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Ramadan, fasting and educational outcomes*

Hessel Oosterbeek Bas van der Klaauw

Abstract

Using a difference-in-differences framework, we estimate the impact of Ramadan on educational outcomes of Muslim students living in a non-Muslim country. For identification we exploit the fact that the number of Ramadan weeks during the course that we study, varies from year to year, ranging from zero to four. Our main finding is that Ramadan observance has a negative impact on performance; one additional Ramadan week lowers the final grade of Muslim students by almost ten percent of a standard deviation.

JEL-codes: I11, I20, Z12
Keywords: Ramadan, nutrition, educational achievement, intention-to-treat

1 Introduction

This paper examines the impact of Ramadan on the academic performance of Muslim students in the economics program at the VU University Amsterdam in the Netherlands. Like in other non-Muslim countries, the number of Muslim-students in the Netherlands is expanding, and will continue to expand in the near future (Pew Forum on Religion and Public Life, 2011). This makes it increasingly important to know to what extent the academic achievement of these students is affected, if at all, by observing Ramadan. A key element of Ramadan is the fast, which means that for a period of 29 or 30 days all healthy post-pubertal Muslims avoid the intake of all food and drink between sunrise and sunset. Eating is only allowed during the night (Kocturk, 2002).[1] If fasting is the main mechanism through which Ramadan affects

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[1]Fasting is assumed to teach patience, modesty and spirituality. Individuals who cannot fast for legitimate reasons (traveling, illness, menstruation) should compensate for this by fasting an equal number of days at some other time.

academic performance, our results are informative about the relation between nutrition and educational outcomes.

Based on previous research, we hypothesize that observing Ramadan, and especially observing the fast, will have a negative impact on participants' academic achievement. Research among people observing Ramadan indicates lower mental activities during daytime and increases in these activities after sunset. Self-perceived abilities to perform mental activities follow this same pattern (Waterhouse et al., 2008, see also Roky et al., 2000).[2] In a study among 265 university students who observed the Ramadan fast, Afifi (1997) reports reduced activity, less desire to study and lower ability to concentrate among more than 50 percent of subjects.[3] These behavioral responses to Ramadan are observed within Muslim societies.[4] Our study inquires the impact of Ramadan on students' academic achievement in a non-Muslim setting in which teaching schedules and exam dates or times are not adjusted to Ramadan. This deviates from a Muslim environment in which teaching schedules are adjusted to Islam's holy days.

Although Ramadan observance entails more than only the fast, it seems likely that the fast is the main element affecting academic performance.[5] An extensive experimental literature shows the importance of nutrient intake for the cognitive functioning of schoolchildren (Benton, 2008; Muthayya et al., 2007; Simeon and Grantham-McGregor, 1989; Taras, 2005; Wesnes et al., 2003). The vast majority of this literature focuses on short-run effects of short-lived interventions, and not much is known about long-run effects or the effects of long-lasting interventions.[6] Based on a survey of the literature, Taras (2005) states that "[l]ong-term studies are recommended as an important next step for researchers in the field of school nutrition." The literature on long-term effects of nutrient intake mainly focuses on

[2]Waterhouse et al. (2008) studied 64 Muslims concerning their food and fluid intake, naps, physical, mental and social activities, and their ability to perform physical and mental tasks. Information was gathered through five questionnaires per subject per day for a period of eight weeks (two before, four during and two after Ramadan).

[3]Afifi (1997) conducted a cross-sectional study to explore the effect of the Ramadan fast on daily practices, health and performance. More people got involved in stress reducing and spiritual activities. They drank less caffeine-containing beverages and smoked less. Food intake appeared to improve during Ramadan with higher proportions eating foods from all food groups. The amount of foods did not differ significantly except in the case of foods from the cereal, meat and vegetable groups.

[4]The study by Waterhouse et al. (2008) also covers 31 Muslims in the United Kingdom.

[5]A similar assumption is made by Almond and Mazumder (2011) and Van Ewijk (2009) who examine the impact of Ramadan observance by pregnant women on the (long-term) health outcomes of their children. Both studies attribute the negative effects they find, to the fast.

