Military Service and Human Capital Accumulation: Evidence from Colonial Punjab

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This version, 20 August 2011 (First version, May 2010)

Abstract

Voluntary military service could provide rare educational opportunities to recruits from disadvantaged groups. However, there is little evidence on the relationship between military recruitment and educational outcomes in developing countries. This paper estimates the impact of military recruitment on human capital accumulation in colonial Punjab. The empirical strategy exploits the exogenous increase in recruitment by the Indian Army during the First World War. Higher military recruitment is found to be associated with increased literacy at the district-religion level. The results indicate that 10 additional WWI recruits per 1,000 of the 1911 male population are on average associated with 3 more literate males per 1,000 in 1931. Further analysis indicates that the observed improvement in the human capital stock was mainly driven by the direct acquisition of literacy skills by illiterate soldiers. Limited evidence is found of inter-generational spill-overs. Finally, a political economy mechanism is not supported in this context: military recruitment was not associated with increased investment in public education.

Keywords: military service, human capital, colonial institutions

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1 Introduction

Voluntary military service in professional armed forces is often thought to offer rare educational opportunities to disadvantaged groups (Khalidi, 2001; Moskos and Butler, 1996). The risk premium on military wages could force the military to hire low-skilled recruits and to provide training on the job, rather than to pay the market wage for skilled labour. The claim that disadvantaged groups benefit disproportionally from military service gains additional policy relevance because the military is one of the largest employers in most countries (WDI, 2006). In the context of the US armed forces, evidence suggests that disadvantaged groups benefit mildly from voluntary service (Angrist, 1998). However, very little evidence is available on how this finding translates to a developing country context. Nevertheless, the returns to military service in professional armies could be higher in developing countries, as the average human capital in their populations tends to be lower.[1] In spite of the central importance of military support and training to the relations between developing countries and the developed world, not much is known about the role that military service could play in economic development.[2]

Research into this topic faces two key challenges.[3] First, the confidentiality of military data restricts subnational work on this topic. Second, selection into voluntary military service is typically non-random, which could bias the estimated returns to military service. This paper addresses these challenges by focusing on the recruitment surge in colonial Punjab during the First World War (WWI). This setting is unique in that recruitment patterns can be reconstructed and exogenous factors determined the extent to which communities were exposed to a demand shock for military labour. The size of this demand shock enables an analysis at the aggregate level: out of a total population of approximately 20 million, more than 362,000 Punjabi men (1.8% of the population) served in the Indian Army during the First World War. Two key questions will be explored. First, did military recruitment during the First World War boost the literacy rate of recruited communities? Second, through which of three possible channels did military service affect literacy: (i) direct skill acquisition by serving soldiers, (ii) increased demand for the education due to higher earnings, or (iii) preferential public spending on primary education?

[1] Benoit (1978) argues that defense expenditures could spur growth in developing countries. Stroup and Heckelman (2001) find a positive relationship between military spending and growth in countries with low levels human capital. Dunne, Smith and Willenbockel (2006) survey the extensive related literature on military expenditures and growth.

[2] Observers indicate that 80 per cent of recruits in the Afghan army are illiterate (BBC News, "Afghanistan and Pakistan face decisive year", http://news.bbc.co.uk/1/hi/8424289.stm, last accessed 4 January 2011). Hence, the scope of large-scale military recruitment to contribute to human capital development seems substantial. The recent 25 January revolution in Egypt also illustrates the importance of military training in shaping the views of soldiers (BBC News, "Egypt unrest: Military at heart of Egyptian state", http://www.bbc.co.uk/news/world-middle-east-12368711, last accessed 11 February 2011).

[3] See also Annan and Blattman (2010).

For information on the recruitment patterns of the Indian Army, this paper relies on the "Debt of Honour Register", which is administered by the Commonwealth War Graves Commission (CWGC). Using individual records of Indian casualties in the Register, information on the place of origin of soldiers who died in WWI can be aggregated at the district level. A name-based algorithm enables a further split-up of war casualty estimates into two religious communities: Hindu-Sikhs and Muslims. These data on military war deaths at the district-religion level are used as a proxy for military recruitment. Historical evidence supports the use of casualty numbers as proxies for recruitment. My main results are derived from a panel of literacy outcomes at the district-religion level in colonial Punjab for the period 1901-31.

The identification strategy used in this paper corresponds to a continuous difference-in-difference approach: I compare male literacy rates in years before and after WWI, between communities with different ratios of military war casualties. This approach relies on the fact that recruitment into the British army was restricted to certain groups from specific geographical areas. Historical sources suggest that the recruitment patterns of the Indian Army during the First World War were mainly based on the recruitment grounds that had been identified by British recruitment officers at the end of the 19th century. This initial selection favoured the recruitment of so-called 'martial races'. It can be assumed that the martial qualities of communities were not linked to their potential for literacy improvements during WWI. An analysis of the baseline characteristics of recruited communities and their literacy trends before the war is consistent with this hypothesis. Therefore, the intensity of the WWI recruitment surge, as proxied by the ratio of military war deaths, is considered as an exogenous treatment in the main analysis. However, this analysis cannot fully address certain endogeneity concerns, including the possibility that the proxying approach leads systematic errors. To address these remaining concerns, I also present IV results for a restricted sample. In this robustness check, I instrument the observed recruitment patterns with an indicator of "recruitment suitability" that is based on the assessments of the fighting potential of Hindu-Sikh communities by British recruitment officers at the end of the 19th century.

The results indicate that an increase in war casualties is associated with a significant increase in the number of male literates. On average, ten additional recruits per thousand of the 1901 male population are associated with an increase in the ratio of male literates by three per thousand in 1931. A further split-up of the baseline results per age group indicates that positive impact on literacy is strongest for the group of men aged over 20. This finding is consistent with the hypothesis that direct skill

acquisition during military service was a key channel through which military recruitment influenced literacy outcomes. Historical evidence confirms that recruits were typically illiterate but often acquired literacy skills on service. These sources also suggest that the observed effect is likely to result from informal learning and skill transfers rather than from formal literacy training. Further analysis confirms that the positive impact of military recruitment is not driven by a supply shock of education or by a political economy channel: heavily recruited districts did not attract more investments in education by the Punjabi District Boards. The latter finding points at constraints on the long-run distributional impact of military recruitment in this context.

This paper adds to previous work on the economic impact of military recruitment.[4] It is one of the first contributions to exploit largely exogenous variation in military recruitment to provide evidence on the relationship between military recruitment and human capital formation in a developing economy. One exception is a recent contribution by Annan and Blattman (2010), who examine the labour market impact of forced child soldiering in Uganda. They conclude that military service is a poor substitute for schooling in this context.[5] However, it is not not clear whether these results would carry through to the volunteer forces of professional armies. One contribution that shares my focus on human capital accumulation in the Indian army, is the recent work of Jha and Wilkinson (2010). Their analysis indicates that the combat experience of Indian World War II veterans helped these ex-soldiers to organise violence against minorities. They find that the average duration of combat assignment at the district level can explain the observed patterns of ethnic cleansing across the subcontinent during the Partition in 1947. This paper complements their study and suggests that the human capital impact of military service could also have more benign aspects: improving the literacy skills of recruits and their families.

The second strand of literature to which this paper contributes is the fast growing body of research on the effects of colonial institutions on economic growth. In their seminal contribution, Acemoglu *et al.* (2001) assert that settler mortality has a persistent impacts on economic growth through institutions. In contrast, Glaeser *et al.* (2004) emphasise that colonisers exported human capital alongside institutions. These authors point out that there is very little evidence on which specific colonial policies promoted institutional development and/or human capital accumulation. Bridging this gap in our

[4] Key contributions on the individual returns to military service include Angrist (1990 and 1998), Angrist and Krueger (1994), Bedard and Deschenes (2006), Imbens and van der Klaauw (2005).

[5] These findings are consistent with earlier survey evidence from the Sierra Leonean civil war (Humphrey and Weinstein, 2007). Costa and Khan (2010) find that US civil war veterans faced higher mortality due to war time stress. See Blattman and Miguel (2010) for a review of the literature on the role of veterans in post-war reconstruction.

understanding of colonial economic history, a large literature has recently emerged on the economic impact of specific colonial institutions in specific regions.[6] Chaudhary (2009; 2010) shares my focus on human capital accumulation in colonial India. She finds that public spending on primary education is positively associated with male literacy and that private investment in education was more limited in districts with high religious diversity. This paper complements these findings by exploring if military service could promote human capital development in this context of severe private and public underinvestment in education. More broadly, it is striking that, in the large literature on colonial institutions, the role of colonial armies has received little attention.[7] Nevertheless, one could argue that no other colonial institution required as much close collaboration and interdependency between local non-elite groups and their colonisers. This paper provides one of the first attempts at assessing the developmental effects of recruitment into the colonial armies.

Finally, this paper relates to the large literature on literacy and education. While public education reaches an ever growing number of students in the developing world, educational attainment remains low.[8] Recent work highlights how non-traditional and informal learning environments could play an important role in improving educational outcomes.[9] In the context of the Indian Army, historical evidence suggests that the military service dramatically boosted the personal returns to acquiring literacy skills. As a mail service was provided to soldiers, being literate facilitated the soldier's correspondence with his family. Moreover, the Indian Army provided literature (including religious books and pedagogical material) to entertain soldiers. Hence, the direct acquisition of literacy skills by Punjabi soldiers could reflect the effectiveness of non-traditional learning environments that offer increased personal returns to literacy in combination with decreased learning costs.

This paper is organised as follows. First, I outline the historical background of military recruitment in colonial Punjab. Second, I discuss the mechanisms through which military recruitment could affect literacy. Third, I introduce the data set I use in this study. Fourth, I present the empirical strategy. Fifth, I interpret the empirical results. Sixth, I discuss the robustness of my findings. Finally, I offer concluding remarks.

[6]Key contributions include Acemoglu, Johnson and Robinson (2001), Banerjee and Iyer (2003), Cassan (2009), Cogneau (2008), Dell (2010), Donaldson (2009), Huillery (2009), Moradi (2008) and Nunn (2008 and 2009).

[7]Moradi (2008, 2009) uses information on recruits in the African colonial armies to assess the impact of colonisation on nutritional status, but he does not assess the developmental impact of military recruitment in itself. Fafchamps and Moradi (2010) find that soldiers entering the British Colonial Army in Ghana based on referrals performed worse than their non-referred colleagues. Echenberg (1975) argues that conscription in French West Africa during the First World War contributed to the subsequent economic stagnation of this region.

[8]UNESCO (2008). See also Glewwe and Kremer (2006), and Duflo, Dupas and Kremer (2009).

[9]For example, Aker, Ksoll and Lybbert (2011) evaluate a programme that teaches adults literacy skills by using mobile phones. Given the low cost of text messages sent by mobile phones, the personal returns of acquiring literacy skills are very large in this programme.

