Decomposing the Behavioral Responses to the Flu Vaccine Shortage of 2004[†]

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Abstract

This paper uses a randomized encouragement design to decompose the behavioral responses to shortage announcements. The objective is to understand how effectively can scarcity be managed in a non-market setting. Given an unexpected shortage of flu-vaccines, we observed the responses of the members of a campus community to two distinct experimental treatments: a deadline reminder, and the same deadline reminder plus an appeal for cooperative restraint to favor priority groups in the general population. This experiment and two subsequent follow-up surveys allow us to distinguish between different types of behavioral responses: hoarding (an increase in demand induced by scarcity), the mobilization of procrastinators, cooperation, and cheating. We find that the management of scarcity started on the wrong foot as the announcements mobilized an unusually large number of first-timers for vaccination (hoarders) and induced many procrastinators to seek vaccination, increasing demand by 48%. Results indicate, however, a strong "net" cooperative response, helping reduce this demand by 54%. In addition, screening by health center personnel was effective in reducing demand by an additional 37%, even though quite a few cheaters remained un-detected, absorbing 39% of the vaccines handed out.

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Hoarding:

"We knew that once people heard there was a shortage, more people would try to get the vaccine." *San Francisco Chronicle*, October 11, 2004

Cooperation:

"There is a strong spirit of cooperation during this crisis. We have no intention of taking any draconian steps to enforce this state of emergency." *San Francisco Chronicle*, October 9, 2004

Cheating:

"Flu shots, often a test of bravery, became a test of character ..., and not everyone was passing." *San Francisco Chronicle*, October 7, 2004

I. INTRODUCTION

While history is replete with situations where societies have been confronted with unexpected commodity shortages, the way shortages have been handled has been quite varied. When a market exists, rising prices serve as a rationing device, and targeted subsidies can be used to ease the burden of adjustment on selected groups. When the price is fixed, allocation of the scarce commodity across wanting individuals is done by the introduction of rules, presumably to distribute the scarce commodity to those most in need. Rules are implemented by screening and/or by appeals to cooperative restraints. Appeals to voluntary cooperation in response to a shortage cannot, however, be expected to produce the same net outcome as appeals to cooperation under normal times. In the context of a shortage, cooperative response is met not only by defaults on cooperation (cheating), but also by hoarding and by a decline in normal-time procrastination that both diminish the impact of cooperative response.

Hoarding occurs when new demand is induced by the shortage announcement itself. The announcement of shortage and accompanying deadlines for obtaining the commodity may also result in increased demand due to less procrastination. Finally, rationing may induce individuals to behave in a non cooperative way by self-declaring themselves to satisfy the distribution criteria when in fact they do not (hence by cheating). Cheating may neither increase nor decrease demand, since many cheaters are likely former consumers of the now scarce commodity who have to cheat to continue to access the good. Cheating and getting away with it, though, decreases efficiency in attempting to restrict access to the scarce commodity to those who need it the most.

Given these contradictory behavioral responses at play, the net effect may be in favor of cooperation and screening, with an aggregate decline in demand, or of hoarding, reduced procrastination, and cheating, resulting in an increase in demand. While, in the longer run, initiatives can be taken to respond to the shortage by increasing supply, understanding what motivates the short-run demand response to the shortage is important to more efficiently manage scarcity in a non-market setting.

In this research, a field experiment was designed to observe and analyze behavioral responses to a large unexpected flu-vaccine shortage in the Fall of 2004. The analysis took place during two flu-clinics at a California university campus medical center. For the flu-clinics, the center was open not only to the campus population (faculty, staff, and students), but also to the non-campus community. Prior to the first clinic, we subjected the campus community randomly to two experimental treatments. Departments were assigned at random into three groups: a control group, that received no email from us (C); a treatment one group (T1) that received an email reminder about deadlines for the next two clinics without mentioning the shortage; and a treatment two group (T2) that received an email like the previous one, but additionally describing the shortage situation and appealing (as the Center for Disease Control was recommending at the time) for voluntary cooperation from non-members of defined priority groups in refraining from seeking vaccination. Prior to the second clinic, the medical center sent an email to all campus members announcing that this last clinic was only open to priority groups.

This randomized encouragement design, and the follow up surveys done at two campus clinics, allow us to decompose empirically the different behavioral responses at play: hoarding and reduced procrastination contributing to increase demand; and cooperation and the screening of cheaters helping to reduce demand. The net effect of these four types of responses can be measured, and the relative contribution of each group in the campus population to each type of response can also be identified.

The paper is organized as follows. Section 2 reviews the literature on behavioral responses to a shortage. Section 3 describes the experimental design and the surveys at the two clinics. Section 4 presents the data and decomposes the behavioral responses. The implications of the results are discussed in section 5.

II. BEHAVIORAL RESPONSES TO A SHORTAGE: A LITERATURE REVIEW

2.1. Hoarding as a response to scarcity

Hoarding of commodities and earlier acquisition of services is a common behavioral response to expected scarcity. Examples are the stockpiling of Strategic Petroleum Reserves that varies with the likelihood of a war outbreak; the oil “buyer panic" of late 1973 that resulted in long lines at the gas pumps (Adelman, 2004); and the “Great Toilet Paper Shortage" caused in zest by Johnny Carson in 1973[1]. In fact, at the time of the flu vaccine shortage announcement, hoarding was expected to happen as a response to the shortage.[2] In a market setting, given a contraction in supply, if demand expands as a response to the shortage, then the price increase is greater than the one caused solely by the leftward supply shift.[3]

2.2. Procrastination, including on one’s own health

As previously mentioned, another force that may increase demand due to shortage is that the deadlines associated with the distribution of a scarce resource (that shall eventually run out) may reduce the occurrence of procrastination. Procrastinators are individuals who delay tasks until a later period, and who, when the later period arrives, delay those tasks again and again (Akerlof, 1991; Silver, 1974). This is consistent with studies that find, for example, that if manufacturers remove the redemption deadline on the coupons they distribute, lack of a deadline reduces the probability of redemption (Silk, 2004); and that the longer students are given to complete a task, the greater the likelihood that they will fail to complete it (Tversky and Shafir, 1992).

No matter what prompts postponing and perpetually putting off an onerous task, procrastinators almost always experience regret for not getting things done in a timely fashion. Several studies found that this regret may cause anxiety, stress, and unhealthy behavior (Sirois et al., 2003; Tice and Baumeister, 1997). Sirois et al. (2003) also find empirical evidence that individuals procrastinate with respect to decisions related to their own health. One such decision that we study here may be getting a flu shot in normal times.

2.3. Cooperative responses

While non-cooperative responses to scarcity can be expected as the default option, there is also abundant evidence of voluntary cooperative responses to scarcity. Individuals not in priority groups may voluntarily incur a loss to allow the scarce resource to reach the people most

[1] In his Late Night Show monologue, Johnny Carson said: “You know what's disappearing from the supermarket shelves? Toilet paper. There's an acute shortage of toilet paper in the United States.” The consequence of this statement made in the early 1970's, a time of shortages -- oil in particular --, was that the next morning many of the 20 million television viewers ran to the supermarket and bought all the toilet paper they could find. By noon, most of the stores were out of stock since, despite trying to ration it, they couldn't keep up with demand.

[2] A County Public Health Department spokesperson said: "We knew that once people heard there was a shortage, more people would try to get the vaccine." *San Francisco Chronicle*, October 11, 2004.