[6]The findings of Figlio and Winicki (2005) suggest that schools are aware of the link between nutrition and short-term cognitive functioning. They find that school districts having schools that face potential sanctions under the school accountability system respond by increasing calories in their menus on testing days, while districts without such immediate pressure do not change their menus.

periods of malnutrition during childhood, and mainly considers developing countries. Benton (2008) provides some evidence that malnutrition early in life or even during pregnancy can have lasting effects on brain development. Most of this evidence does not come from randomized experiments like the evidence on short-run effects discussed above. An exception is Maluccio et al. (2006), who find for Guatemala that a nutrition intervention during the first three years after birth improved educational outcomes. Belot and James (2009) consider school meals in the United Kingdom. In a difference-in-differences setting they find that the switch from low-budget to healthier primary school meal improves outcomes and reduces absence.

In this study, we examine how the performance of Muslim students on an introductory course in microeconomics is affected by exposure to Ramadan. To identify this impact, we use a difference-in-differences approach. The first difference contrasts Muslim students and non-Muslim students, thereby assuming that non-Muslim students are unaffected by Ramadan. The second difference uses that the number of Ramadan weeks during the course differs across years. This is due to the fact that the timing of Ramadan follows the Islamic calendar in which a year is about 11 days shorter than in the commonly used Gregorian calendar. As a result, during our period of observation (2003-2007) Ramadan shifts over the course which always starts in the first week of September and lasts till the second week of October.

Our study differs in some important respects from previous studies that examine the link between nutrition and cognitive outcomes. First, we focus on a different population, undergraduate students instead of schoolchildren. Second, we consider the performance of these students in a real-life setting in which they have a strong incentive to perform as good as possible on the test. This incentive is often absent in the experimental evidence mentioned above. Finally, Ramadan implies one entire month of changed nutrient intake, which is much longer than the usual experiments. This implies that our study goes beyond the short spells of fasting usually considered in the literature.

Our main finding is that one additional week of Ramadan exposure reduces the final grade of Muslim students for the microeconomics course by almost ten percent of a standard deviation and there is no difference between male and female students. Since not all Muslim students actively participate in Ramadan and we do not have information which students actually did participate, this estimate should be interpreted as an intention-to-treat effect for Muslim students. This is then a lower bound on the actual treatment effect. The decrease in performance is not the result of reduced attendance, i.e. we do not find any evidence that due to Ramadan Muslim students attend fewer classes.

The remainder of the paper continues as follows. The next section provides details of the institutional setting, which is the first year of the undergraduate economics and business program at the VU University Amsterdam. Section 3 describes the data and provides summary statistics. It also reports results from a questionnaire we conducted in 2007 and which gives information about Ramadan observance among Muslim students in the program. Section 4 reports and discusses our empirical findings. Section 5 summarizes and concludes.

2 Institutional setting

The first year of the economics and business program at the VU University Amsterdam consists of 18 compulsory courses, which add up to 60 credit points. We focus on the introductory microeconomics course of three credit points. The course is taught during the first eight weeks of the academic year, from September to October. This first block consists of six weeks of teaching. There are no classes during the seventh week and the exam takes place in the eighth week.

During the six weeks of teaching, there is a general two-hours lecture in the large auditorium on Wednesday (around lunchtime) for all students. Participation in this lecture is not compulsory and attendance is not registered. Every week the students receive a problem set, which deals with the topics discussed during the general lecture. Students can hand in the solutions to these problem sets to collect a bonus point for the final grade. To receive the bonus point students not only have to score sufficiently good on the problem sets, but they also have to participate in workgroups. The workgroup meetings are every other week in groups of at most 24 students.[7] Attendance at these workgroup meetings is registered. Participation in the workgroups is not compulsory. Students who do not attend only lose entitlement to the bonus point. During the workgroups the problem sets are discussed.

The exam in the eighth week consists of multiple-choice questions (about 25 percent) and open questions (about 75 percent). At the exam students can collect 100 points. In the exam the maximum number of points awarded for each question is explicitly noted. The exam grade is the number of points divided by ten, so exams are graded on a scale from zero to ten. There is no grading on a curve or any other form of adapting grades to overall performance.[8] The final grade is the exam grade plus the bonus received for the problem sets

[7] Students are assigned to the groups and cannot switch between group. There are meetings both in the morning and afternoon.