2 Historical background

The identification strategy of this paper relies on the outbreak of WWI in 1914 and uses this event as an exogenous shock that dramatically increased military recruitment. In this brief historical overview, I sketch the context in which military recruitment took place in colonial India.

In the seventeenth century, the Indian Army was conceived by the East India Company as just a small irregular force that would draw recruits from the local population. However, the importance of this so-called "native army" grew steadily and, by 1856, the British Raj relied on the Indian Army for most of its security needs.[10] Throughout the 19th century, the Indian army remained of central importance to the Raj to counter the advances of Russian forces in Afghanistan.

When WWI broke out in 1914, the Government of India had more troops at its disposal than it strictly needed for its internal security. For this reason, the Indian Army entered the war in 1914.[11] As the war developed, the Indian Army kept on providing ever more troops. Raw figures illustrate the enormous scale of the war-time recruitment effort in colonial India: out of a population of approximately 20 million, the number of Punjabi troops increased from 69,458 to 362,027 over the period 1910-19. The underlying recruitment efforts had to rise even more to keep up the size of the army in the face of casualties. During the war, India sent 138,000 men to France, 675,000 men to Mesopotamia and 144,000 men to Egypt. Of these 957,000 recruits, at least 74,260 men died, of whom approximately 19,000 had been recruited in Punjab.[12] The Indian army kept on playing an important role in the Middle East and on the Indian-Afghan border until 1921 (i.e., after Armistice). Therefore, the full demobilisation of WWI recruits was not reached until the mid-twenties.

Historians argue that the First World War was crucial for the industrialisation of India and that large-scale recruitment and the foreign experience of soldiers had contributed to the emerging independence movement (Lawrence, 1997).[13] An assessment of the economic impacts of the first World War is well beyond the scope of this paper. Similarly, this paper is not be able to identify the general equilibrium impact of military recruitment. For instance, the fact that the Indian Army was financed by taxes raised by the Raj would have to be taken into account to make any assessment about the net impact of military recruitment. However, this paper illustrates a specific result of the outbreak of the

[10] The potential dangers of this strong dependence on native troops became apparent when the so-called Sepoy mutiny broke out in 1857. The mutiny was initiated by native soldiers and shook the British interests to their core. The Sepoy mutiny marked a clear shift in the regional composition of the military, which will be discussed in more detail later.

[11] See Mason (1974, p. 410) on the motives of the Indian Government to assist mainland Britain in the war.

[12] Figures drawn from Mazumder (2003, p.18) and the CWGC Debt of Honour Register.

[13] The relationship between large-scale war-time military service and the demand for political and economic reforms is explored by Prezworski (2007), Scheve and Stasavage (2010), and Ticchi and Vindigni (2008).

Great War: the distributional impact of First World War recruitment on human capital development.

3 Mechanisms and conceptual framework

The key focus of this paper is on the impact of military recruitment on literacy rates. There are multiple channels through which military recruitment could affect literacy outcomes at the district-religion level, three of which are discussed here: (i) direct skill acquisition by serving soldiers, (ii) increased demand for the education due to higher earnings, or (iii) preferential public spending on primary education.

First, soldiers could acquire literacy skills on service. While most military cantonments provided some schooling in peace time, extensive schooling cannot have been an important part of the standard training of the large numbers of new recruits who were set to serve abroad in WWI. However, historical accounts highlight the strength of the personal relationships between British officers, Indian sub-officers and the soldiers under their command. They point at the extent to which skills were shared during the many hours that soldiers had "to kill" in their small companies.[14] Such a direct learning channel appears to be referred to by the census report of 1931, as one of the reasons why heavily recruited districts saw an increase in literacy rates (Khan, 1932, p216):

> "[...] Ludhiana and Shahpur, and most of the district with the next highest percentage of increase, namely Rawalpindi, Jhelum, Gujrat and Mianwali, also owe the increase in literacy to the return home of demobilised soldiers, who very often pick up reading and writing in Roman or any other of the vernaculars in the course of their military career."

Similar statements can be found in the reports of the Censor of letters from soldiers serving abroad (Censor of Indian Mail, 1915):

> "Under stress of necessity many Indian soldiers during their stay in Europe have learned to read and write their own languages, and primers and spelling books come in large quantities from India to the army."

The latter quote suggests that the main channel through which soldiers acquired literacy was not formal training, but the boost in the personal returns to becoming literate. Unfortunately, the report does not explicitly identify the factors that contribute to the "stress of necessity" it refers to. In other

[14] In WWI, all Indian soldiers and low-ranking officers were under direct command of British officers, as native soldiers were not deemed capable of fulfilling officer roles.

sections the Censor Reports mention several contributing factors. First, the Indian Army maintained a postal service. Hence, literacy skills could facilitate the communication between soldiers and their families enormously. Interestingly, this channel could operate both within the army and in their home region. Given that this study identifies the impact on aggregate literacy, the results could capture both the impact on serving soldiers and on their families who remained in India. Second, acquiring literacy skills could have been particularly important for soldiers who were heavily wounded in the fighting, as this could allow them to take on relatively well paid jobs that did not require hard physical labour. Third, literacy could have facilitated communication at the battlefield. Finally, and perhaps most importantly, military life outside of the battlefield was often uneventful and the demand for leisure activities of any sort was strong. In response to this demand, the Indian Army published magazines that brought soldiers news from India and from the front line. Similarly, the army provided soldiers with a steady supply of religious literature (Censor of Indian Mail, 1915). In brief, the military could have offered a unique environment, in which the costs of acquiring literacy skills were reduced and the returns were boosted.

A second broad channel through which military recruitment could affect literacy is through an income effect. The inflow of military income could have fuelled a demand shock for education, both in formal schools as informally through learning from relatives or friends. The recruited communities were most likely to be affected by the remittances of soldiers who were on duty and by pensions for ex-soldiers. Mazumder (2003) provides mainly anecdotal evidence on the impact of military incomes on a large number of outcome variables, including clothing, housing, dietary choices and education. Mazumder notes that "[t]he education of children was another investment soldiers willingly made" (2003, p.42). While primary education was free, books, stationary and uniforms would cost about 37 rupees per year on average in rural areas (Darling, 1934, p.173). The income effect could potentially be further boosted by changes in preferences that were induced by military service. The following Jat soldier writing from France is quoted in Mazumder (2003): "What we have to do is educate our children, and if we do not we are fools and our children will be fools also". While demand for education (as a normal good) should increase in response to an inflow of income, the loss of male labour forces in the home communities due to the mobilisation of men for military service can counteract this effect. In the presence of credit and labour market imperfections, the opportunity cost of sending children to school may increase substantially if households have less labour available to work on the land held by the household. Hence, the opportunity cost effect could outweigh the income effect and the impact of

large-scale military recruitment on the demand for education remains theoretically ambiguous.

A third channel through which military recruitment may influence literacy is the supply side of education. It is possible that heavily recruited communities attracted more public spending on education. While public spending on education could be exogenously driven by the preferences of the colonial authorities, it is also possible that the public spending reflects increased demand from certain communities. The remarkable success of the military in securing favours for their personnel, often under an implicit threat of rebellion, is indeed a central element in the political economy literature on the military (Collier, 2007). However, the Government of India faced an important trade-off from a recruitment perspective if it were to invest in educating its recruitment grounds: promoting schooling might raise the reservation wage of future recruits. Therefore, the colonial authorities may have preferred not to invest more in education in their recruitment grounds.[15] The responsibility for investments in primary education lay almost exclusively with the so-called District Boards. Chaudhary (2010) reports that the District Boards accounted for 18% of total spending on education, 85% of total primary education spending and 93% of public spending on education in Punjab in 1912-1913. Chaudhary provides historical evidence that suggests that revenues from land taxes were the main determinant of public spending on education. Given that Punjab was subject to the same land revenue system (in which land taxes were collected directly by the British authorities and laid down in so-called "settlements"), the revenues and total spending on education in Punjabi districts should be driven mainly by the agricultural potential of the district and not by the intensity of recruitment. Also, given the strong relationship between public spending and tax revenues, increasing public spending on education would probably come at the cost of higher taxation. Furthermore, Chaudhary's evidence suggests that upper-caste elites had considerable influence over the allocation of funds (Chaudhary, 2009). Nevertheless, it remains possible that soldiers or the British authorities could influence district boards to invest more in education in the recruitment grounds, both as an indirect remuneration of its soldiers in response to their political pressure and in an attempt to boost the skills of its future recruits.[16]

In sum, there are three main channels through which military recruitment could affect literacy outcomes in their home communities: direct learning and demobilisation, a demand shock for education

[15] Pasha (1998) links military recruitment in Pakistan to underdevelopment on these grounds.

[16] A specific provider of primary education which could be relevant to this study were the army cantonment schools. These would be open to children of soldiers if they chose to have their family stay at the cantonment. Unfortunately, there is little evidence on the number of military families that lived in the cantonments and made use of these facilities. At one particular WWI recruitment rally, free education up to the secondary school level was promised for the children of deceased and disabled soldiers (Mazumder, 2003). Again, there is no direct evidence on how many children made use of this system and whether it was actually implemented at all.

due to higher earnings and preferential spending on education by the district authorities. In an attempt to tease out the mechanism underlying the main result, I rely on two approaches. First, I repeat the main analysis for different age groups. If demobilised soldiers are driving the results, the effects should only hold for men of military age and they should be visible immediately after the war. If, by contrast, the effect is driven by younger age groups, then the demand and supply channels for education are more plausible. A second approach, which allows me to disentangle demand and supply shocks, is an analysis of investment data on education. Assuming that these do reflect the independent decision of the local authorities of how much to fund eduction in a given district, higher investment in recruited districts could reflect a supply shock. If investment does not change noticeably, then a demand-driven change seems more likely.

4 Data

In my main analysis, I use military war casualties as proxies for military recruitment. I collect data on the district of origin from a list of soldiers who died during WWI, the "Debt of Honour Register". This register is administered by the Common Wealth War Graves Commission (CWGC) and has the names of 74,260 Indian military personnel who died in WWI. For virtually all soldiers, the name, the rank, the regiment and the date of death are provided. For 68% of entries, the name of the father and the district of birth have been recorded.[17] This proxy approach necessarily induces some measurement error and this issue will be picked up in detail in section 5.

Based on the information in the register, the names of soldiers are used to assign them to two religious groups: Hindu-Sikh or Muslim.[18] The main results will be presented using this distinction and including all soldiers and low-ranking officers in the register (all higher ranking officers were British).[19]

[17]This information was in principle recorded on all of the individual service records of each soldier, but according to the CWGC there is no reason to expect missing entries to be systematically different. Several hypotheses can be put forward as to why some entries are incomplete. According to CWGC, the missing information is most likely the result of different attitudes of the clerks who recorded the information of new recruits. These differences in the punctuality of individual recruitment clerks are unlikely to produce a systematic bias. The loss of service records and the ease with which they could be accessed by the Indian administrators who prepared the information for the CWGC is another potential cause of missing records. These hypotheses were put forward by Peter Holton, Records Supervisor at the CWGC.