[3] This did not occur in the flu-vaccine shortage, since the price is fixed. There were, however, several cases of price gouging attempts and subsequent legal charges.

in need, even under conditions of anonymity and lack of enforcement.[4] A number of recent behavioral experiments (e.g., Fehr and Gachter, 2000; Gintis et al., 2003; Heinrich et al., 2001; Ostrom et al., 1992) have found that individuals behave more cooperatively than the "self-interest individual model" would predict. Cooperative behavior can be further strengthened when individuals are given the option of incurring a cost to themselves in order to limit other people's cheating and free-riding (Fehr and Fischbacher, 2004; Ostrom et al, 1992; Ostrom, 1990).

As shown by Hollander (1990), voluntary cooperation is possible even in large social groups as it can be motivated by contagion games (the fear that social norms will collapse) or by self-satisfaction in cooperating (Trivers, 1971). Cooperation is more likely to occur in smaller social groups, such as families or in a closed campus community such as the one in the present experiment, where individuals can monitor (purposefully or haphazardly) each other's cooperative responses and ostracize those who fail to cooperate.

III. THE EXPERIMENTAL DESIGN AND THE DATA COLLECTION

3.1. Background, Time Line, and Information about the Shortage

On Tuesday October 5, 2004, half of the U.S. supply of flu-vaccine was pulled back from the market because of possible contamination.[5] Starting on Wednesday, October 6, numerous media articles about the flu-vaccine shortage informed the American public. The Center for Disease Control (CDC) devised and announced distribution guidelines and procedures to most efficiently allocate the scarce vaccine to people in high priority groups. The basic procedure during the first week of the shortage was for the CDC to appeal to the public to forego vaccination if not in the priority groups. On October 6, the university campus clinic in our experiment held the first of six previously scheduled and announced campus flu-clinics. For the flu-clinics, the center was open not only to the campus population (faculty, staff, and students), but also to the non-campus community. At the October 6 clinic, following CDC recommendations, voluntary restraint from people waiting in line at the clinic was advocated via a large poster indicating the priority groups. Three days later, on Saturday October 9th, the media

[4] Many individuals give blood, donate to charities, and show general consideration for their fellow citizens. During the 2001 California Electricity crisis, Californians were asked to reduce demand via voluntary conservation ("Flex Your Power" campaign). The most successful demand reducing campaign, known as "20/20", though, was associated with a promise of a 20% rate reduction if they reduced electricity demand by 20%.

[5] British regulators cut the U.S. vaccine supply in half by condemning 48 million doses at a Liverpool factory owned by Chiron Corporation, a U. S. company based in Emeryville, California, after bacterial contamination was found.

announced that some California counties had declared an emergency to enforce a State directive so that flu-shots should be saved for the neediest. The county where the university is located did not at that time officially announce the enforcement of that same state directive.[6] According to our research of the events at that time, we believe that there was general awareness about the shortage, but not about its seriousness. Moreover, there was little awareness about the subsequently implemented measures to distribute the vaccines via screening, so that they would reach the members of defined priority groups.

On Monday October 11, one week after the shortage was first announced, the two experimental treatment emails (T1 and T2) were sent out to the campus community. Monday the 11th was a national holiday and on the next day, Tuesday October 12, the second clinic, henceforth referred to as clinic A, took place, offering flu-shots for the campus and non-campus communities but screening all candidates. This screening measure was not previously announced by the medical center to the campus and to the community. Individuals had to sign an affidavit declaring that they met the requirement of belonging to one of the priority categories. These categories were: children 6-23 months of age, adults 65 years of age and older, women expecting to be pregnant during the flu-season, health care workers with direct patient care, out-of-home care givers, individuals with household contacts of children less than 6 months, adolescents on chronic aspirin therapy, and persons ages 2 through 64 with a chronic medical condition (such as asthma, diabetes, heart disease, chronic kidney disease, who had chemotherapy or immuno-compromised conditions).

On Wednesday the 13th, the campus medical center posted on its web-site that all remainder clinics had been canceled and recommended the community to check for updates. The update came two weeks later. On Wednesday October 27, the campus population received a common email, originating from the medical center, informing about the date for a final clinic (hence, that there was a terminal deadline) and that, given the shortage, all candidates for a flu shot would be asked to sign an affidavit that they belong to one of the priority groups. By the time of this last clinic (that we henceforth call clinic B), screening of participants was common practice across the U.S. and, most likely, the information sent via email to the campus population was by then also known to the non-campus community. In particular, at the time of clinic B, most U.S. counties had declared a state of emergency and were enforcing screening procedures in order

[6] "There is a strong spirit of cooperation during this crisis," said the respective County Public Health Officer. "We have no intention of taking any draconian steps to enforce this state of emergency." *San Francisco Chronicle*, October 9, 2004.

to save available flu vaccines for those most in need. On Monday, November 1, we conducted the second and last survey during clinic B.

Two months after the shortage was announced, with a reported mild flu activity, media articles pointed to doses of vaccine that were at risk of waste and the CDC recommended loosening the flu-vaccine restrictions.[7] From a nation-wide CDC survey on health issues conducted in December 2004, there was national level evidence that many people in priority groups still had not receive the vaccine. Several reasons were given by CDC-survey respondents and also in a telephone survey conducted by the Harvard School of Public Health[8]: respondents had not even tried, respondents were not able to get vaccination when they tried, some did not realize that they were eligible, and some reported that they were being cooperative (despite being in priority groups) and were abstaining in order to save vaccines for others.

3.2. The Experiment at Clinic A

Given distance to the campus medical center, departments were randomly allocated to three groups, and two of the groups received two different kinds of email treatments.[9] The first subset of departments (henceforth called treatment one, T1) received an email reminder about dates for the only two flu-vaccination clinics planned, without explicitly mentioning the shortage. The second subset (henceforth called treatment two, T2) received an email that contained a reminder about the flu-clinic dates (like T1) and also detailed information about the shortage situation. Also in T2, in accordance with CDC recommendations at that time, individuals were asked for voluntary cooperation in refraining from seeking vaccination if they did not belong to a priority group. The priority groups were described in detail in the T2 email. The third subset of remaining departments, henceforth called the control group C, received no email.

We intended to treat everybody within the randomly selected departments, but obviously we did not expect everybody to have read their email (what matters to be treated is to have read the email before the actual clinic). There is, therefore, a difference between the intended treated and the individuals who were actually treated. Only a subset of members of the chosen departments read the email, but we believe that this selection was orthogonal to the treatment, so

[7] *The New York Times*, December 17, 2004; *USA Today*, January 7, 2005.

[8] Blendon, R. et al, "Project on the Public and Biological Security: FLU SURVEY," October 29-November 9, 2004.

[9] For the content of the two emails please see the appendix. A similar experimental design was used in Duflo and Saez (2002, 2003) who subjected a stratified subset of members of randomly chosen departments in a campus community to treatments sent via snail mail. Their objective was to access the role of information and peer-effects on the decisions to enroll in employer-sponsored Tax Deferred Account retirement plans.

that what we find for the actually treated sub-group (subset of intended treated department who read the email) reveals as much about the average treatment as if we had treated the whole group. One final potential problem, though, is that some department members may have read the email and told others about it. If these social interactions are among co-workers within the same treated department then this is a less serious problem for measuring the average treatment than if interactions are across departments (that differ in intended C, T1, and T2 groups).[10] Next we discuss how we treated the departments with the objective of minimizing this problem.