[8] This is indicated by the fluctuations in pass rates across years; 0.69, 0.61, 0.64, 0.56 and 0,56 from 2003/4-2007/8, respectively.

and workgroups. After rounding the final grade to an integer, a six is required to pass the course. Overall pass rates are about 60 percent (of the exam-takers). Students who do not pass at the October exam, can do a re-take exam in December.

The Netherlands is a multiform society, also with respect to religion. Of a total population of 16 million people, around 50 percent does not subscribe to any religion. Around 25 percent is Catholic and another 16 percent is Protestant. The Muslim community is small and consists of 850,000 people, which is about five percent of the population. This implies that about half of the non-western immigrants in the country subscribes to the Islam. There are two large Muslim groups in the Netherlands: people with a Turkish background (around 325,000 people) and people with a Moroccan background (slightly more than 260,000 people).[9] These groups are concentrated in the country's biggest cities (Amsterdam, Rotterdam), and their share is larger in younger cohorts. A fast majority of Turks and Moroccans in The Netherlands subscribe to the Islam. This is not different among young or high educated people.

At the VU University Amsterdam, Ramadan does not cause any changes in schedules. In particular, teaching schedules and exam dates or times are not adjusted to Ramadan. This implies that we consider the effects of Ramadan in a non-Muslim setting. In a Muslim setting, social and professional life are adjusted to the scheduling of Islam's holy days.

3 Data

We have data for five academic years: from 2003/4 to 2007/8. During this period the introductory microeconomics course was always taught by the same teacher (Van der Klaauw) and there was almost no variation in course content (same book, very similar exercises, etc.) and method of instruction.[10]

Table 1 shows for each year the dates at which Ramadan starts and ends, the dates at which the course starts and ends, the exam date, and whether the exam took place in the morning (am) or in the afternoon (pm). Lectures always start in the week of the first Monday in September. The exam, therefore, always takes place towards the end of October. The table shows that during our period of observation Ramadan shifts over the course, with no

[9] The third largest group is much smaller and comes from Suriname (about 33,000 people).

[10] From 2008 onwards the course has been taught by a new teacher leading to changes in the contents of the course, the exam setup and the determination of the grade. It is unclear if year fixed effects (capturing also a teacher fixed effect) can capture all these changes. Furthermore, the university administration only registers final grades, so information on workgroup attendance, exercise grading and exam grading is done by each teacher, not all collecting the same information. For this reason we restrict our analysis to the period 2003/4-2007/8.

Table 1. Timing of Ramadan

Year	Ramadan		Classes		Exam		Overlap	Exam in
	begin	end	begin	end	date	am/pm	weeks	Ramadan
2003	Oct 27	Nov 26	Sept 3	Oct 10	Oct 21	am	0	0
2004	Oct 15	Nov 14	Sept 8	Oct 15	Oct 26	pm	0	1
2005	Oct 2	Nov 1	Sept 7	Oct 14	Oct 28	am	1	1
2006	Sept 23	Oct 22	Sept 6	Oct 13	Oct 27	am	3	0
2007	Sept 13	Oct 12	Sept 5	Oct 12	Oct 26	am	4	0

Ramadan weeks in 2003 and 2004, one week in 2005, three weeks in 2006 and four weeks in 2007. Only in 2004 and 2005 the exam took place within the Ramadan period. The variation is due to the fact that the timing of Ramadan follows the Islamic calendar in which a year is about 11 days shorter than in the commonly used Gregorian calendar. Consequently each year Ramadan starts about 11 days earlier. This is the variation we exploit in our analysis to identify the impact of Ramadan exposure on student performance.

For each academic year in the period 2003-2007, we have access to two sources. The records of the course collected by the teacher form the first source. This gives the names of the students enrolled in the course together with their student-number, participation in workgroups, scores for problem sets, and the exam score. This is the information underlying the final grade. The second source is the university administration. This gives information about students' background characteristics including their birthday, gender and secondary school performance. Since both sources contain students' names and student-numbers, we were able to merge the two datasets. The empirical analyses are based on all students (i) who were registered as economics and business student and (ii) who actively participated in the introductory microeconomics course. The first requirement eliminates students from, for example, the business administration, econometrics or earth and life science programs taking the introductory microeconomics course as elective. The latter requirement implies that a student either attended at least one workgroup, or handed in at least one solution to a problem set, or participated in the exam. The reason for making this sample selection is that without any additional tuition students can register for multiple programs, which some students do. After these selections our data contain 959 students.