[18]The algorithm relies on the recognition of Muslim names (such as "Khan" and "Abdullah") or Hindu-Sikh Names (such as "Singh" and "Ram") in either the name of the father or the name of the casualty. While there is no theoretical ground not to further distinguish between Hindus and Sikhs, some names (in particular the surname "Singh") are common to both religions. Results not presented in the paper indicate that the main results are robust to a further split-up between Hindus and Sikhs. However, in any such analysis assumptions need to be made about how to assign casualties called "Singh" to either the Hindu or the Sikh community.

[19]The Indian army did not just employ soldiers, but hired personnel in a multitude of roles. Approximately 10% of the Punjab casualties were employed as labourers or as part of the transport corps. These are not included in my estimates, as their roles are not strictly military and their recruitment may not have been driven by the same principles as the

Literacy and population details for each of the three religious groups are collected at the district level in Punjab for the four census years (1901, 1911, 1921 and 1931). Twenty-eight districts provide literacy data for all four census years. Nominal expenditures on education by the District Boards are also collected for each of the four census years and for 1892 (the earliest available figures) at the district level.[20] These data will be important to distinguish the channels through which recruitment could affect literacy outcomes.

Figure 1 maps the number of war deaths recorded in the CWGC register as a proportion of the 1911 population in colonial Punjab. The death rates per district are shown separately for both religious communities (Muslim and Hindu-Sikh). The non-coloured areas correspond to the so-called 'princely states' which were not directly governed by the British. As recruitment policies in these areas differed and are less well documented and the availability of data (e.g. on public education spending or literacy among minority religious groups) is more limited for these areas, the princely states are not included in the main analysis.[21]

recruitment of soldiers.

[20]"Reports on the Progress of Education in the Punjab", annual from 1892-1931.

[21]Relying on the princely states would also give rise to serious comparability concerns, for example because most of them are much smaller in size than British districts and were different in several relevant dimensions. See Iyer (2006) for an in depth discussion. In the appendix (A.2.), I show that the main results are robust to the inclusion of the princely states.

Figure 1: War deaths in colonial Punjab

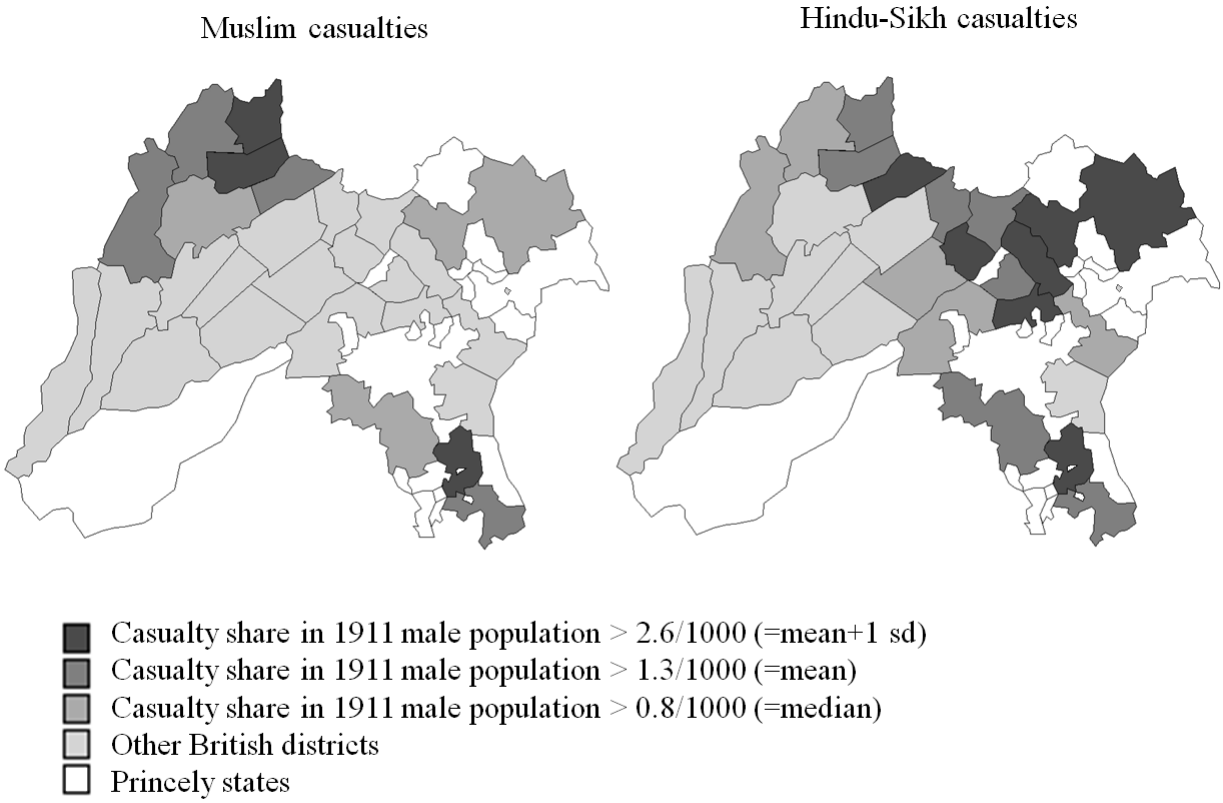


Table 1 presents summary statistics for all the key variables at the district-religion level. The large standard deviations are indicative of the vast differences between the levels of these variables across communities.[22] As my analysis relies on the comparison of communities that were recruited with varying intensity, I provide separate summary statistics for 'heavily' and 'lightly recruited' districts (based on whether ratio of war casualties is above the sample mean). Recruited communities tend to be less literate, but this difference is not significant. In contrast, the increase in the literacy rate (1911-31) is significantly higher for heavily recruited communities. The share of casualties in the 1911 population is one per thousand at the sample mean.[23]

[22]The econometric specification will take the large variation in average literacy between religious communities into account by including fixed effects and religion-year-effects on the one hand and by measuring outcomes in logarithms on the other hand.

[23]I focus on the male population because this group is most directly affected by military recruitment and educational policies. Female literacy in Colonial Punjab was much lower than male literacy and focusing on combined literacy measures would not change the results. Repeating the analysis of this paper for female literacy suggests a *negative* but non-robust impact of military recruitment on female literacy (appendix A.5.). The size of the male population will also

Table 1: Summary statistics (district-religion level)

	Sample	Lightly recruited	Heavily recruited	P-value
Male literacy rate 1911	0.11	0.12	0.10	0.57
	(0.12)	(0.13)	(0.11)	
Male population 1911	187,428	176,058	207,893	0.30
	(111,440)	(114,369)	(105,678)	
Muslim dummy	0.50	0.58	0.35	0.10*
	(0.50)	(0.50)	(0.49)	
Difference in literacy rate	0.019	0.012	0.031	0.05*
(1931-1911)	(0.036)	(0.038)	(0.031)	
Casualty share	0.0013	0.0004	0.0030	0.00***
(in 1911 population)	(0.0015)	(0.0004)	(0.0014)	
Observations	56	36	20	

Notes: District-religion level observations for two religious groups (Muslim or Hindu-Sikh) in 28 districts. Heavily recruited communities have recruitment above the relevant sample average. The table records sample averages and standard deviations (in parentheses). P-values are based on a t-test on the equality of means for Lightly and heavily recruited communities.

In table 2, summary statistics are provided at the district level. As several variables of interest are only available for districts, part of the analysis will be conducted at the district level. It is comforting for the subsequent empirical approach that most of the baseline variables fail to gain significance. One exception is the colony status of districts.[24] These districts and were recipients of extensive irrigation projects and tended to be lightly recruited, which also helps to explain why heavily recruited districts tend to have a larger share of the population that is born in the district of enumeration in 1911. The potentially confounding effect of colony status and migration will be dealt with explicitly in the robustness checks.

While the census data used in this study are very rich in comparison to other contemporary data sets, they still give rise to two measurement concerns. First, the definition of literacy has changed over the years. In the 1901 census, literates were expected to be able to "both read and write any language" (Kaul, 1912, p316). In practice, it was often sufficient for respondents to be able to spell out words from a book or to be able to sign with one's name to be recorded as "literate" (Kaul, 1912). It is suggested in the census report that this would mostly affect people who were able to

be used in all per capita measures in this paper.

[24]These are located band of lightly recruited districts existed in the South-West in figure 1.

Table 2: Summary statistics (district level)

	Sample (1)	Lightly recruited (2)	Heavily recruited (3)	P-value (3)-(2)
Male literacy rate 1911	0.07 (0.04)	0.07 (0.04)	0.07 (0.02)	0.76
Male population	379,601 (125,758)	392,421 (142,958)	356524 (89,001)	0.42
Casualty share	0.0015 (0.0014)	0.0006 (0.0005)	0.003 (0.0011)	0.00***
Primary education spending 1911 (Rs per male)	0.07 (0.04)	0.07 (0.04)	0.07 (0.02)	0.90
Primary education fees 1911 (Rs per male)	0.005 (0.003)	0.005 (0.003)	0.006 (0.002)	0.15
Colony dummy	0.21 (0.42)	0.33 (0.49)	0.00 (0.00)	0.01***
Fraction of males born in district of enumeration	0.87 (0.15)	0.83 (0.18)	0.93 (0.04)	0.05**
Population density (ha/male population)	149 (83.6)	142 (87.2)	161 (79.5)	0.56
Fraction of Muslims (in 1911 male population)	0.56 (0.27)	0.59 (0.24)	0.51 (0.33)	0.50
Fraction of Hindus (in 1911 male population)	0.32 (0.27)	0.30 (0.20)	0.37 (0.34)	0.52
Fraction of Sikhs (in 1911 male population)	0.10 (0.10)	0.09 (0.08)	0.11 (0.14)	0.79
Observations	28	18	10	

Notes: District level observations in 28 districts. Heavily recruited districts have recruitment above the sample average. The table records sample averages and standard deviations (in parentheses). P-values are based on a t-test on the equality of means for Lightly and heavily recruited districts.

read religious texts. From 1911 onwards, the definition became more strict: "[a] person should not be entered as literate unless he can write a letter to a friend and read the answer to it". While this change in definition makes the literacy numbers not directly comparable, the inclusion of year-effects in my econometric specification can account for the effect of this administrative change that was common to all units of observation. While differences in enumerator practices are unlikely to produce systematic measurement error, I choose not to include 1901 in the sample for the main results. However, I use the 1901 data to estimate pre-treatment effects.[25] A second measurement concern relates to boundary changes. Several districts were subject to boundary changes over the census years. While it would be possible to merge and drop districts, this limits the number of observations severely. Moreover, the areas affected by boundary changes were less densely populated, so I expect the impact on literacy to be limited. It is not clear how this measurement error could bias the estimates upwards, but they can clearly raise the standard errors on the estimated coefficients.[26]

5 Empirical strategy

5.1 Main specification

To account explicitly for the possibility that the recruited communities enjoyed different levels of literacy, the main identification strategy is based on the comparison of literacy rates in years before and after the war, for heavily and lightly recruited communities. This approach could be interpreted as a continuous difference-in-difference analysis. The corresponding econometric specification is:

$$Log(literacy_{r,d,t}) = \sum_{\tau=1921,31} \beta_\tau * (casualties_{r,d,1911}) * I(t=\tau) + \varphi_{r,t} + \theta_{r,d} + \varepsilon_{r,d,t} \quad (1)$$

$Log(literacy_{r,d,t})$ is the logarithm of the male literacy rate of religion r in district d in year t (1911, 1921, 1931).[27] β_{1921} and β_{1931} are the key parameters of interest. They measure the impact of the intensity of military recruitment, as proxied by the casualty share, on subsequent literacy rates. $\vartheta_{(r,d)}$ and $\varphi_{(r,t)}$are respectively district-religion and religion-year fixed effects. This specification accounts

[25] Chaudhary (2010) does not include 1901 in her sample on the grounds that the 1901 data on literacy would suffer from substantial variation across provinces in the methods adopted. Given that I am focusing on just one province (i.e. Punjab), I expect the 1901 data to be relatively comparable in the cross-section and the impacts of the change in definition to have proportional effects that do not systematically bias my results.