Emails were sent to faculty, staff, and graduate students by the management services officers (MSO) of the different departments. Of the 87 departments on campus, 13 were drawn for T1 and 14 for T2, leaving 60 for C. The emails to undergraduate students were sent by the student affairs officers (SAO) for declared majors and by the dean of the college for undeclared majors. 13 majors and the undeclared from one college were drawn for T1, and 11 majors and the undeclared from one college were drawn for T2, leaving the rest for C. All MSOs, SAOs, and Deans we contacted and recruited were willing to participate in the distribution of our email to their faculty, staff, and students only. We explained what the study was about and gave them instructions on how to forward the email only to their administrative unit. When the emails were sent out, we were either blind cc-d or we ex-post confirmed with the MSOs and SAOs that the emails had indeed been sent before the clinic date.

By sending the emails through administrative channels, we believe that this helped minimize the chances of social interactions (see Manski, 1996) within and across departments.[11]

3.3. The Surveys at Clinics A and B

All participants in clinic A were newly aware through the media that there was a vaccine shortage. For clinic A, no screening had been announced. Yet, the list of qualifying priority groups was posted at the entrance of the health center, and some screening was performed by the registration personnel. Among candidates for a flu vaccination, some walked away upon reading the list of priority groups, others were screened out by the center personnel.

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[10] Although this is not a guarantee that social interactions did not affect the experiment, clinic A occurred the day after a national holiday, giving people limited time to interact on the morning of October 12th, the day of clinic A, after they potentially read their emails. Staff are less likely to have read their campus-account email on the holiday (day it was sent), compared to faculty and students, and so faculty and students had a potentially longer time to interact, by forwarding the email to each others, than staff.

[11] First, the reason not to forward the email to someone within the same department is that they observe that their friends/colleagues/co-workers received that same email (it is in the email alias). Second, there is less motivation to forward the email to people outside the department since each email recipient believes it is likely other departments were also receiving such email from their official administrative units directly.

Our survey forms were distributed to people waiting in the long line and were filled out by basically everybody. This may be because either our survey looked official, or because the opportunity cost of completing the survey given the waiting period was very small. We also surveyed the people who came in and, upon seeing the poster and noticing the screening, decided on their own to forgo the vaccine.

In the survey questionnaire, we asked individuals to report their age, gender, campus affiliation including the department, whether they got a flu-shot in the last years, and whether it was at this same campus clinic if affirmative. We also asked them how they had heard about the clinic, in particular if it was through an email received from campus during the last two days.

Before clinic B, a campus wide email was sent, originating from the campus medical center. The email announced the date of the last clinic and clearly stated, this time, that the clinic would screen all recipients. On the day of clinic B, once again, we presented our survey forms to the individuals waiting in line. The response rate was once again close to 100% once we started distributing the survey.[12]

Although only the campus population had received the email, all participants at clinic B were aware that there was a serious shortage and that available vaccines were reserved to members of the defined priority groups. The signature of an affidavit was required from all candidates, certifying membership in one of the priority groups. However, no hard proof of qualification in one of these groups was requested by the screening personnel.

3.4. The data and randomization tests

The numbers of intended treated faculty, staff, and students in the T1, T2, and C groups are given in Table 1. At clinic A, seven hundred and thirty eight individuals filled questionnaires, with 498 from campus and 240 from the community. Out of the people surveyed, 73% of those showing up had not received an email, and were therefore in the control group, 16% of the people showing up were in the treatment group T1, and 11% of the people showing up were in the treatment group T2. At clinic B, six hundred and ten persons filled questionnaires, with 385 from campus and 225 from the community.

Because the randomization was based on departments and because departments have different configurations in terms of faculty, staff, and student composition (see Table 1), each of

[12] This time, the clinic started about one hour earlier than announced to accommodate the long lines, so our survey team missed the first hour of people who got the shot during clinic B. But, for the other individuals who showed up (after we started surveying) with the intention of receiving a flu-shot, the response rate was close to 100%.

these groups gives rise to stratified samples of the campus population. For that reason, we use weights to obtain campus population statistics.

We do randomization tests on observables for the three groups T1, T2, and C in order to verify that they do not differ in any systematic fashion. Relevant dimensions that could affect behavior toward vaccination are differentials in age, gender, and years of service for faculty and staff, and gender differences for students. Faculty distributions by age, gender, and years of service show no significant pair-wise differences between T1, T2, and C (Table 2.1). The same applies to staff (Table 2.2). Testing for graduate and undergraduate student differences by gender pair-wise between T1, T2, and C also shows that the hypothesis of equality of percentage compositions cannot be rejected (Table 2.3). These results can thus be taken to indicate no systematic differences between the three groups in these observed characteristics.

IV. ANALYSIS OF BEHAVIORAL RESPONSES

4.1. Definitions

In testing for the four types of behavioral responses to the vaccine shortage, we use the following definitions:

Hoarder: An individual whose demand for vaccination is induced by the shortage. This is a legitimate, rational response to perceived risk that availability will run out and that an epidemic will be induced by the shortage.

Procrastinator: An individual whose desire of getting a flu shot is always postponed unless he faces a deadline

Cooperator: An individual who voluntarily refrains from getting a flu shot in response to a call for the population not at risk to defer vaccination in order to make flu shots available to the general population at risk.

Cheater: An individual who falsely declares belonging to one of the priority groups. Cheaters may be detected by screeners, or be successful in escaping detection.

4.2. Hoarding as a response to scarcity

There is no counterfactual observation for what would have been the demand for vaccine in a “normal” Clinic A, i.e., in a year without scarcity. We will, however, attempt to measure the exceptional demand observed in the campus control group and the community from stability assumptions.

Assume that the demand for flu vaccine is stable over time (as reflected by the fact that the campus health center has been offering the same number of six clinics every year since 1999, and prices have remained the same since 2002). This stability assumption is based on the presumption that, while there is annual renewal of the population, the distribution of characteristics must be constant, the underlying demand function for flu vaccine is stable, and there was no change in supply, except for the scarcity outburst that we are analyzing.

Under these conditions, the proportion of new-comers n_t in the number vaccinated N_t should be the same each year:

$$\frac{n_{02}}{N_{02}} = \frac{n_{03}}{N_{03}} = \frac{n_{04}}{N_{04}}.$$

We, however, do not observe $\frac{n_{02}}{N_{02}}$ and $\frac{n_{03}}{N_{03}}$, but only these proportions among the candidates for a flu-vaccine in clinic A this year:

$$\frac{n_{02} P\left(Y^A = 1 \middle| Y_{02} = 1, Y_{01} = 0\right)}{N_{02} P\left(Y^A = 1 \middle| Y_{02} = 1\right)} \text{ and } \frac{n_{03} P\left(Y^A = 1 \middle| Y_{03} = 1, Y_{02} = 0\right)}{N_{03} P\left(Y^A = 1 \middle| Y_{03} = 1\right)},$$

where Y_t denotes the event of having received a flu vaccine in year t and Y^A the event of having come to clinic A. Making, in addition, the reasonable assumption that the probability of coming to clinic A, conditional on having received a flu vaccination the previous year, is independent of whether one had or not a flu vaccination the previous year, allows to impute growth rates from the ratios within the observed candidates to Clinic A. The impact of the general sense of scarcity, as it was perceived on the date of Clinic A, could then be measured by the difference between the proportion of first-timers in clinic A and the stable ratio:

$$\frac{n^A}{N^A} - \left(\frac{n_{02}}{N_{02}} = \frac{n_{03}}{N_{03}}\right).$$