Neither dataset contains information regarding students' religion or ethnicity. We, therefore, inferred students' ethnicity from their names. We asked three business administration students from Moroccan, Turkish and Syrian origin to assign Muslim status based on names. Our three coders all have a Muslim background. They independently coded the names of all

Table 2. Number of observations by year

Year	Total	# Muslims	# Non-Muslims	Share Muslim
2003	205	35	170	0.17
2004	164	21	143	0.13
2005	152	14	138	0.09
2006	189	28	161	0.15
2007	249	35	214	0.14

the students in our database. There were only three conflicting codings and in those cases, we assigned the coding of the majority. Table 2 lists the numbers of students registered in the course during each of the years 2003-2007, broken down by assigned Muslim status. Total enrollment in the course varies between 150 and 250 per year, with the share of Muslim students varying around 13 percent. The share of Muslim students at the VU University Amsterdam is relatively large because of its religious roots (in Protestantism) which is apparently more attractive for Muslim students than a university without such roots (the University of Amsterdam has only 1-2% Muslim students).

We do not know whether students with an assigned Muslim status are indeed Muslims, whether they observed the Ramadan, and if so how strictly they complied to the rules. To acquire this type of information we administered a short questionnaire to the students taking the exam, in the last year of our sample period. To have a high response rate and for privacy reasons, the questionnaire was anonymous. This prevents us from checking the correspondence between assigned and actual Muslim status.

Information from the questionnaire is reported in Table 3. Of the 155 respondents, 17 participated in Ramadan. The participation rate of 11 percent is reasonably close to the 14% of the students in that year that were assigned a Muslim status. Differences can be due to (1) some people with assigned Muslim status not being Muslim, (2) some Muslims not participating in Ramadan, and/or (3) a different response rate between Muslims and non-Muslim students. In any case, we interpret the closeness of the participation rate in Ramadan and the share of students with assigned Muslim status as evidence that our procedure to identify Muslims is accurate.

The questionnaire asked whether those respondents who report that they participated in Ramadan complied to all the Ramadan rules. We also asked them to assess whether observing Ramadan made them study more or fewer hours, and whether observing Ramadan made it more difficult or easier for them to concentrate during classes. As Table 3 shows, three quarters of those who participated in Ramadan complied to all the rules, 41 percent studied

Table 3. Descriptives of short survey in 2007

Exam takers	227
Respondents	155
Participated in Ramadan	17
Complied to all Ramadan rules	76%
Studied fewer hours due to Ramadan	41%
Studied more hours due to Ramadan	12%
More difficult to concentrate during classes due to Ramadan	24%
Easier to concentrate during classes due to Ramadan	12%

fewer hours and 24 percent report to have more difficulties to concentrate during classes. In contrast, 12 percent claim that they studied more hours due to Ramadan, and a same percentage claim that they find it easier to concentrate during classes. The non-monotonicity of the perceived impact of Ramadan on study hours and concentration during class is remarkable.

Table 4 shows both for students with assigned Muslim status and for other students the means and standard deviations of our outcome variables by year. The means of the final grade and of the exam grade of Muslim students are always lower than those of non-Muslim students. The difference is, however, increasing between 2005 and 2007. Recall that these are the years in which an increasing period of Ramadan was included in the teaching period. We return to this issue in the next section. Only in 2004 the Muslim students had a higher pass rate than the non-Muslim students and it seems that between 2005 and 2007 the difference in pass rates is increasing. There is no clear pattern in exam taking. Also for the bonus point, Muslim students scored higher in 2004 than the non-Muslim students and the gap in mean bonus point between both groups is increasing between 2005 and 2007. This cannot be explained from changed attendance to the workgroups meetings.

4 Empirical analyses

4.1 Main results

To assess the impact of Ramadan exposure on student outcomes we adopt a difference-in-differences approach. Figure 1 illustrates the method and previews our main finding. The dots indicate (on the left vertical axis) the number of weeks of Ramadan exposure during the course in different years. The squares indicate (on the right vertical axis) for each year the difference in final scores between Muslim students and non-Muslim students. A negative difference indicates that Muslim students perform worse than non-Muslim students. The fig-

Table 4. Summary statistics for the main outcome variables.