[26] Results using merged districts or a set of districts with stable borders are quantitatively very similar (see appendix, A.1.)

[27] As recruitment practices were set out at the district-religion level, this is also the most natural unit of observation in this context. In the main tables, I use standard errors adjusted for clusters at the district-religion level, but using district level clusters instead does not affect the significance of most results.

for omitted variables at the district-religion level that do not change over time and time-varying determinants of literacy that are specific to one of the religious groups.

In $Log(literacy_{r,d,t})$, the use of the literacy rate on raises the concern that effects could be driven by both the denominator (the total male population) instead of the numerator (the total number of literates). To account for this possibility, the main specification is repeated with the logarithm of the size of the male population as a dependent variable. Furthermore, the logarithmic specification is used to make estimates less dependent on observations with high literacy rates. This specification seems appropriate given the large differences in the level of the dependent variable in various districts (which is reflected in the large standard deviations on the literacy rate in table 1). This specification also ensures the proportionality of all estimated effects. Also, on theoretical grounds, one can expect the process that is driving the creation of more literates to be multiplicative to the existing stock of literates.[28]

The impact of military recruitment is captured by the coefficients β_τ on the number of war deaths as a proportion of the 1911 male population for a religious group $casualties_{r,d,1911}$. The estimation of two separate coefficients allows me to interpret the timing of the effect. Given that full demobilisation was only reached in the mid-twenties, one could expect β_{1931} to be higher than β_{1921}.

The religion-time fixed effects $\theta_{r,t}$ account for factors determining literacy of all communities of the same religion in the whole of Punjab. The inclusion of religion-year effects (rather than just year-effects) can be justified because Muslim communities were characterised by larger proportional increases in literacy rates than Hindu-Sikh communities during the period under study. The distinctive literacy characteristics of different religious groups are well documented.[29]

The fixed effects $\theta_{r,d}$ account for unobservable determinants of literacy that remain constant over time at the district-religion level. The inclusion of district-religion fixed effects may alleviate concerns that recruitment grounds were selected or that recruits could choose to join the army on the basis of unobserved determinants of literacy.[30]

In the results section, variations on the main specification will be presented to address specific endogeneity concerns or to tease out the relevant channel.

[28] The findings are robust to alternative functional specifications of the dependent variable, including the use of literacy rates as level, a log-odds specification (which ensures full support of the dependent variable) and the logarithm of the number of literates.

[29] The 1921 and 1931 census reports discuss the causes of these different patterns in detail (Marten, 1921 and Khan, 1932).

[30] All results reported here have fixed effects because this seems the most conservative specification.

5.2 Endogeneity

For the above main specification to yield causal estimates of the treatment effects, I rely on three assumptions:

1. The recruitment patterns of the Indian army did not change substantially over the course of the First World War and reflected the demand side constraints imposed by the British recruiters.

2. The selection of recruitment grounds was unrelated to the potential for literacy improvements between 1921 and 1931.

3. The measurement error induced by using war casualties as a proxy for recruitment is non-systematic and small.

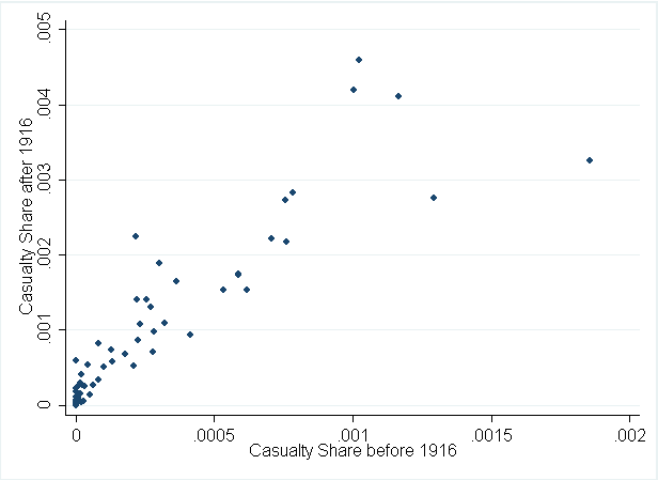
Regarding the first assumption, the historical context provides evidence of the persistence of recruitment patterns. The recruitment policies in place during the First World War had been established in the second half of the 19th century, when recruitment shifted towards the so-called 'martial races'. The 1857 Sepoy mutiny had justified a shift in the recruitment patterns away from high-caste Hindus from present-day UP, who had constituted the core of the pre-mutiny army. The supposedly superior fighting skills of the martial races, who were predominantly living in North-West India, were deemed to be crucial for the Indian Army to withstand a Russian invasion of India.[31] Recruitment handbooks, commissioned by the Quartermaster-General, provided religion-specific assessments of the 'martialness' of the population at the district or even village level.[32] The recruitment policy also shaped the organisational structure of the Indian army, in which most battalions were composed of men of the same caste, religion and region. Recruitment policies from the late 19th century onwards helped to entrench the composition of the army, because the army mainly relied on serving soldiers to identify "good recruits" in their home villages. The result of this policy was that recruitment patterns did not change substantially during the First World War. Hence, the main effect of increased military recruitment during the world war was a demand shock for military labour in those groups that had already been identified as good military recruitment grounds.[33]

[31] According to Mazumder (2005, p 16-17), the rationale behind the martial races theory included: (1) a further justification to stop recruiting from disloyal groups implicated in the 1857 mutiny; (2) the increased need for troops that could engage in guerrilla war fare, for which men living the North West were supposed to be the best pick; (3) Quartermaster-General Frederick Robert's personal prejudice, as he had himself only served in the North of India; and (4) the fashionable trend in European anthropology to explore and exploit the intrinsic qualities of different races.

[32] Falcon (1892) and Bingley (1897a, 1897b, 1899).

[33] 'The bulk of the army was drawn from those classes which had traditionally been recruited' (Cohen, 1971, p.69) Even though the recruitment grounds could not be met entirely by these so-called traditional classes, the Indian Army kept on restricting recruitment rigidly: 'Of the seventy-five new classes which the army recruited, many were either closely related to classes already on the army list [...] and many were formerly recruited classes[...]' (Ibid., p.73).

Figure 2: Time Pattern of Casualty Shares at the District-Religion Level



Notes: Observations are at the district-religion level, for 56 districts and 2 religious groups (Hindu-Sikh and Muslim). Casualty shares are relative to the 1911 population.

In support of this hypothesis of entrenched recruitment patterns, figure 2 plots war deaths before and after 1916 for each district-religion.[34] I expect casualty numbers in the beginning of the war to reflect the pre-existing recruitment patterns. In contrast, the casualty numbers in a later stage of the war could reveal shifts in the recruitment pattern during the war. The linear pattern in figure 2 strongly supports the hypothesis that recruitment patterns at the district-religion level remained stable over the course of the war.[35]

The second assumption paraphrases the common trend assumption. There is no historical evidence that the British targeted communities that had a higher potential for literacy improvements over the period 1911-31. Praising the fighting skills of Jat Sikhs, Falcon writes (1892, p.107):

> "Hardy, brave and of intelligence too slow to understand when he is beaten, obedient to discipline, devotedly attached to his officers [...], he is unsurpassed as a soldier in the East [. . .]"

It is interesting to note that the criteria were not just limited to caste or religion, but also took into account the regional characteristics of potential recruits:

> "The cultivation of sugar cane to any great extent seems to me to give a softer character to the cultivator" (Falcon, 1892, p.83)

[34]War deaths before 1916 account for approximately 22% of all recorded military casualties who originated from Punjab.

[35]The correlation between the casualty shares is 0.89.

"The Sikhs of this area are of a softer type - their Sikhism is very diluted by Hinduism"
(Falcon, 1892, p.84)

These recruitment handbooks suggest that recruitment officers relied on a multitude of selection criteria that have no obvious connection with the potential for literacy improvement. Besides, the selection of recruitment grounds took place well before the First World War. Therefore, the historical evidence seems to justify the interpretation of the observed recruitment surge as an exogenous shock. For this reason, I rely on a standard (continuous) difference-in-difference specification to derive my results. However, it remains possible that a few selection criteria (such as sugar cane production) are correlated with determinants of human capital formation in the period of this study. My analysis deals with these concerns in two ways. First, tables 1 and 2 fail to find significant differences between heavily and lightly recruited communities/districts for most relevant variables. As a robustness check on the main results, time-effects of these baseline controls are included to account for the possibility that military recruitment is merely picking up the effect of another variable. Second, direct evidence of the validity of the common trend assumption is provided by the estimation of a 'pre-treatment' effect that relies on observations between 1901 and 1911.