Information on these ratios in Table 3 shows stability of growth in the community, but some growth between 2002 and 2003 among the campus population. The impact of the general sense of scarcity, as perceived by the community on the date of Clinic A, can thus be evaluated at approximately 10%. On the campus side, although six clinics were announced in 2002, delays in shipment disturbed the announcement of clinic dates, which were progressively scheduled as vaccines became available, and at the end only five clinics were effectively held. To the extent that unreliable supply and uneven announcements discourage potential newcomers more than regular customers, this could explain a lower value for the ratio of newcomers in 2002 compared to 2003. Therefore, the "normal" share of newcomers among campus candidates could take any value from 2.5% to 10%, depending on whether one assumes an accelerating growth (predicting a "normal" 20.7% newcomers in 2004 from the observed 6.7 and 13.7% in 2002 and 2003) or a stable demand (predicting a "normal" 13.7% in 2004 equal to the 2003 ratio).

General awareness about the existence of a flu vaccine shortage obtained through the media increased demand, resulting in a sharp rise in first-timers for vaccination compared to previous years.

This can be seen in Table 3 by the incidence of first-timers for a flu shot among participants this year, compared to the incidence of first-timers in the previous year, in the community and campus group C in clinic A, and in the community in clinic B. These are the three groups that did not receive any special information from campus about deadlines or affidavits, and hence who were responding to general knowledge about scarcity. At clinic A, 12.4% of community participants were first-timers in 2004, compared to a rate of first-timers of 3% the year before. In group C, 23.2% were first-timers in 2004, compared to a rate of 10.5% the year before. The phenomenon of rising demand was even sharper in Clinic B, with information on shortage more widely available in the press. At this clinic, 22.6% of community participants were first-timers in 2004 compared to a rate of first-timers of 4.4% the year before. Note that the rates of first-timers the year before are quite consistent between clinics A and B in the community, with 3% for the first and 4.4% for the latter. Note also that there were significant reported increases in first-timer demands between 2003 and 2004.

These sharp increases in first-timers for flu vaccines can be due to any of the 2004 year effects. However, the dominant phenomenon that year was greater information in the media about the existence and importance of flu shots, and about the existence of a shortage. We can thus conclude that the spread of information about a fall in supply led to a sharp increase in demand from people who had never requested a flu shot before. This is a well known response to non-market scarcity in motivating behavior: rising scarcity increases demand, which is, for consumer goods, similar to stockpiling or hoarding.

4.3. Procrastination as a response to strict deadlines

4.3.1. Impact of deadlines on demand in Clinic A

Let denote by Y the binary variable for coming to a clinic, and by D the binary variable for "having a deadline for action Y (and knowing it)".

We defined procrastinators as people who positively respond to deadlines. They are thus defined by:

$Y = D.$

Non-procrastinators include "never-takers", i.e., $Y = 0$ for whatever value of D, "always-takers", i.e., $Y = 1$ for whatever D, and "defiers", who react in the opposite direction to deadlines, i.e., $Y = 1 - D$. We will assume that deadlines always induce a non-negative response, i.e., that there is no defier (monotonocity).

Procrastination in a population defined by X is thus estimated by comparing the share of the population that would come to the clinic under the D circumstances:

$$E\left(Y \middle| X, D=1\right) - E\left(Y \middle| X, D=0\right).$$

We do not observe D, i.e., whether anyone is aware of the deadline imposed by the shortage. What the experimented did was to subject a campus sub-group to a treatment T_1: "has been sent an email informing of the deadline". The impact of this treatment on participation to a clinic is:

$$E\left(Y \middle| X, T_1=1\right) - E\left(Y \middle| X, T_1=0\right).$$

This effect differs from the measure of procrastination in two ways:

- T_1 could have a direct effect on Y, independently of the deadline effect. The deadline may carry a message about scarcity that, as seen before, induces an increase in demand.
- If there is no direct effect of T_1 on Y, and T_1 is orthogonal to potential outcome, conditional on X, then the causal effect of T_1 on Y is:

$$E\left(Y \middle| X, T_1=1\right) - E\left(Y \middle| X, T_1=0\right) = \left[E\left(Y \middle| X, D=1\right) - E\left(Y \middle| X, D=0\right)\right] * \left[E\left(D \middle| X, T_1=1\right) - E\left(D \middle| X, T_1=0\right)\right]$$

  where the last term shows the impact of the information treatment on knowledge of a deadline. We can safely assume that this term is positive (the email cannot decrease awareness of a deadline), but likely less than one. This is because some people that were sent the email did not read it, and other people that had not received the email may have been aware of the deadlines by other information channels.

  This suggests that the information treatment effect is lower than the deadline effect, so that it underestimates procrastination.

In addition to these differences, what we really measure is whether people come to clinic A, Y^A, and not whether they would come to any clinic, Y. In particular, knowledge of the deadline may have induced people that had planned to come to a later clinic to re-schedule their vaccination to clinic A, so that:

$$E\left(Y^A | X, T_1 = 1\right) - E\left(Y^A | X, T_1 = 0\right) \geq E\left(Y | X, T_1 = 1\right) - E\left(Y | X, T_1 = 0\right).$$

Results on the simple difference estimator $E\left(Y^A | X, T_1 = 1\right) - E\left(Y^A | X, T_1 = 0\right)$ are reported in Table 4 by category of campus populations and for the campus population as a whole. Expected value by campus category X is simply estimated as the ratio $p_{XT} = n_{XT} / N_{XT}$ of observed numbers that came to the clinic n_{XT} to the group population N_{XT}, with standard error computed with the binomial formula $p_{XT}(1 - p_{XT}) / N_{XT}$. Expected values for the campus population are obtained as weighted averages of the categories with weights equal to their share on campus (N_X / N).

When reporting results conditional on a characteristic X that we do not observe among the campus population at large (i.e., N_{XT} not observed), such as whether they were vaccinated last year or not, we cannot compute the probability $P\left(Y^A | X, T_1\right)$ but only $P\left(Y^A, X | T_1\right)$, which is equal to $P\left(Y^A | X, T_1\right) P\left(X | T_1\right)$. The orthogonality of T_1 to any characteristic X implies that $P\left(X | T_1 = 1\right) = P\left(X | T_1 = 0\right) = P(X)$. We can therefore measure the relative impact of T_1 on Y^A as:

$$\frac{P\left(Y^A | X, T_1 = 1\right) - P\left(Y^A | X, T_1 = 0\right)}{P\left(Y^A | X, T_1 = 0\right)} = \frac{P\left(Y^A, X | T_1 = 1\right) - P\left(Y^A, X | T_1 = 0\right)}{P\left(Y^A, X | T_1 = 0\right)}.$$

This is what is reported in the last two rows of Table 4, for first-timers and old-timers.

Deadlines induced an increase in demand.