	Final grade	Pass rate	Exam taking	Exam grade	Bonus	Attendance
Muslim students						
2003	5.87 (1.62)	0.63	0.89	5.25 (1.39)	0.60	2.31 (1.04)
2004	5.66 (2.30)	0.67	0.95	5.26 (2.11)	0.47	2.40 (1.05)
2005	5.35 (1.88)	0.57	0.93	5.00 (1.64)	0.31	2.23 (1.17)
2006	4.55 (1.54)	0.54	0.89	4.17 (1.43)	0.36	2.43 (0.96)
2007	4.21 (1.83)	0.40	0.80	3.96 (1.68)	0.27	2.19 (1.03)
Non-muslim students						
2003	6.11 (1.99)	0.70	0.91	5.47 (1.75)	0.68	2.47 (0.97)
2004	5.92 (2.12)	0.61	0.93	5.49 (1.94)	0.46	2.35 (1.00)
2005	5.74 (1.72)	0.65	0.86	5.38 (1.59)	0.35	2.38 (0.96)
2006	5.15 (1.70)	0.57	0.89	4.73 (1.52)	0.43	2.33 (1.08)
2007	5.43 (2.15)	0.58	0.89	4.92 (1.92)	0.51	2.38 (0.98)

Note: mean and standard deviation in parentheses.

ure clearly shows that while exposure to Ramadan increases, the gap in final scores between Muslim and non-Muslim students increases. This suggests that the achievement of Muslim students is negatively affected by exposure to Ramadan.

While Figure 1 is suggestive of a negative impact of Ramadan exposure on the academic achievement of Muslim students, we need statistical analyses to establish whether this relationship is significant, and holds up to the inclusion of control variables. To that end we estimate regressions of the following specification:

$$y_{it} = \beta_0 + \beta_1 M_{it} \times R_t + \beta_2 M_{it} + \beta_3 X_{it} + \mu_t + \varepsilon_{it} \tag{1}$$

where y_{it} is the outcome of student i in year t, M_{it} is a dummy which equals one if student i has been assigned Muslim status and zero otherwise. R_t is the number of Ramadan weeks[11] during the course in year t and X_{it} is a vector of individual characteristics. Parameter β_2 captures the difference in outcomes between Muslim students and non-Muslim students in the absence of Ramadan exposure. The year fixed effects μ_t capture the variation in mean outcomes from year to year for non-Muslim students. The main parameter of interest is β_1, which measures how the difference between Muslim students and non-Muslim students is affected by the number of weeks during the course that Muslim students are exposed to Ramadan. Finally, ε_{it} are the error terms.

There is some variation in the mean and the standard deviation of the final scores over the

[11] We actually divided the number of Ramadan days during the course period by 7.