The third identifying assumption is that the error resulting from my proxy approach is orthogonal to the regressors. As a first check of the validity of the proxy, the casualty data can be compared to independent sources of information. Of the six districts of which the 1931 Census Report suggests that demobilised soldiers may be boosting literacy rates,[36] five have a proportion of military war deaths in the 1911 population that is above the median and the mean at the district level. The assumption that casualties are proportional to recruitment can also be examined explicitly at the Province level. Out of 50,935 casualties for which the records provide information on the father and place of birth, 19,073 casualties could be matched to Punjabi districts. Under the assumption that all remaining casualties originated from other Provinces, the implied percentage of Punjabi soldiers in the Indian Army was 37%. This percentage should slightly underestimate the actual percentage of Punjabi recruits, as it assigns imprecise Punjabi records that did not allow for matching to the other Provinces. Independent sources put the actual percentage of Punjabi soldiers in the Indian Army between 39% and 44% during the First World War.[37] Therefore, the casualties at the state level appear to be largely proportional to the underlying number of recruits.[38] The proportionality of war casualties could have been a direct

[36] Ludhiana, Rawalpindi, Jhelum, Gujrat and Mianwali are in my sample.
[37] Figures drawn from Mazumder (2003, p.18) and the CWGC Debt of Honour Register.
[38] Jha and Wilkinson (2010) can compare recruitment estimates from the CWGC casualty records to actual recruitment numbers for certain provinces, including Punjab, during the Second World War. They find that casualty data are "broadly

result of strategic considerations. Historical evidence indicates that the Indian Army deliberately sent representative units on its foreign missions.[39] Based on its experience from the Sepoy mutiny, the Indian army made regiments sufficiently heterogeneous to limit the risk of mutiny. Hence, regiments would typically recruit from different districts (and sometimes even religions). In support of the idea that the Indian Government sent "representative" units on its foreign missions, I find that the regiments for which I observe Punjabi casualties recruited on average from at least 10 different Punjabi districts. A final concern regarding the proxy approach is that literate soldiers faced different probabilities of death. However, Indian soldiers could not typically rise to the rank of officer during WWI (Mazumder, 2003). Therefore, literate soldiers should not have faced dramatically different hazards in battle than illiterate soldiers.[40] For all these reasons, I rely on a proxy approach in the main results. However, in recognition of the remaining concerns related to measurement error, I also present IV results that should not suffer from bias due to measurement error. The IV approach takes the early assessments of British officers seriously and uses these as an instrument for the observed WWI casualty share. If the first two identifying assumptions hold, the IV estimates will be unbiased. The IV estimates should also remain unaffected by temporary economic conditions that could affect recruitment during the World War.[41]

6 Results

6.1 Main specification

The results from the baseline specification can be found in table 3. Column (1) shows that an increase in the casualty share by one per thousand of the male population is associated with an increase in the literacy rate by 4.6 per cent (proportional). This implies that for 10 additional recruits per thousand of the male population, the literacy rate increases by 2.4 per cent in 1931.[42] Evaluated at the sample

reflective" of recruitment patterns.Areas with an intermediate recruitment intensity were underrepresented in these casualty numbers. Unfortunately, I cannot assess to which extent this conclusion carries through to WWI. Nevertheless, the results presented in this paper are robust to a variety of alternative specifications (including an analysis based on recruitment quantiles rather than a continuous measure).

[39] This argument is put forward by Jha and Wilkinson (2011).

[40] See appendix A.3 for robustness checks based on rank.

[41] One final caveat to this identification strategy is that the selection of recruits within districts (or religious communities in a given district) is not random. At the level of individuals, recruitment was targeted at young and healthy men of particular castes. Similarly, within the groups who qualified for recruitment, the poorest individuals were most likely to enlist. While this within-group selection is relevant for the interpretation of the treatment effect, it does not invalidate the identification strategy, which relies on the comparison between groups.

[42] I assume an equal probability of dying and compare the aggregate recruitment of Punjabi men for overseas service (app. 360,000) by the number of Punjabi war deaths (app. 19,000) to obtain an estimate of the number of recruited soldiers corresponding to one war death (18.94).

mean, this corresponds to an increase of three additional literate males per thousand of the male population. The left-hand-side columns confirm that military recruitment did not have an impact on the size of the population, which addresses the concern that the observed effects on literacy rate are driven by changes in the denominator. In particular, war casualties should not have a large direct impact on the aggregate population size, as that the casualty rate remained relatively low (on average, 1 out of 18 recruited soldiers were recorded as a war casualty in the Debt of Honour Register).

Table 3: Baseline specification

	Log(male literacy rate)			Log(male population)		
	All ages	Over 20	Under 20	All ages	Over 20	Under 20
	(1)	(2)	(3)	(4)	(5)	(6)
Casualty share*1921	33.1**	40.4**	5.78	12.9	13.2	13.5
	(16.1)	(15.3)	(21.3)	(16.9)	(17.3)	(16.5)
Casualty share*1931	46.5*	49.6**	30.2	10.1	10.5	9.37
	(23.9)	(20.4)	(33.0)	(19.2)	(18.7)	(19.6)
Observations	168	168	168	168	168	168

Notes: District-religion level observations for two religious groups (Muslim or Hindu-Sikh) in 28 districts, for three census years (1911-31). All regressions include district-religion fixed effects and religion-year effects. Standard errors are clustered at the district-religion level. *** p<0.01, ** p<0.05, * p<0.1.

Table 3 also provides the first piece of evidence on the mechanism. In columns (2) and (3), the baseline regression is run for two age groups separately: over-20-year-old males and under-20-year-old males.[43] While military war deaths are not associated with significant literacy improvements for the under-20-year-olds (column 3), the over-20-year-olds in recruited communities improved their literacy significantly relative to other communities (column 2). The fact that over-20-year-olds are driving the main results supports the hypothesis that direct skill acquisition is a key mechanism through which military recruitment improved literacy. If the improvements in literacy are driven by the return of demobilised soldiers to their home communities, then we should only expect literacy to improve for men above military age and for the impact to be visible immediately after the war (in 1921). If over-20-year olds would see their literacy improve in response to higher earnings, one would expect to see

[43]One important caveat on the analysis of these numbers for different age groups is that a large proportion of respondents would typically not know their age. This may have resulted in ad hoc assessments by the enumerators, but if numeracy and literacy go together, one can expect his problem to be less severe for studying literates. Besides, the resulting measurement error is likely to be classical (Chaudhary, 2010). My focus on the number of literates instead of literacy rates can further increase the confidence in this particular age group analysis.

Table 4: Pre-treatment Effect

	Log(male literacy rate)			Log(male population)		
	All ages	Over 20	Under 20	All ages	Over 20	Under 20
	(1)	(2)	(3)	(4)	(5)	(6)
Casualty share*1911	2.47	9.65	-12.6	-36.8***	-34.1**	-41.2***
	(11)	(11.3)	(21.9)	(12.9)	(12.9)	(13.5)
Casualty share*1921	32.3*	46.6***	-8.98	-20.7	-18.5	-23.6
	(17.1)	(15.4)	(28.4)	(26.4)	(25.7)	(27.4)
Casualty share*1931	40.6	51.8**	6.91	-23.2	-20.7	-27.7
	(26.3)	(21.7)	(40.4)	(29.6)	(28.4	(31.1)
Observations	204	204	204	204	204	204

Notes: District-religion level observations for two religious groups (Muslim or Hindu-Sikh) in 26 districts, for four census years (1901-31). All regressions include district-religion fixed effects and religion-year effects. Standard errors are clustered at the district-religion level. *** p<0.01, ** p<0.05, * p<0.1.

a similar (if not a stronger) effect on under-20-year olds, as they have the lowest opportunity cost of acquiring literacy skills through education. The further increase in the literacy rate literates from 1921 to 1931 is consistent with the fact that complete demobilisation was only reached after 1921.

The estimated returns to military service are large in economic terms. Chaudhary (2009, 2010) highlights the limited effectiveness and efficiency of the public education system in terms of improving adult literacy. In this context, it is striking that military service was able to improve adult literacy. In fact, military service appears to have been more efficient in terms of producing literate adults than the public schooling system.

In table 4, the sample is restricted to allow for the estimation of a 'pre-treatment effect' by including the first census years.[44] While the use of the 1901 census data gives rise to additional measurement concerns, the results are in line of earlier findings. Most importantly, the pre-treatment effect on the male literacy rate is estimated to be insignificant and close to zero, which addresses the concern that the casualty share could be picking up an existing trend. The estimates in columns (4)-(6) show that higher war deaths are associated with a significant decline in the male population relative to other districts. This effect is due to the fact that none of the districts with canal colonies were heavily recruited (as shown in table 2), while these canal colonies attracted large numbers of immigrants over

[44]Rawalpindi and Attock are dropped because of large boundary changes.

the period 1901-11. This effect disappears as soon as year-effects for the canal status of a district are included in the regression, while the results on the literacy rate remain very similar.[45]

6.2 Public spending on education

To rule out the possibility that investments in education by the District Boards are driving my results, this section analyses the extent to which education expenditures can explain the observed literacy patterns. Three outcome variables are considered: total primary school expenditures, primary school fees paid by parents and the net expenditures on primary education. The total amount of fees collected by a school could in theory provide information on the demand for public education. Given that primary public education was in principle free, these fees correspond mainly to expenses for school uniforms, books, materials etc. Unfortunately, it is unclear if fees were set according to the same criteria in different districts. Nevertheless, the total amount of primary school fees paid in a district may still be indicative of the demand for public education. More insightful than total fees are the total expenditures on education. If recruited districts were successful in attracting more educational investment by the local authorities after the war, one would expect a positive effect on these expenditures and on top of any effects on fees paid.

As school expenditure data are only available at the district level, the variables of interest have to be aggregated at the district level instead of at the district-religion level. Before I turn to the analysis of expenditure data, I check if the baseline results found earlier at the religious-community level still hold at the district level. The results of this exercise are qualitatively similar to those obtained earlier (table 5).

Table 6 relies on the main specification (now estimated at the district level) to examine the association between military war deaths and primary education expenditures.[46] Column (1) of table 6 uses total spending on primary education at the district level as the dependent variable. This column shows that the evolution of spending on primary education bears little relationship to the proportion of military war deaths to the 1911 population. If anything, heavily recruited districts spent less on primary schooling after the war. This finding goes against the hypothesis that the colonial authorities

[45] Results with inclusion of these controls are reported at the district level in table 10.

[46] Chaudhary (2009 and 2010) argues that literacy in colonial India mainly depended on the availability of primary schools, which justifies the focus on this category of spending. The results are robust to the use of total (net) education spending by the District Boards instead of primary education spending. A difference-in-difference analysis of student enrolment between 1914 and 1921 also shows a negative but non-significant impact of military recruitment on the number of students in vernacular primary schools (both in public and private education). Unfortunately, I have not been able to locate student enrollment data for years after 1922. The main results are robust to the inclusion of year effects for 1914 student enrolment (results not reported).

Table 5: District level analysis

	Log(male literacy rate)			Log(male population)		
	All ages	Over 20	Under 20	All ages	Over 20	Under 20
	(1)	(2)	(3)	(4)	(5)	(6)
Casualty share*1921	46.3**	52.7***	23.7	3.68	2.76	5.62
	(16.7)	(16.2)	(19.1)	(23.8)	(24.5)	(23.4)
Casualty share*1931	47.9*	48.2**	42.5	1.3	-2.14	5.52
	(23.8)	(23.4)	(29.8)	(25)	(24)	(26.1)
Observations	84	84	84	84	84	84

Notes: Observations are at the district level for three census years (1911-31). All regressions include district fixed effects and year effects. Standard errors are clustered at the district level. *** p<0.01, ** p<0.05, * p<0.1.

Table 6: Expenditures on education

	Primary education		
	Log(expenditures)	Log(fees)	Log(net expenditures)
	(1)	(2)	(3)
Casualty share*1921	-49.7*	-98.2	-43.9
	(26.5)	(108)	(28.6)
Casualty share*1931	(40.6)	12	-40.6
	(51.1)	(183)	(54.4)
year=1921	1.13***	0.26	1.17***
	(0.066)	(0.28)	(0.071)
year=1931	1.47***	-1.23***	1.55***
	(0.065)	(0.38)	(0.07)
Observations	84	84	83

Notes: Observations are at the district level for three census years (1911-31). All regressions include district fixed effects. Standard errors are clustered at the district level. *** p<0.01, ** p<0.05, * p<0.1.