Comparing demands for a flu vaccine at Clinic A between groups C and T1 (Table 4) shows a large increase in the overall percentage of the campus population that came in response to information about deadlines. Participation rates were 1.3% in group C and 1.8% in group T1, a significant 31.5% increase. While there were no significant changes for faculty and students, staff is the group that responded most positively with a near tripling in participation from 1.8% to 4.8%. This can indicate a “procrastinator” effect overcome with information about specific and terminal dates, resulting in an increase in demand. It can also result from a “rescheduling” effect for those who were intent on participating in one of the later clinics initially announced. Staff was the main participant in this behavioral response.

There was greater response to information about deadlines among people who never had a flu shot before compared to those who did.

In Clinic A, the percentage of first-timers increased from 22.4% in group C to 27.3% in group T1 (Table 4), implying that the number of first-comers in the campus population increased by 60.5%. Rising information about deadlines thus induced a sharp increase in demand among people who had never taken a flu shot before.

We can thus conclude that deadlines (T1 vs. C) and appeals to voluntary restraints (T2 vs. T1) induced two contradictory effects on aggregate demand: on the one hand cooperative behavior by many in curtailing demand, on the other hand mobilization of procrastinators and re-schedulers resulting in rising demand, i.e., in non cooperation. Happily for campus, the net of these two effects was one of curtailing aggregate demand. This can be due to civic behavior or to pressures to conform in a context where anonymity on campus is not guaranteed and social capital can be undermined by unexpected encounters while failing to cooperate.

The contrast in responses to deadlines between first-timers and old-timers is also revealing. While old-timers represent a larger share of the campus population than first-timers, they showed a much smaller response (a 21.5% increase) to deadlines than the latter (a 60.5% increase). First-timers thus appear to be disproportionately made up of procrastinators responding to announcements of stricter deadlines.

4.3.2. Evidence of procrastination in clinic B

In clinic *B*, which took place long after the shortage was known and many clinics had been cancelled all over the place, we can safely assume that everyone knew that the clinic was likely to be the last chance of getting a vaccination, whether from the campus or not. There is no possibility of observing any no deadline counterfactual at that time. We thus resort to finding a counterfactual in the previous year.

Consider the subgroup of persons that belonged both in 2003 and in 2004 in what is defined as a priority group in 2004 and had not yet received a flu-shot by the time of Clinic *B*. As member of a priority group in 2004, they were not affected by the restriction of access to priority groups that were to be strictly enforced. As people with high risk last year (R_{03}=1), they should have been aware that vaccination was highly recommended for them (the target groups were larger last year[13]). By restricting our analysis to this subgroup, we hope to minimize a difference

[13] In the 2003-04 season, the primary target groups recommended for annual vaccination were: 1) persons at increased risk for influenza-related complications (e.g., those aged >65 years, children ages 6–23

in demand between the two years. From that subgroup, one can identify the procrastinators that were not vaccinated last year as:

$$\sum\left(Y=D\middle|R_{03}=R_{04}=1,C^{<B}=0\right)=\sum\left(Y_{03}=0,Y_{04}=1\middle|R_{03}=R_{04}=1,C^{<B}=0\right),$$

where $C^{<B}=0$ indicates someone who had not been vaccinated by the time of Clinic *B* and $R_{04}=1$ a person at risk in 2004. The underlying identification assumption is that nothing else has affected the demand for vaccination by this sub-group between the two seasons, else than the deadline associated with Clinic *B*. This is reported in Table 5, as a percentage of the new comers:

$$\frac{\sum\left(R_{03}=R_{04}=1\middle|Y_{03}=0,Y_{04}=1,C^{<B}=0\right)}{\sum\left(Y_{03}=0,Y_{04}=1,C^{<B}=0\right)}$$

and, in Table 6, as a percentage of the participants of category *X*:

$$\frac{\sum\left(R_{03}=R_{04}=1\middle|Y_{03}=0,Y_{04}=1,C^{<B}=0,X\right)}{\sum\left(Y_{04}=1,C^{<B}=0\middle|X\right)}.$$

The response to deadlines among people chronically in priority groups reveals procrastination.

In Clinic B, we have information about self-declared membership in priority groups among candidates for vaccination for this year and for last year. The questionnaire guaranteed anonymity, so self-reporting should be largely truthful. Clinic B announced a strict deadline: This was to be the last clinic offered on campus. First-timers, that is, people who did not get a flu shot in 2003, are reported in Table 5. There are three categories among current first-timer candidates for a flu shot. (1) People who are not in a priority group and who were not into one last year either. They represent 8.9% of candidates in the community and 21% in the campus. These are first-timers who are attempting to get a flu shot despite the rule. (2) First-timers who were not at risk last year, but are in a priority group this year. These are legitimate first-timers who represent 13.3% of the community participants and 34.7% of campus participants. (3) First-timers who were at risk last year (but in spite of this did not seek a vaccine) and who are again at risk this year. These are the true procrastinators who should be vaccinated, and are coming out in response to a strict deadline which they did not face last year. They represent 73% of community

months, pregnant women, and persons of any age with certain chronic medical conditions; 2) persons ages 50–64 years because this group has an elevated prevalence of certain chronic medical conditions; and 3) persons who live with or care for persons at high risk (e.g., health-care workers and household contacts who have frequent contact with persons at high risk and who can transmit influenza to those persons at high risk.

participants and 32% of campus participants, both surprisingly large numbers. The shortage thus acted as a natural experiment allowing to identify how large is procrastination among campus and community participants in obtaining proper medical treatment. Procrastinator response also contributed, along with hoarding, to the observed increase in demand induced by scarcity.

The incidence of first timers and, among those, of procrastinators mobilized by the strict deadline in Clinic B, differs across categories of participants (Table 6). As can be expected, the highest share of first-timers is among students, reaching 46.3%. There is no drastic pattern in the incidence of procrastination among categories of participants, else than noting that the incidence is double among staff (10.3%) than it is among faculty (5.8%): staff has more first-timers than faculty and, among them, more procrastinators. Among first timers, procrastinators are particularly important in the priority groups corresponding to out of home care-giver, chronic medical conditions, and age.

4.4. Cooperation: appeals to voluntary restraints in demanding a flu vaccination were effective

Cooperation is here defined as "not coming to a clinic in response to a call for the population not at risk to defer vaccination". It should theoretically be measured by an expression such as:

$$E\left(Y \middle| X, R=0, CC=1\right) - E\left(Y \middle| X, R=0, CC=0\right)$$

where R = 0 restricts the population to people not in priority groups, and CC stands for "being aware of the call for cooperation".

Like in the case of procrastination, we never observed whether any given person is aware of the call for cooperation sent by the Center for Disease Control. What we compare is the behavior of two populations that randomly received treatments T_1 (email sent with information on deadlines) and T_2 (which include a call on cooperation in addition to the same information on deadlines). The difference in behavior between the two groups thus reveals the effect of a treatment T_2^* "email calling on cooperation" conditional on having been sent the information on deadline.

We observe conditional participation rates to clinic A such as $E\left(Y^A \middle| X, T_2^*, T_1=1\right)$. This allows us to compute conditional treatment effects:

$$E\left(Y^A \middle| X, T_2^*=1, T_1=1\right) - E\left(Y^A \middle| X, T_2^*=0, T_1=1\right),$$

for the characteristics X known in the population at large on campus, and relative treatment effects:

$$\frac{P\left(Y^A \middle| X, T_2^* = 1, T_1 = 1\right) - P\left(Y^A \middle| X, T_2^* = 0, T_1 = 1\right)}{P\left(Y^A \middle| X, T_2^* = 0, T_1 = 1\right)},$$

for X characteristics unobserved for the campus population at large. This is what is reported in Table 7.