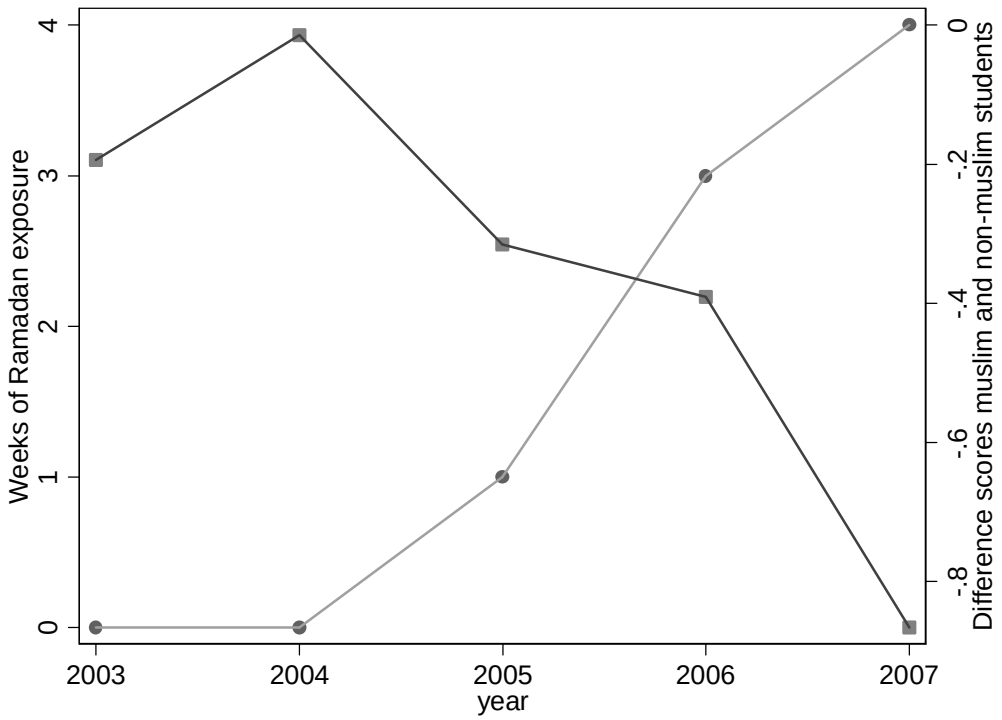

Figure 1. Difference in final scores between Muslim and non-Muslim students (squares, measured on the right vertical axis) and Ramadan exposure (dots, measured on the left vertical axis) by year (horizontal axis)

years. This might, for example, be caused by variations in the difficulty of the exam and the problem sets and the conditions during the exam. We therefore use the outcomes of the non-Muslim students to normalize outcomes of all students within each year. We do this for the final score, the exam grade and the workgroup bonus. This also implies that when estimating equation (1) for these outcomes, we exclude year fixed effects.

Table 5 reports the main results of this paper. For each outcome we report results from a regression without individual characteristics and a regression with gender and math score in secondary school as control variables. Female students obtain better outcomes than their male counterparts and outcomes are positively associated to math score. Although these control variables almost always have significant effects on the outcomes, including these additional control variables does not change the effect of Ramadan exposure on any of the outcomes. This is reassuring as it indicates that the findings without controls are not driven by changes in (observed) composition of Muslim and non-Muslim students.

The first two columns show a statistically significant and substantial impact of Ramadan exposure on Muslim students' final grade. One additional week of Ramadan exposure reduces this grade by almost ten percent of a standard deviation. This substantial reduction in final grades causes pass rates to drop by about three percentage points for an extra week of Ramadan exposure. This latter effect is, however, not statistically significant. Also the effect of Ramadan exposure on exam taking is insignificant. The final grade is the sum of the exam grade and the workgroup bonus. Ramadan exposure has a similar effect on both components of the final grade, i.e. each week of Ramadan exposure reduces both the exam grade and the workgroup bonus by about nine percent of a standard deviation. Recall that to obtain the workgroup bonus students have to hand in solutions to problems sets and they have to attend the workgroup meetings. Columns (11) and (12) show that there is no significant effect of Ramadan exposure on workgroup attendance. Muslim students thus did not skip more classes during Ramadan.

4.2 Sensitivity analyses

In two of the five years that our sample covers, the final exam took place during Ramadan. Moreover, one exam took place in the afternoon, all others in the morning (see Table 1). This variation allows us to analyze whether the timing of the exam with respect to Ramadan matters for the relative performance of Muslim students. Table 6 reports the results. This shows that the scheduling of the exam during Ramadan has no (additional) negative impact

Table 5. Main results

	Final grade		Pass rate		Exam taking		Workgroup bonus		Exam grade		Attendance	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Ramadan	-0.099**	-0.094**	-0.032	-0.026	-0.016	-0.014	-0.092**	-0.091*	-0.088*	-0.083*	-0.010	-0.011
(weeks)	(0.046)	(0.047)	(0.026)	(0.026)	(0.018)	(0.017)	(0.046)	(0.047)	(0.046)	(0.048)	(0.055)	(0.056)
Muslim	-0.111	-0.005	-0.010	0.017	0.012	0.021	-0.077	-0.005	-0.118	-0.012	-0.058	-0.036
	(0.121)	(0.135)	(0.066)	(0.067)	(0.039)	(0.038)	(0.134)	(0.143)	(0.120)	(0.132)	(0.147)	(0.145)
Female		0.188**		0.084**		-0.002		0.319***		0.123*		0.191***
		(0.075)		(0.036)		(0.023)		(0.077)		(0.075)		(0.073)
Math		0.390***		0.110***		0.038***		0.230***		0.389***		0.121***
		(0.035)		(0.016)		(0.011)		(0.037)		(0.035)		(0.037)
N	857	857	959	959	959	959	874	874	857	857	893	893

Note: Robust standard errors in parentheses. Final score, workgroup bonus and exam score are normalized within years using only the non-Muslim students. The regressions for the other outcomes include year dummies. *) significant at the 10 percent level, **) significant at 5 percent level, ***) significant at the 1 percent level.