Table 7: Controlling for education at the district level

	Log(male literacy rate)					
	All ages		Over 20		Under 20	
	(1)	(2)	(3)	(4)	(5)	(6)
Casualty share*1921	47.4***	47.8***	50.8***	54.3***	32.9*	26.2
	(16.9)	(16.4)	(17.0)	(15.9)	(16.7)	(18.5)
Casualty share*1931	48.9*	49.3**	46.7*	48.2**	50.1*	49.4*
	(24.2)	(23.8)	(23.2)	(23.4)	(29.2)	(28.0)
Log(Primary expenditures)	0.023		-0.037		0.19*	
	(0.067)		(0.064)		(0.097)	
Primary expenditures in 1911 - year effects		Yes		Yes		Yes
Observations	84	84	84	84	84	84

Notes: Observations are at the district level for three census years (1911-31). All regressions include district fixed effects and year effects. Standard errors are clustered at the district level. *** p<0.01, ** p<0.05, * p<0.1.

targeted education spending to heavily recruited districts. As suggested when I introduced the conceptual framework, the Government of India may have feared that too much educational investment in the recruitment zones could undermine the recruitment potential of these regions by improving the outside options of prospective soldiers. Column (2) of table 6 shows that military recruitment is associated with a decrease in the fees component of education spending. This could be interpreted as weak evidence in favour of the hypothesis that military recruitment increased the opportunity cost of sending children to school and resulted in drop-outs in some communities. The results on net expenditures on primary education (column 3) remain close to those obtained in column (1), which reflects the fact that fees only accounted for a small fraction of total spending on primary education. The positive relationship between education spending and literacy in column (5) is consistent with Chaudhary's evidence (2010). In conclusion, the results on public expenditures on education indicate that education expenditures are unlikely to drive the observed improvements in the human capital stock of recruited communities relative to lightly recruited communities.

The hypothesis that public investment in education is not driving earlier findings is further confirmed in table 7 (at the district level). In the odd columns, contemporary spending on primary education is included as a control in the main regression. This specification checks if the observed

effects of war deaths can be explained by expenditures on public primary education. The odd columns allow for initial investment in education (in 1911) to have a year-specific effect on literacy outcomes. This specification addresses the concern that recruited districts had already attracted preferential investments in education before the war. The interaction between initial spending on education and year dummies allows for a delayed impact of initial investments on literacy rates. Again, the findings from this specification are in line with earlier results.

In conclusion, the results presented in this section seem mostly consistent with direct skill acquisition by serving soldiers. There is no evidence that recruited districts were directly targeted by investments in education. Nor is there evidence of stronger private spending on education in public schools, as measured by primary school fees, in the recruited districts. The fact that military recruitment did not lead to strong inter-generational spill-overs (as shown in the previous subsection) or to higher public spending on education may have limited the long-run distributional impact of military recruitment in Punjab.

7 Robustness

In this section I discuss the robustness of the results presented earlier in more detail. First, I return to the identification of the main result and present an alternative IV approach. Second, I go over confounding policies and alternative explanations for the results presented earlier.

7.1 An IV approach

The historical evidence presented in section 5 and the insignificance of pre-treatment effects justified an identification strategy based on raw proxies for military recruitment. As a further robustness check, I present an instrumental variable (IV) approach based on the classification of districts in terms of their recruitment potential by British recruitment officers. My key source of information for this exercise is a set of publications by Captain A. H. Bingley, who wrote detailed handbooks for the recruitment of Sikhs, Dogras and Brahmins (Bingley, 1897a, 1897b, 1899).[47] Based on the qualification of districts in these publications, I construct an indicator variable to measure "recruitment suitability". For recruitment suitability to be a valid instrument, it needs to be correlated with the proxy for military recruitment and it cannot influence the observed literacy pattern through any other channel than through military recruitment (as proxied by war deaths). Given that the recruitment officers were

[47] Both Dogras and Brahmins are Hindu castes.

led in the first place by a wish to identify the best fighting races, regardless of their average willingness to enlist, one could expect the classifications made by these officers to have no relationship with the determinants of literacy in these Hindu-Sikh communities. Moreover, the assessments of recruitment suitability were made well before the start of the First World War.

As the information provided by Bingley differs for each publication, the construction of an indicator variable requires certain choices. For Sikhs, Bingley provides a ranking of tahsils (sub-districts) based on their suitability for military recruitment (ranging from "very good" to "very bad"). I choose to record a district as a suitable recruitment ground ($z = 1$) if at least one tahsil is supposed to provide "good" Sikh recruits. For Dogras and Brahmin recruits, information is only available on which districts/tahsils make good recruitment grounds (without further distinction). I code a district as a "suitable recruitment ground" if one of its tahsils (or the entire district) was considered a good recruitment ground. Since Bingley's detailed assessments are only available for Hindu-Sikhs, I have to limit the IV analysis to this religious group.

Table 8: IV approach

	Log(Male Literacy)		Casualty share
	OLS	IV	First Stage
	(1)	(2)	(3)
Casualty share*1921	60.0**	97.5***	
	(24.5)	(30.5)	
Casualty share*1931	78.2**	118.4***	
	(34.8)	(39.7)	
Hindu Indicator			0.0017***
			(0.0003)
Hindu Indicator			-0.0028*
* Sikh Fraction			(0.0016)
Sikh Indicator			-0.0003
			(0.0004)
Sikh Indicator			0.0065***
* Sikh Fraction			(0.0021)
F-statistic			11.94
Observations	84	84	28

Notes: Observations include Hindu-Sikh communities in 28 districts and three census years (1911,21,31). All regressions include district fixed effects and year effects. Year interactions of the 1911 Sikh fraction are controlled for columns (1) and (2). Column (3) includes the 1911 Sikh fraction in levels. Interaction terms include the demeaned fraction of Sikhs (as in equation 3). Standard errors are robust in (3), and clustered at the district level in (1) and (2). *** p<0.01, ** p<0.05, * p<0.1.

The instrumental variables include the "recruitment suitability" indicators for Hindus ($h_{r,d}$) and for Sikhs ($s_{r,d}$). The relationship between "recruitment suitability" and observed casualties could also depend on the relative size of each religious group. To account for this possibility, I include interactions of the suitability indicators with the (demeaned) fraction of Sikhs in the 1911 Hindu-Sikh population ($f_{d,11}$). The resulting first stage regression is given by:

$$Casualties_{d,11} = \lambda_0 + \lambda_1 f_{d,11} + \lambda_2 h_d + \lambda_3 h_d * (f_{d,11} - \overline{f}_{11}) + \lambda_4 s_{r,d} + \lambda_5 s_{r,d} * (f_{d,11} - \overline{f}_{11}) + \varepsilon_{d,11} \quad (2)$$

In this equation, the r subscript is dropped as I can only include Hindu-Sikhs. The construction of

the instrumental variables implies that the first stage equation has to include year effects of the 1911 Sikh fraction:

$$Log(literacy_{d,t}) = \sum_{\tau=21,31} \left\{ \beta_\tau \widehat{casualties}_{d,11} + \gamma_\tau f_{d,11} \right\} * I(t=\tau) + \varphi_t + \theta_d + \varepsilon_{d,t} \quad (3)$$

Table 8 presents the results of the IV approach. The first stage in column (3) confirms the relevance of the instrument. The interactions with the relative size of the religious group are significant and have the expected sign. In the IV results, the coefficient on the casualty share retains its significance and its magnitude is higher than in the OLS results.[48] These findings suggest that if the OLS estimate is biased, the bias could be downwards rather than upwards. Of course, the instrumentation approach is only valid if the initial selection of recruitment grounds is exogenous. Hence, this robustness check mainly addresses the endogeneity concerns that relate to the proxy approach and endogeneous selection into the army during the First World War. However, it is comforting that the IV results are consistent with attenuation bias being the main endogeneity concern.[49]

7.2 Further robustness checks

In this subsection, I go over certain alternative explanations of the observed effects that are suggested by the historical literature. In response to these challenges, this section also presents two alternative specifications of the main regressions which help to counter these arguments.

7.2.1 District level controls

One way to check more broadly if any policy that affected districts rather than religious communities can explain the observed pattern in literacy rates, is to include district-year effects in the main regression. These effects fully absorb the impact of all district-level variables that affected both communities to the same extent. The availability of transport and trade infrastructure could be one example of an omitted variable that mainly operates at the district level.[50] Of course, a key concern of this approach

[48] Based on an overidentification test, I cannot reject the hypothesis that the instruments are exogenous (the p-value on the Hansen J statistic is 0.47).

[49] The higher IV estimates could also capture a local average treatment effect.

[50] Given its strategic importance, Punjab received significant investments in its transport infrastructure. Due to its geographical closeness to the North West Frontier, it was an area that in itself was of great military importance. This was the primary motivation for the British to invest strongly in roads, railways and cantonments. Lines of communication and supply were essential in case of an emergency at the frontier. In 1931, the North Western Railway System accounted for 23% of the total open mileage in India totaling 7,092 miles (Mazumder, 2003, p.56). In contrast, Punjab and the North West Frontier province accounted for less than 12% of India's total area and population. More than one third of these lines were built out of military needs. Similarly, Punjab benefited from major investments in its road network at the end of the 19th century. These investments in infrastructure are not restricted to recruited communities nor do they

Table 9: Baseline results with district-year effects

	Log(male literacy rate)			Log(male population)		
	All ages	Over 20	Under 20	All ages	Over 20	Under 20
	(1)	(2)	(3)	(4)	(5)	(6)
Casualty share*1921	25.6*	25.6*	20.7	-3.7	-1.79	-5.83
	(14.7)	(14.2)	(21.4)	(6.99)	(8.97)	(4.79)
Casualty share*1931	72.6***	59.6***	94.3***	-11.7	0.73	-26.2**
	(23.6)	(22.2)	(32.4)	(11.6)	(10.9)	(12.7)
District-year effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	168	168	168	168	168	168

Notes: Observations are at the district-religion level for three census years (1911-31). All regressions include district-religion fixed effects. Standard errors are clustered at the district-religion level. *** p<0.01, ** p<0.05, * p<0.1.

is that religious communities are affected differentially by these investments, even though I estimate proportional effects by relying on a semi-log-specification. Another concern in my relatively small panel is that relevant variation is lost because those districts with similar recruitment intensities for both religions are no longer used to identify the main effect. Subject to these caveats, the results presented in table 9 are broadly consistent with earlier findings. One difference with earlier findings is that the coefficient on the casualty ratio in 1931 gains significance for under-20-year-olds. This result suggests that inter-generational spill-overs could previously have obscured by variables affecting literacy at the district level. However, the immediate impact remains only significant for over-20-year-olds. It should also be noted that the size of the population under-20-years-old decreases significantly in column (6), which implies that the observed increase in the literacy rate for under-20-year-olds could partly reflect a decrease in the denominator.