Note that we cannot assume that the T_2^* treatment effect is independent of the T_1 treatment effect, and hence cannot derive from this experiment any information on a "cooperation call" that would have been sent independently of the deadline information. As we do not know for the campus population the shares of its members that belong to a priority group, we can only compute the relative impact of T_2^* conditional on not belonging to a priority group.

Similar to the measure of procrastination, there is a difference between the treatment T_2^* and the "awareness of a call for cooperation" CC. One common difference between the two groups compared is that some persons may have received but not read the email. Define as RT (with either T_1 or T_2) the treatment "received and not read the email". The probability of coming to the clinic, conditional on treatment T, is written as:

$$P\left(Y^A \middle| X, T\right) = P\left(Y^A \middle| X, RT\right) P\left(Read \middle| X, T\right) + P\left(Y^A \middle| X, T = 0\right)\left(1 - P\left(Read \middle| X, T\right)\right).$$

With randomized treatment, the percentage of the campus population that have read their email that same morning is the same in the two treatment groups, i.e., $P\left(Read \middle| X, T_1\right) = P\left(Read \middle| X, T_2\right) = P\left(Read \middle| X\right)$. The absolute measure of impact is reduced by the same rate, but the relative impact is unaffected.

The second issue is that some people in the T_1 group may have heard of the Center for Disease Control's call for cooperation through other means than the email sent to them. This would induce an underestimation of the cooperation.

There has been, overall, a strong cooperative response among members of the campus population to announcement that there was a serious shortage, and to appeals for voluntary restraint from those not in priority categories in order to save scarce flu vaccine supplies for the general population at risk in the State.

Results reported in Table 7 show that the percentage of the overall campus population demanding a flu shot decreased from 1.8% in T1 to 1.1% in T2, i.e., a significant 36.7% decline.

Appeals to cooperative behavior were thus met with a strong positive response in the campus population.

As we saw in Table 1, the campus population is composed of 1,440 faculty, 5,852 staff, 9,618 graduate students, and 22,891 undergraduate students. Comparing demands for a flu shot among the T1 and T2 groups in the campus population categories, shows that undergraduates were the ones with the largest (-45.9%) significant decline. The other three categories had non-significant declines of 31.2% for faculty, 33.9% for staff, and 31.9% for graduate students.

There is also an interesting contrast between old-timers (people who had a vaccination in 2003) and first-timers (people who did not). There was more cooperation among old-timers who reduced demand in response to appeals by 39.6% compared to first-timers who did not significantly reduce their demand.

4.5. Cheating: cheating was prevalent in spite of overall cooperation and effective screening

Among first-timers with complete information, categories at risk (2: new risk) and (3: procrastinators) in Table 5 are legitimate candidates for a flu shot, representing 90.7% and 76.1% of the community and campus participants for whom we have complete information, respectively. Cheating rates, by difference, are 9.3% in the community and a larger 23.9% among campus participants. These are lower bounds on the true incidence of cheating since there was some misreporting about membership to a priority group in the confidential survey (that we analyze below). There was, however, no reason to misreport membership to a priority group for 2003. Hence, underestimation of cheaters is in favor of new risk and does not affect our measure of procrastinators.

The incidence of cheating was higher among those responding to deadlines (procrastinators) and to scarcity (hoarders).

How can cheaters be detected? The anonymous survey, filled by candidates for a flu shot while waiting on line to be interviewed by a nurse, asked for a self-declaration as to whether the person belonged to a priority category or not. Some walked away after filling the questionnaire as they admitted not belonging to a priority category. For those who remained in line, the medical personnel engaged in verification that the individual qualified for receiving a vaccination or not. All candidates for a flu shot thus had to officially announce membership in one of the priority categories in order to be considered for vaccination, had they declared confidentially in the survey that they were in one or not. The screening nurse then decided to accept or reject the candidate. We thus have information from each candidate for vaccination about: (1) whether self-declared in a priority group or not, and (2) whether the individual received a flu shot or not (as he either walked away or was denied). This allows us to construct four categories in columns 1 through 4 of Table 8:

- Effective screening: These are the candidates not in priority groups who were not serviced, either because they walked away by themselves or were screened out by the center staff. Some of them might have been uninformed of the call for self-restraint and screening (screening was not announced for clinic A), while others probably came with the intention to cheat (the schedule for clinic B was never given without information that screening would be enforced).
- Legitimate service: Those are the candidates who declared in the survey belonging to the priority groups and were indeed serviced.
- Exclusion error (Type II): Those are the candidates who declared belonging to the priority groups, but were however denied the flu-shot. While this could be a genuine exclusion error, it is more likely a category of persons that were properly detected not being priority while they self-declared being priority in an attempt to cheat.
- Inclusion error (Type I): non-priority that was serviced (cheaters). Those are people who probably spoke the truth in the survey, but still orally declared being in a priority group to the staff.

Effective screening, revealing lack of information or intention to cheat, was unimportant for community participants (column 1): the rejection rate was very low (2.9% in clinic A and 1.9% in clinic B). This was not the case among campus candidates in Clinic A where it reached 18.1% in group C and was higher in T2 (39%) than in T1 (36.8%). While non-priority candidates may have come to the clinics because of lack of information on the existence of priority groups, this could not be the case for at least campus group T2 in Clinic A and for the campus in Clinic B (where screening was announced). And yet, it is interesting that screening was higher in the treatment than in the control group, and higher among those informed about priority groups (T2) than among the less informed (C and T1). This result suggests attempt to cheat the system is reinforced by the anxiety created by the information on scarcity.

Legitimate service (in column 2) was almost universal in the community (92.5% at clinic A and 97.2% at clinic B). It was also high among campus participants in clinic B (88.2%). It was low, however, among campus participants to clinic A, and lower in the treatment groups T1 and

T2 than in C. In the last column of Table 8, we measure efficiency as the ratio of legitimate services (column 2) to total services offered (column 2 plus column 4): it was high in the community (95.3% in clinic A and 99.1% in clinic B) and for campus in clinic B (95.5%). It was 87.6% among C in clinic A, and only 69.3% among T1 and 61% among T2. Efficiency thus fell as deadlines and appeals to voluntary restraint brought out more people anxious for a vaccination who did not qualify and yet who made it through the screening system.

Exclusion errors, whereby members of priority groups are denied a vaccination, were almost non-existent in both clinics and for all groups (see column 3). Screening was thus on the side of concern for exclusion errors, at the cost of greater inclusion errors. If the objective was to weight exclusion errors more heavily than inclusion errors, to make sure that a minimum of people at risk would be left un-serviced, then screening was indeed effective.

Finally in column 4, cheaters are those who self-declared not being in a priority group, yet were given a flu shot. There were very few in the community (4.6% in A and 0.9% in B) and few among campus participants to Clinic B as well (4.2%). Percentages are, however, important among campus participants in Clinic A, and higher when deadlines and scarcity are better known. Thus, the incidence of cheating reached 10.1% in C, 19.3% in T1, and 23.6% in T2. Once again, the incidence of cheaters rose with the pressures of deadlines (procrastinators) and appeals to restraint (hoarders). Non cooperation by these groups thus diminished, but did not erase, campus cooperative response.