Table 6. Effect of timing of exam on exam grade

Ramadan weeks	-0.083*	-0.077	-0.072
	(0.048)	(0.051)	(0.052)
Ramadan exam		0.055	-0.011
		(0.219)	(0.284)
Ramadan exam afternoon			0.122
			(0.367)
Muslim	-0.012	-0.038	-0.049
	(0.132)	(0.156)	(0.158)
Female	0.123*	0.122*	0.123*
	(0.075)	(0.075)	(0.075)
Math	0.389***	0.389***	0.390***
	(0.035)	(0.035)	(0.036)

Note: Robust standard errors in parentheses. *) significant at the 10 percent level, **) significant at 5 percent level, ***) significant at the 1 percent level. Number of observations equals 857.

on the relative performance of Muslim students.[12] This is independent from the exam being held in the morning or in the afternoon. An explanation might be that the exam is always held towards the the end of October; during that time sunrise in the Netherlands is around 8:30, meaning that Muslim students can eat breakfast until that time.[13]

The timing of Ramadan is supposed to affect academic performance through the shortage of nutrition during daytime and the resulting reductions in mental activity, concentration and desire to study. There is no reason to assume that this mechanism operates differently for male Muslim students than for female Muslim students. We thus expect that academic achievement of male and female Muslim students is affected similarly by exposure to Ramadan. Table 7 shows separate results for men and women of the impact of Ramadan exposure on final grades. The point estimates of the impact of Ramadan for women and men are very similar, and we cannot reject the null-hypothesis that Ramadan exposure has the same impact on men and women. (Due to the small number of Muslim women, the estimate for women is not very precise, and we can also not reject that there is no effect on women. We can, however, reject that there is no impact on men.)

[12]This is not explained by Muslim exam takers being exempted from the obligation to fast. Browsing the Internet, we found some fora where Muslim students explicitly asked whether exam taking qualifies as a reason to break the fast. In all cases we read, the answer to this question is a definite "no".

[13]More precisely, on the two exam days that coincide with Ramadan, sunrise in the Netherlands was at 8:24 on October 26 2004 and at 8:27 on October 28 2005. In contrast, on September 13 2007 which is the earliest day in the year that Ramadan started in our period of study, sunrise was at 7:10.

Table 7. Effects of Ramadan exposure on final grade by gender

	Female	Male
Ramadan weeks	-0.092	-0.089*
	(0.098)	(0.054)
Muslim	-0.002	-0.019
	(0.242)	(0.162)
Math	0.472***	0.364***
	(0.067)	(0.041)
N	200	657

Note: Robust standard errors in parentheses. *) significant at the 10 percent level, **) significant at 5 percent level, ***) significant at the 1 percent level.

4.3 Compositional differences

The identification of the impact of Ramadan exposure in this paper hinges on the assumption that without Ramadan exposure the difference in outcomes between Muslim students and non-Muslim students in years with Ramadan exposure would have been the same as the actual difference in outcomes between both groups in years in which there was no Ramadan exposure. In other words, the difference in outcomes between Muslim students and non-Muslim students in 2003 and 2004 (years without Ramadan exposure) indicates what the difference in outcomes between the two groups would have been in 2005 to 2007 if there would have been no Ramadan exposure in these years.[14]

This assumption is less likely to hold, if the composition of the student population changes over the years. For instance, the findings of this paper could also be explained if for some reason the incoming Muslim students are – conditional on their observed characteristics – less motivated in years with more weeks of Ramadan exposure. As a check on this, Table 8 reports estimates of the "effect" of Ramadan exposure on several background characteristics on students. None of these estimates is significantly different from zero. While this does not prove that different cohorts have the same composition in terms of unobservable characteristics (such as motivation), this finding is reassuring.

