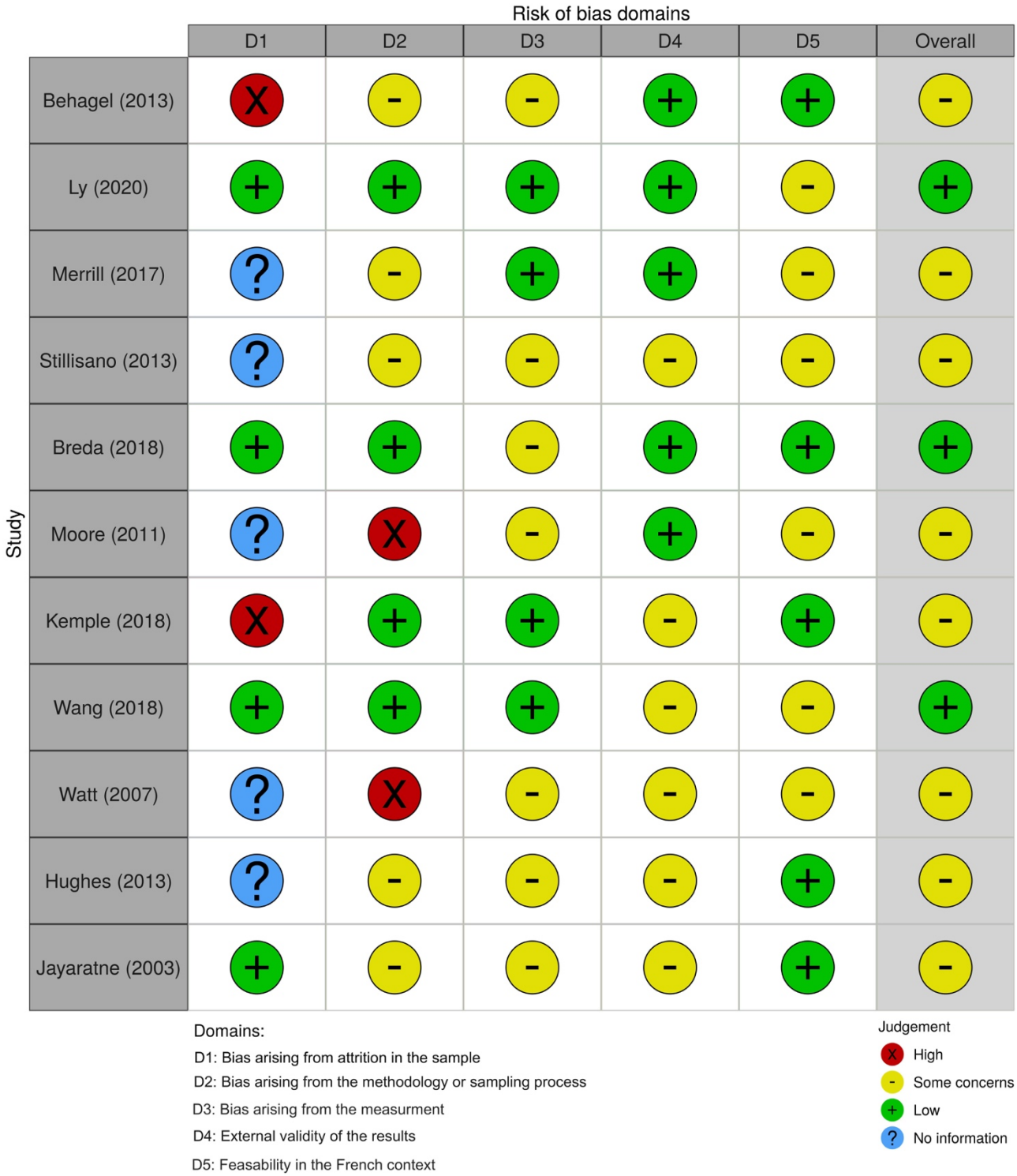
Appendix 2 - Article-by-article risk of bias assessment



A decision algorithm for the overall risk of bias

IF((D1 AND D2 AND D3 AND D4 AND D5) >= 2*High)
Then (Overall = High)

OTHERWISE (IF (D1 AND D2 AND D3 AND D4 AND D5) > 2*Some concerns)
Then (Overall = Some concerns))

ELSE (Overall = Low)

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