The contrast between first-timers and old-timers is also quite revealing of who is this group of first timers. It is quite clear that it contains a greater share of individuals uninformed and/or intent on cheating, both in the community and on campus. They are also more effective at cheating. As a result, the efficiency in servicing this group is notably low: the share of legitimate vaccinations among campus participants was only 64.9% (group C), 43.7% (T1 and T2, regrouped because of small sample size), and 89.4% (Clinic B). Low efficiency in the treatment groups shows their determination to obtain a vaccination given scarcity, deadlines, and in spite of appeals to cooperation.

Cheating varies by demographic categories

We contrast, in Table 9, cheaters by pairs of demographic categories. This allows revealing which categories are relatively more prone to cheating. Results indicate the following statistically significant contrasts in the incidence of cheating:

- More cheating among campus participants (10.1% in A and 4.2% in B) than among community participants (4.6% in A and 0.9% in B).
- More cheating in the treatment groups (T1 and T2) (21%) than in the control group (10.1%).
- More cheating among females (20% in A) than among males (10.7% in A).
- More cheating among first-timers (7.6% in B) than among old-timers (0.8% in B).
- More cheating among students (7.8% in B) than among faculty and staff (2% in B).

Cheating on self-declared age to qualify in a priority category was extensive.

How else can cheaters be detected? What we used above to identify cheaters was presumed truthful self-reporting in the survey of not being in a priority category, and yet making it through scrutiny of the medical personnel and receiving a flu vaccine. There can, however, also be cases where self-reporting may not have been truthful. In this case, cheaters are people who falsely declared themselves to be in a priority category in the survey, did this again on the required affidavit, and were not detected by medical personnel because providing hard proof of being in the category was not demanded. How can we know that self-reporting was not truthful? Only if there are obvious statistical irregularities in the risk categories invoked. Two priority categories were easier to use. One was a self-declared age of 65 when near that age. The others were categories of risk that showed an unusual increase between 2003 and 2004 among old timers. Note that new timers do not provide a "smell test" along this line as it is expected that they would show high rates of individuals at risk since the group is mainly composed of procrastinators and people newly at risk.

Figures 1 and 2 representing the distribution of self-declared ages are striking in showing a peak at age 65, preceded by a dip with missing numbers between ages 60 and 64.[14] This is true for community as well as campus participants. The corresponding data are given in Table 10. We see that the ratio of number of participants 65 years old compared to average per age between 60 and 64 is, at clinic A, 3.9 for the community, 4.1 for campus group C, and 3.0 for the un-weighted campus population at large (the campus groups T1 and T2 have samples that are too small to perform an analysis by age in this age range); and at Clinic B, 8.2 for the community and

[14] In the context of evaluating training programs, several studies have found this regularity (see Ashenfelter, 1978 and for a survey Heckman, LaLonde and Smith, 1999), sometimes called the "Ashenfelter dip" or the "pre-program dip". Individuals, after knowing the selection criterion, self select themselves into the program rather than being exogenously assigned to it: the observed mean in earnings in program participants declines prior to the entry into the program.

6.0 for campus. The 65 age group is also two to three times higher than the average per age between 66 and 70.

The existence of an abnormally high number of participants of age 65 is formally analyzed with the estimation of an age profile for participants. Since age 65 was a criterion for eligibility, we do expect a discontinuity in the number of participants between age 64 and age 65. The discontinuity must consequently be measured from above: To do this, we thus estimate the age profile of participants 66 years old and above only, and predict the participation at age 65 from above. We explored different functional forms (polynomials in age of 2nd, 3rd, and 4th degrees, 1/(1+ age), and $1/(1+ \text{age} + \text{age}^2)$), and retained the model that gave the best fit for age 65. The estimated curves are reported in Figures 1 and 2, and the corresponding predicted values are given in Table 11 where they can be compared with the observed values. In both clinics, the number of participants from the community is more than twice the predicted value (17 observed compared to a predicted value of 7.9 in clinic A, and 18 observed compared to 8.6 predicted in clinic B). The discrepancy is similar for campus participants, with a number of 19 for campus group C compared to 11.2 predicted, and observed 29 compared to 12.2 predicted in clinic B. The ratio is lower when one considers the campus participants to clinic A without sampling weights.

High increases in the incidence of old-timers at risk between 2003 and 2004 raises suspicions of cheating.

While we have no way of verifying if reasons invoked for being in a priority group were truthful or not, we can infer cheating among old-timers from categories where there was a huge increase in self-declared priority condition between this and last year (Table 11). Categories that naturally change from one year to the next, such as pregnancy and caring for infants, cannot be used for this test. We see that age has a benchmark growth rate of 5.5%, including knowing that the category was abused by some. Suspicious are reported increases over one year in chronic aspirin therapy (25.3%), chronic medical condition (19.5%), out-of-home care giver (9.1%), and health care worker (5.2%). These large percentage increases suggest that these categories may have been used to qualify as member of a priority group.

High anxiety not to miss days of work or study due to sickness was prevalent among campus participants not in priority groups.

Participants who self-reported that they were not in a priority category indicated "other reasons" to want a flu shot (Table 13). Most clear among them is "not being able to afford to miss days of work or study due to sickness". At Clinic B, many also indicated that they had recently discovered the importance of flu shots, that they were concerned with an epidemic, and that they were particularly exposed to others. It is notable that a high share of these participants was denied a flu vaccine by the medical personnel. Anxiety about loss of days of work or study was even higher among those who were denied a flu shot. This indicates that, while the population at risk was effectively serviced, a large effective demand also exists among people not in priority categories, yet considering that access to a flu shot is very important to them to meet their work and study plans.

V. CONCLUSION

In response to the sudden shortage of a vital commodity, appeals to voluntary cooperation combined with soft-handed screening to save supplies for the general population most in need may result in a net decline or in a net increase in effective demand. This is because responses to the shortage originating in hoarding and reduced procrastination may be smaller or larger than the gains from cooperation and screening. Assessing the contribution of each of these behavioral responses to total demand is an empirical question of relevance to help design more efficient approaches to the management of scarcity in a non-market setting.

The flu vaccine shortage of October-November 2004, combined with a randomized treatment of information across departments on a California university campus to control for the effects of strict deadlines and appeals to voluntary cooperation, allowed us to identify separately the roles of hoarding, procrastination, cooperation, and cheating on the demand for flu shots and their allocation. The surveys implemented at the last two clinics offered on Campus revealed that a large number of first timers were motivated by the shortage and by strict deadlines, creating new demands for vaccination and inducing procrastinators to come out and also add to demand. At the same time, we observed strong cooperative responses across all population categories, particularly undergraduate students. Screening was also effective in rejecting candidates for a shot among those attempting to cheat. However, cheating, revealed by confidential self-declaration of non-membership in priority groups, that remained undetected in soft-handed screening by health personnel at the clinic, allowed many to receive a flu shot.