In table 10, the main regression at the district level is repeated with both year effects for baseline controls (odd columns) and additional contemporary controls (even columns). These results are remarkably similar to those obtained in table 9 and they confirm that district-level variables cannot account for the observed effect on the literacy rate.

target these communities in particular: by 1911, all but two districts were connected to the railroad network (Marten, 1911, Census Report). Therefore, it seems unlikely that differential investment in transport infrastructure is driving my earlier findings.

Table 10: District level controls

	Log(male literacy rate)					
	All ages		Over 20		Under 20	
	(1)	(2)	(3)	(4)	(5)	(6)
Casualty share*1921	37.7**	41.8**	39.8**	39.9**	36.5	47.2
	(17.6)	(18.8)	(17.3)	(17.7)	(26.4)	(29.6)
Casualty share*1931	46.6***	59.1***	39.5*	52.2***	70.0***	75.5***
	(17.2)	(17.9)	(19.7)	(18.3)	(20.1)	(22.6)
Baseline Controls- year effects	Yes	Yes	Yes	Yes	Yes	Yes
Migration, area, education and population controls		Yes		Yes		Yes
Observations	84	84	84	84	84	84

Notes: observations are at the district level for three census years (1911-31). "Baseline controls- year effects" include year effects of the 1911 value of proportion of the Hindus in the male population, the proportion of Sikhs, the proportion of Muslims (with other religions omitted), population density, colony status, primary education expenditures per capita, primary fees per capita, and the fraction of the male population born in the district of enumeration. Even columns includes contemporary values of the logarithm of the district area, the logarithm of primary education expenditures per capita, the logarithm of the size of the relevant age population, and the fraction of the population born in the district. District fixed effects and year effects are also included. See table 2 for summary statistics. Standard errors are clustered at the district level. *** p<0.01, ** p<0.05, * p<0.1.

7.2.2 Alternative explanations

Throughout the analysis, the potential impact of military recruitment on the total size of the population was carefully examined for each specification. This analysis could not uncover strong impacts, which makes it unlikely that the main effect of military recruitment on literacy was through a demographic channel. Nevertheless, a very specific type of demographic shocks could still affect the results. A first key source of concern is the possibility that heavily recruited communities faced different survival rates for literates versus illiterates. Unfortunately, the census category of over-20-year-olds is too broad to distinguish between a higher survival rate of individuals who are already literate or the growth in the number of *new* individuals who can both read and write. However, my findings are robust to using the logarithm of the number of literates instead of the literacy rates.[51] This result implies that military

[51] In the absence of significant effects on the aggregate population, this is not a key concern for the main results and this robustness check is not reported. However, some results in the appendix (A.1.) point at negative impacts on the size of the population. For these results, the alternative specification using the number of literates is reported in the

recruitment should have a positive impact on the survival of literates to confound the main results. Hence, the most likely drivers of different demographic trends can be ruled out, including higher mortality in recruited communities as a direct result of military service or delayed demobilisation. Furthermore, any confounding factor that has a positive impact on the size of the literate population should mainly affect the recruited communities (even within the same district, as argued in 7.2.1) and mainly affect the population of male over-20-year-olds to be consistent with the results. Only if an alternative shock satisfies this restrictive set of conditions, my analysis cannot rule out the possibility that it biases the main results. A second differential demographic shock could be due to migration. If more literates moved into recruited districts (perhaps in the hope of being recruited), they could boost the number of literates in their new home districts. Again, this would require only literates to immigrate. Also, the regressions in table 10 controlled explicitly for migration movements.

A second set of alternative explanations for my findings relate to my interpretation of the results in terms of the main mechanisms. It is possible that, on top of the main channels on which my analysis has focused, other (more indirect) channels were important. In his detailed historical account, Mazumder provides historical evidence on a wide range of policies that were to some extent related to Punjab's status as a military recruitment ground. A first policy directly targeted recruited soldiers. Soldiers were among the main beneficiaries of land grants in the so-called canal colonies. These colonies contained newly created tracts of cultivable land irrigated by canals. The primary aim of these projects was to generate more revenue by developing potentially fertile areas and moving some of the population away from densely populated regions to the newly established colonies (Mazumder, 2003, p.66).[52] Even though most canalisation projects were completed before the war, Mazumder notes that soldiers were given preference in the allocation of new tracts of land after WWI. This policy is unlikely to lead to an upward bias of our estimates, as ex-soldiers who moved to the colonies would dampen the extent to which recruited communities would have benefited from improvements in literacy. A second policy that directly benefited recruited districts was taxation after the war. The main source of income of the Raj came in the form of taxes on agriculture. These taxes were laid down in so-called revenue assessments. Anecdotal evidence suggests that, mainly after the WWI, heavily recruited districts enjoyed more favourable assessments. I do not think this policy is driving the results, given that it was only implemented after the war and there is evidence of a positive impact from 1921

tables.

[52]By 1931, Punjab had 9,929,219 acres of land irrigated by government canals, which corresponds to 46% of land irrigated by canals in the whole of British India.

onwards. However, this channel may have caused spill-overs of military service on household incomes in the home communities. A third policy that may have affected recruited communities is the Punjab Land Alienation Act (1901), which protected agricultural castes (among whom mainly martial races) from indebtedness by outlawing land sales from agricultural to non-agricultural castes.[53] While the families of recruited soldiers could have benefited from the Land Alienation Act, the Act applied to all martial races in the whole of Punjab and not just to those that delivered recruits. Also, the Act was implemented well before First World War. Therefore, it seems unlikely that the results presented earlier are merely capturing a different human capital development path for the communities that benefited most from the Land Alienation Act.

8 Conclusion

This paper exploited the exogenous increase in military recruitment during the First World War to estimate the impact of recruitment on human capital accumulation. My results suggest that ten additional recruits per thousand of the 1911 male population were on average associated with three more literate males per thousand in 1931. Further analysis suggests that this improvement in the human capital stock was mainly driven by direct skill acquisition. There is only mixed evidence that military recruitment also raised the literacy rate of children. However, no evidence could be found of preferential spending on primary education in heavily recruited districts. These results on inter-generational spill-overs and on public investments put bounds on the long-run distributional impact of military recruitment in this context. While the proxy approach of this paper gave rise to certain econometric concerns, it does have the interpretational benefit of highlighting a substantial cost to the observed improvements in literacy. The estimates suggest that for every six additional literates per thousand, one Punjabi soldier gave his life. The fact that volunteer soldiers made this trade-off at some level is suggestive of the harsh economic conditions that the Indian population faced during this period.

Earlier work on public education in colonial India has highlighted the failure of the public education system to teach lasting literacy skills to its students. In this context, it is striking that military service improved literacy outcomes for adults. One interpretation of this result is that the military provided a unique environment in which the personal returns to education (including the ability to

[53] See Cassan (2010) for a detailed description of the Punjab Land Alienation Act and the incentives it created to manipulate caste identity.

communicate with one's family) were boosted and the costs of acquiring literacy skills were strongly reduced. Obviously, this paper does not promote war-time military service as an alternative to public education. However, the positive results of this paper could be replicated in non-military adult literacy programmes. Such programmes could offer non-traditional learning environments that strongly change both the returns to literacy and the costs of acquiring these skills. In the light of the poor quality of public education in many developing countries, non-traditional learning environments could prove to be powerful complements to the public education system.

Finally, this paper is one of the first studies to confirm the long-standing hypothesis that disadvantaged groups could benefit substantially from military service. Such evidence on the returns to military service could be important for policy makers who design military recruitment policies. It is interesting to note that post-independence India has moved away from the old recruitment patterns, but it only did so in the course of the 1970s. A simple archive search reveals that military recruitment policies are now regularly discussed in the Indian Lok Sabha. This paper indicates that military recruitment policies could have important distributional impacts. Therefore, the political salience of military recruitment policies could be well justified.

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Appendix

A.1. Robustness to Border Changes

The districts analysed in this paper were subject to several border changes of the period under consideration. While most of these border changes were small and are not expected to affect the literacy rate systematically, this section explores the robustness of the main findings to accounting more explicitly for border changes. In table 11, I conduct the analysis at the level of merged districts with stable borders. The main results carry through, but there is some evidence in these adjusted samples of negative impacts of military recruitment on the size of the population. To address the concern that the impacts on literacy are reflecting changes in the composition of the population, the main results are also shown for the logarithm of the number of male literates rather than the corresponding literacy rates in columns (3) and (4).

Table 11: Baseline specification for merged districts

	Log(male literacy rate)		Log(male literates)		Log(male population)	
	Over 20	Under 20	Over 20	Under 20	Over 20	Under 20
	(1)	(2)	(3)	(4)	(5)	(6)
Casualty share*1921	60.1***	38.2	44.8**	21.9	-15.3	-16.2*
	(21.8)	(34.8)	(19.2)	(34.7)	(13.4)	(9.09)
Casualty share*1931	90.6***	107***	86.8***	89.8***	-3.75	-17.7
	(31.0)	(36.9)	(35.6)	(38.6)	(25.9)	(25.2)
Observations	96	96	96	96	96	96

Notes: District-religion level observations for two religious groups (Muslim or Hindu-Sikh) in 16 merged districts, for three census years (1911-31). Standard errors are clustered at the district-religion level. *** p<0.01, ** p<0.05, * p<0.1.

A.2. Inclusion of Princely States

As reported in section 4, the Princely States were omitted from the main analysis for reasons of comparability and data availability. In this section, I show that the main results are robust to the inclusion of the princely states in the analysis. Table 12 repeats the main analysis with the inclusion of all religion-districts in Princely states (excluding the Simla Minor Hill States, of which the composition changes over time). These results are quantitatively smaller and no longer significant. However, it turns out that these results are driven by the inclusion of outlying small communities (for which we expect the data to be particularly unreliable). Omitting those Princely State communities with a male population of less than 4,000 individuals in 1911 (all British districts have larger communities), the results become very similar to earlier findings (table 13).

Table 12: Baseline specification with Princely States

	Log(male literacy rate)			Log(male population)		
	All ages	Over 20	Under 20	All ages	Over 20	Under 20
	(1)	(2)	(3)	(4)	(5)	(6)
Casualty share*1921	19.1	26.4	-17.5	12.5	11.8	13.8
	(18.0)	(17.9)	(22.3)	(13.0)	(13.5)	(12.7)
Casualty share*1931	21.5	25.9	-10.3	4.71	3.90	5.29
	(22.7)	(19.4)	(32.5)	(15.6)	(16.0)	(15.3)
Observations	270	270	270	270	270	270

Notes: District-religion level observations for two religious groups (Muslim or Hindu-Sikh) in 45 districts/Princely states, for three census years (1911-31). The regression includes district-religion fixed effects and religion-year effects. Standard errors are clustered at the district-religion level. *** p<0.01, ** p<0.05, * p<0.1.