[14] Actually, the approach also assumes that the difference in outcomes between the two groups in 2005 indicates what would have been the difference in outcomes between the groups in the other years if these years would also have had one week of Ramadan exposure, etc.

Table 8. "Effects" of Ramadan weeks on covariates

	Female	Math	First year	Age	Workgroup registration
Ramadan weeks	0.004	-0.105	0.021	0.008	0.002
	(0.023)	(0.137)	(0.022)	(0.104)	(0.015)
Muslim	0.027	-0.393	-0.068	0.196	-0.001
	(0.060)	(0.366)	(0.063)	(0.283)	(0.039)
R^2	0.006	0.014	0.026	0.018	0.005

Note: Robust standard errors in parentheses. Number of observations equals 959.

5 Conclusion

Exploiting that Ramadan shifted in a few years over an introductory course in microeconomics, we estimate the impact of Ramadan exposure on the academic achievement of Muslim students in a non-Muslim context. Our results indicate that academic achievement of Muslim students is harmed by exposure to Ramadan. One additional week of Ramadan exposure reduces the final grade by almost ten percent of a standard deviation, with similar effects for Muslim men and for Muslim women. We do not find any evidence for changes in composition over the years which could potentially explain our results.

In our empirical analyses we assume that all students who were assigned a Muslim status are exposed to Ramadan. Information from our 2007 survey shows that 11 percent of the respondents participated in the Ramadan, while 14 percent of this cohort was assigned to Muslim status.[15] In addition around 25 percent of all Ramadan participants did not comply with all rules. These two deviations imply that our estimates are best interpreted as intention-to-treat effects, which are lower bounds of the actual Ramadan effects. To arrive at the actual Ramadan effect, the intention-to-treat estimates should be scaled up by between $1.25(= 1/0.8)$ and $1.67(= \frac{1}{0.8 \times 0.75})$, where the lower number assumes that non-compliance is ignorable and the larger number assumes that those that do not comply with all the rules should be regarded as non-participants. If the assumption that non-Muslim students are not affected is violated such that they experience negative spillover effects from the reduced activity of Muslim students, the estimates should be scaled up even further.

In this study we only inquired the effects of Ramadan observance on the results for one exam. In the period that students follow the microeconomics course, they also follow other courses and there is no reason to believe that the achievement of Muslim students on these

[15] Assuming that none of the non-Muslims actually observes Ramadan, this implies a first stage effect of almost 0.8.

other courses is not affected by Ramadan. If Ramadan causes Muslim students to fail one or two courses in their first year, this may also affect their study performance in later years (in addition to possible negative effects of Ramadan in those years). Leuven et al. (2010) show that students who due to an exogenous shock lack behind in their first year, are likely to also perform worse in subsequent years.

The most likely explanation for the reduction in academic achievement of Muslim students due to Ramadan exposure is observance of the fast. Previous research documents that observing the Ramadan fast, leads to reduced activity, less desire to study and lower and concentration ability among a majority of the subjects (Afifi, 1997). Also research on the link between nutrition and cognition strongly suggests that nutrient intake is important for the cognitive functioning of schoolchildren (Belot and James, 2009; Benton, 2008; Maluccio et al., 2006; Muthayya et al., 2007; Pollitt et al., 1998; Simeon and Grantham-McGregor, 1989; Taras, 2005; Waterhouse et al., 2008).

Our findings complement previous results in important ways. First, we show that exposure to Ramadan harms the academic outcomes of Muslims in a non-Muslim environment. This gives them a disadvantage which they would probably not experience in a Muslim environment where everyone observes the Ramadan and where teaching and exam schedules are adjusted to the holy days of the Islam. Second, if we assume that our results are mainly attributable to fasting, our findings extend previous results on the link between nutrition and educational outcomes. Our results apply to a different population, educational outcomes are measured on a high-stakes test, and we look at the impact of one month of fasting during daytime, which is much longer than the duration of the typical experiment.

Like other recent studies that report adverse effects of Ramadan (e.g. Almond and Mazumder, 2011; Van Ewijk, 2009), we are cautious to draw policy implications from our findings. While our analysis establishes a negative causal effect of Ramadan exposure on performance on a course taught during Ramadan, our results have nothing to say about the impact of Ramadan observance on people's well-being (e.g. Gruber, 2005).

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