Table 13: Baseline specification with Princely States (2)

	Log(male literacy rate)			Log(male population)		
	All ages	Over 20	Under 20	All ages	Over 20	Under 20
	(1)	(2)	(3)	(4)	(5)	(6)
Casualty share*1921	28.6	35.4*	-3.03	13.5	13.7	14.0
	(17.7)	(17.8)	(20.9)	(13.6)	(14.0)	(13.2)
Casualty share*1931	40.8*	42.0**	18.7	7.63	7.99	6.96
	(21.2)	(18.4)	(29.2)	(15.4)	(15.2)	(15.8)
Observations	249	249	249	249	249	249

Notes: District-religion level observations for religious groups (Muslim or Hindu-Sikh) of which the male population exceeds 4,000 individuals, in 42 districts/Princely states, for three census years (1911-31). The regression includes district-religion fixed effects and religion-year effects. Standard errors are clustered at the district-religion level. *** p<0.01, ** p<0.05, * p<0.1.

A.3. Rank Analysis

In the empirical strategy (5), it was argued that the proxying approach is unlikely assign higher "recruitment intensities" to communities with increasing literacy rates. In particular, it was argued that literate soldiers should not have faced a different casualty pattern than illiterate soldiers. In further support of this hypothesis, I can distinguish between casualties from three categories of army ranks: soldiers, above-soldier ranks and military personnel in supportive roles (often mechanics). Figure 3 shows the relationship between pure soldier casualties and casualties among higher ranks at the district-religion level. This figure confirms that the geographical pattern of casualties is similar across ranks. An alternative explanation of the key results could have been that higher ranks were driving this impact. This could be the case if higher ranks were recruited from regions with a higher potential for literacy improvement and if they had different casualty patterns (at the district-religion level) than the lower ranks. Under the latter scenario, the proxy approach would lead to an upward bias of the impact of military recruitment. However, the similarity of the recruitment patterns suggest that this is an unlikely scenario. Table 14 further confirms that the key results are robust to relying on casualty rates for strict soldier roles (excluding higher ranks and other groups).

Figure 3: Higher ranks versus soldier ranks at the district-religion level

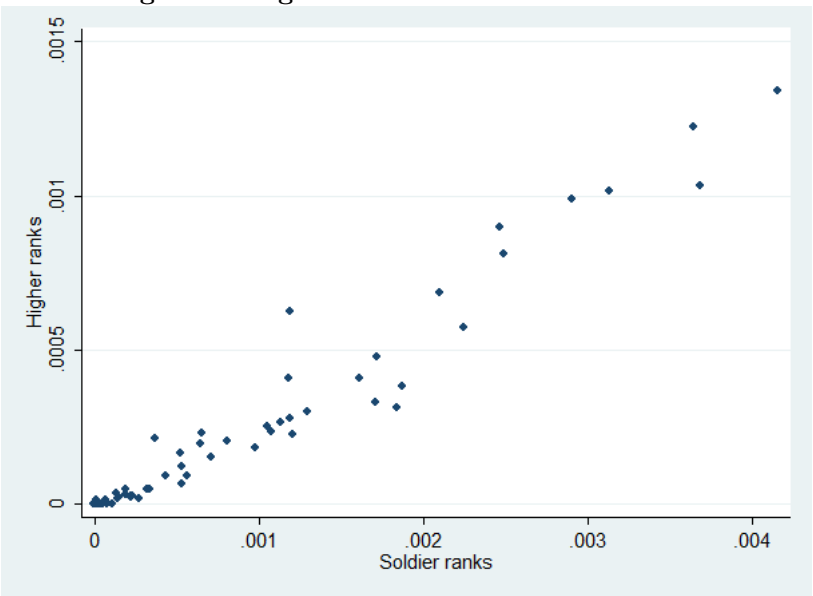

Table 14: Baseline Specification for Soldier Rank Casualties

	Log(male literacy rate)			Log(male population)		
	All ages	Over 20	Under 20	All ages	Over 20	Under 20
	(1)	(2)	(3)	(4)	(5)	(6)
Casualty share*1921	49.6**	59.7**	12.2	17.4	17.5	18.5
	(23.9)	(22.6)	(31.8)	(24.3)	(25.0)	(23.7)
Casualty share*1931	68.0*	71.2**	48.3	11.7	12.7	10.1
	(35.1)	(30.0)	(48.2)	(27.5)	(26.9)	(28.2)
Observations	168	168	168	168	168	168

Notes: District-religion level observations for two religious groups (Muslim or Hindu-Sikh) in 28 districts, for three census years (1911-31). All regressions include district-religion fixed effects and religion-year effects. Standard errors are clustered at the district-religion level. *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

A.4. Cohort Analysis

It was argued in section 6 that the results are most consistent with the direct acquisition of literacy skills by serving soldiers. Under this hypothesis, we should observe that the cohort that served in the war gained additional literacy skills during the war. It should be noticed that the earlier analysis did not correspond to a cohort analysis, as I compared the same age groups at different points in time (which allows the composition of these groups to change). The split up of literacy rates provided in the census does not allow for a detailed cohort analysis in different age categories. However, I can construct a variable that approximates the literacy changes for the cohorts of 10-to-20-year-olds in 1901, 1911 and 1921:

$y_{r,d,t} = log(literacy^{over20}_{r,d,t}) - log(literacy^{10to20}_{r,d,t-1})$

This variable does not correspond to the actual cohort-specific change in literacy rates, as I need to use the more broader category of over-20- year-olds.

Table 15 examines whether the main results are confirmed in a cohort analysis. Column (1) looks at the cohort literacy gain in the 1921 cross section. While the effect is positive, it fails to gain significance. In column (2), district dummies are included to account for any determinants of the cohort literacy gains that are district-specific. These factors could include the occupational structure of the district (e.g. the presence of an administrative services, occupational characteristics and colony status). The effect is now much stronger and significant at all conventional levels. In column (3), I report the results of difference-in-difference estimate that can account for time invariant determinants at the district-religion level of the cohort-literacy gains.

In conclusion, the results of this cohort analysis are consistent with the hypothesis that military recruitment positively affected the literacy of the cohort that served in the first world war.

Table 15: Baseline specification for cohort changes

	Log(male literacy rate over 20/male literacy rate$_{t-1}$10 to 20)		
	(1)	(2)	(3)
Casualty share*1921	14.5	49.3***	49.8**
	(13.9)	(16.8)	(21.0)
Casualty share*1931			37.5**
			(16.6)
District dummies		Y	
District-religion FE			Y
Religion-year effects			Y
Religion dummy	Y	Y	
Observations	56	56	166

Notes: District-religion level observations for two religious groups (Muslim or Hindu-Sikh) in 28 districts, in 1921 (1-2) or for three census years 1911-31 (3). Standard errors are clustered at the district-religion level in (3). *** p<0.01, ** p<0.05, * p<0.1.

A.5. Female literacy

The analysis presented here can also be applied to female literacy. In table 16, I present summary statistics for female literacy. The avarage level of female literacy is very low, with certain communities virtually lacking any literate women. These low literacy rates give rise to additional measurement concerns (which could be exacerbated by the log-transformation employed throughout the emperical analysis). Subject to this caveat, table 17 presents the baseline results for female literacy. The results indicate that the impact of military recruitment on female literacy could have been negative. This result could be consistent with the hypothesis that the loss of male labour increases the opportunity cost of women in education, although the significance of this negative coefficient disappears in most alternative specifications. Furthermore, the estimated impact of recruitment on female literacy evaluated at the sample mean is neglegible from an economic perspective. Nevertheless, these negative coefficients are consistent with a scenario in which direct skill acquisition is the key channel that explains improvements in male literacy in recruited communities.[54]

Table 16: Female literacy summary statistics

	Sample	Lightly recruited	Heavily recruited	P-value
Female literacy rate 1911	0.011	0.010	0.012	0.78
	(0.018)	(0.014)	(0.024)	
Observations	56	36	20	

Notes: see table 1.

[54]While the results on female literacy could be interpreted as a "placebo" test of the direct skill acquisition channel (which should only affect males), this interpretation should be subject to an important caveat. Chaudhary (2010) finds that female literacy is less responsive to educational investments than male literacy. Hence, the differential impact on male and female literacy is not necessarily evidence against the income channel or supply-side channel. Besides, the provision of a postal service to serving soldiers could in theory have spill-overs on women.

Table 17: Female literacy baseline results

	Log(female literacy rate)			Log(female population)		
	All ages	Over 20	Under 20	All ages	Over 20	Under 20
	(1)	(2)	(3)	(4)	(5)	(6)
Casualty share*1921	-59.9**	-53.2**	-73.7**	18.9	17.7	20.8
	(26.7)	(26.2)	(30.6)	(14)	(12.4)	(15.6)
Casualty share*1931	0.88	-7.86	11.1	9.14	6.4	13.2
	(36.1)	(31.7)	(41.2)	(17.2)	(15.6)	(18.5)
Observations	168	168	168	168	168	168

Notes: District-religion level observations for two religious groups (Muslim or Hindu-Sikh) in 28 districts, for three census years (1911-31). All regressions include district-religion fixed effects. Standard errors are clustered at the district-religion level. *** p<0.01, ** p<0.05, * p<0.1.

A.6. Heterogeneity

Subject to the data availability constraints, the district-religion level is the finest level at which the analysis can be conducted. This approach also enables a comparison between the treatment effects of Muslims and Hindu-Sikhs respectively.[55] The results presented in table 18 suggest that the impact is largest for Hindu-Sikhs, but the difference between the treatment effects is not statistically significant and the effect remains positive for Muslims.

[55]Chaudhary and Rubin (2010) highlight the importance of the proportion of Muslims in the district to explain Muslim literacy levels in 1911 and 1921. The Punjabi districts under consideration all have a Muslim population that is larger than 28% of the population and the level effect of the share of Muslims reported by Chaudhary and Rubin should be captured by the district(-religion) fixed effects in my approach.

Table 18: Heterogeneity

	Log(male literacy)		Log(male population)	
	Over 20	Under 20	Over 20	Under 20
	(1)	(2)	(3)	(4)
Casualty share*1921	60.5**	36.6	15.3	13.8
	(25.2)	(31.6)	(21.3)	(22.4)
Casualty share*1931	84.0**	74.6	8.62	6.51
	(31.9)	(49.2)	(31.9)	(34.2)
Casualty share*Muslim *1921	-34.3	-52.6	-3.63	-0.52
	(30.8)	(42.2)	(33.3)	(32.4)
Casualty share*Muslim *1931	-58.5	-75.6	3.14	4.88
	(39.6)	(66.4)	(39.3)	(41.5)
Observations	168	168	168	168

Notes: District-religion level observations for two religious groups (Muslim or Hindu-Sikh) in 28 districts, for three census years (1911-31). All regressions include district-religion fixed effects. Standard errors are clustered at the district-religion level. *** p<0.01, ** p<0.05, * p<0.1.