Analysis at clinic A with the randomization set up among the campus population allows us to decompose these various effects as follows (Table 14). The first step is to project what would have been the population of candidates for a flu vaccination in "normal" times. Without any information from clinics in previous years, we use as a first approximation the observed rate of first timers in 2003 within the control group that came to the clinics. Applying the 10.5% rate of 2003 for the campus control group, rather than the observed 2004 rate of 23.2% (Table 3), we compute what we refer to as the "normal" population of candidates for flu vaccination of 1.17% campus members, and set this number equal to 100 in Table 14. The increase in demand from this "normal" level to the observed level of 1.3% of the campus population (Table 4, control group) which represents a 12.3% increase is thus interpreted as a response to the scarcity as publicly known at that time. The increase in demand between the control C and treatment T1 group (Table 4) translate into a 35.4 percentage points, attributed to the effect of the email announcing strict deadlines for the last two clinics. Adding the call for cooperation in the treatment T2 group reduced the demand by 36.7% (Table 7) or 54.2 percentage points. Screening by the clinic staff of 39% of the candidate in that group reduced vaccination by 36.5 percentage points. This resulted in a decline in vaccination from what would have been 100 shots in a normal year without any restriction to 57.1 shots. Note, however, that even among these 57.1 persons serviced, 39% admitted not belonging to a priority group (where this percentage is the complement of the last column of Table 8 for the T2 group).

In reducing demand, voluntary restraints thus accounted for 60% of the total effect and screening by medical personnel for 40%. Cooperation and screening combined in achieving a 91 percentage points decline in demand once shortages and deadlines were known. First timers for a vaccine were a population particularly strongly determined to obtain a vaccination. They are the group that showed less cooperation, more hoarding, more procrastinators, and more cheating compared to people who had a flu shot the year before. More cheating was observed on campus than in the community, among those more informed about deadlines (T1) and appeals to restraints (T2) than the general campus population (C), among females than males, and among students than faculty and staff. The priority categories of age 65, out of home care-giver, and having a chronic medical problem were used - and abused - to qualify for a priority category.

Appeals to cooperation and soft-handed screening at the clinic helped save 61% of the vaccines that would have been given in 2004 with knowledge of the shortage and deadlines. However, cooperation (inducing a 54.2% decline in demand) barely served to compensate for hoarding and reduced procrastination (resulting in a 47.7% increase in demand).

While 39% of the vaccines distributed were received by cheaters, the story turned out to have a happy ending. Virtually none of the population at risk desirous of obtaining a vaccination was left un-serviced. The leftover of vaccines at the end of the last clinic testified to the effectiveness in servicing the informed and willing population at risk. If the objective in managing scarcity was to minimize exclusion errors of populations at risk, while compensating for hoarding, procrastination, and cheating by appeals to cooperation and screening, the objective was met, with a 61% saving in flu shots made available to the general population at risk in the State of California.

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Table 1. Number of faculty, staff, and students by random treatment and control groups.

Campus Categories	T1	T2	C	Total
Population size				
Faculty	430	197	813	1,440
Staff	292	221	5,339	5,852
Graduate Students	3,308	1,879	4,431	9,618
Undergraduate Students	4,001	10,265	8,625	22,891
Total	8,031	12,562	19,208	39,801

C=control, T1= deadlines email, T2= detailed shortage email and call on restraint.
Source: Campus profile database 2004.

Table 2.1. Randomization tests for faculty

	T1	T2	C
Age groups (% distribution)			
0-24	0.5	0.6	0.8
25-29	5.5	4.4	5.7
30-34	11.7	11.7	12.3
35-39	13.8	14.5	14.5
40-44	9.9	10.7	10.8
45-49	10.0	9.3	10.2
50-54	8.9	9.3	10.8
55-59	9.6	10.7	10.1
60-64	12.1	11.7	10.9
65 and over	18.3	18.2	17.9
Tests of difference	T1-T2	T1-C	T2-C
Chi-sq(9); crit = 14.7	6.92	11.55	6.32
Kolmogorof-Smirnof	0.01	0.05	0.05
pvalue	0.94	0.95	0.95
Gender: %female	33.5%	31.8%	34.1%
Tests of difference	T1-T2	T1-C	T2-C
T-stat	0.78	-1.54	-0.37
Years of service	14.1	14.5	12.7

Source: Human Resources Customized Pivot Tables

Table 2.2. Randomization tests for staff

	T1	T2	C
Age groups (% distribution)			
0-24	7.8	7.6	6.1
25-29	10.6	11.8	9.2
30-34	10.9	12.7	10.8
35-39	11.4	11.5	10.9
40-44	12.8	12.0	12.6
45-49	13.5	13.4	14.0
50-54	12.3	13.3	15.5
55-59	11.3	12.0	13.2
60-64	6.7	3.7	5.2
65 and over	1.6	1.0	1.8
Tests of difference	T1-T2	T1-C	T2-C
Chi-sq(9); crit = 14.7	12.52	11.45	12.29
Kolmogorof-Smirnof	0.04	0.04	0.07
p-value	0.95	0.95	0.95
Gender: %female	66.4%	63.4%	63.4%
Tests of difference	T1-T2	T1-C	T2-C
T-stat	0.96	-1.46	-0.02
Years Service	8.9	8.5	8.8

Source: Human Resources Customized Pivot Tables

Table 2.3. Randomization tests for students

Gender		% Female	T-stat difference with C	T2
Graduate	T1	0.48	1.34	1.24
		(0.01)		
	T2	0.46	-0.19	-
		(0.01)		
	C	0.46	-	-
		(0.01)		
Undergraduate	T1	0.51	-1.18	-0.10
		(0.01)		
	T2	0.52	0.00	-
		(0.00)		
	C	0.52	-	-
		(0.01)		

Standard deviations in parentheses
Source: Campus profile data base

Table 3. Hoarding: New demand induced by the shortage

	Clinic A Campus C	t-stat for difference with previous year	Clinic A Community	t-stat for difference with previous year	Clinic B Community	t-stat for difference with previous year
Percent of participants in 2004 [in same year]						
Had a shot in 2001	54.9		68.8		63.3	
First time in 2002	4.4		2.6		2.2	
	[6.7]		[3.0]		[3.0]	
First time in 2003	10.5	2.24	3.0	0.63	4.4	1.16
	[13.7]		[3.5]		[5.8]	
First time in 2004	23.2	2.78	12.4	3.37	22.6	4.91
	[23.2]		[12.4]		[22.6]	

For 2001, percentage of all participants declaring having received a flu shot in 2001. First time in any other year means that the person received a shot in the current year, but not in the previous (computed among those with explicit information in both the previous and the current years). Percentages do not add to 100 due to missing information.

Standard errors clustered at the department*category level

Source: Flu-shot survey, Fall 2004.

Table 4. Procrastination: Deadlines induced demand (Clinic A)

	Demand for flu vaccine			t-stat on difference
	C	T1	Difference (%)	
Demand by category of campus population (percentage of each population category that came to Clinic A)				
Faculty	10.8	8.8	-18.5	-1.14
Staff	1.8	4.8	163.9	2.36
Graduate students	1.3	0.9	-25.8	-1.38
Undergraduate students	0.7	0.9	36.2	1.38
In percentage of the campus population				
Total demand (weighted average)	1.3	1.8	31.5	1.87
First-timers	0.30	0.48	60.5	1.36
Old timers	1.00	1.21	21.5	1.07

Source: Flu-shot survey, Fall 2004.

Table 5. Evidence on procrastination revealed by final deadlines (Clinic B)

	In risk category in		Percentage of the participants that had not received a flu vaccine in 2003	
	2003	2004	Community	Campus
Not at risk	No	No	8.9	21.5
New risk	No	Yes	13.3	35.5
Procrastinators	Yes	Yes	73.3	33.1
Unassigned	Missing information		4.4	9.9
Number of observations			45	121

Source: Flu-shot survey, Fall 2004.

Table 6. Share of procrastinators in different population groups (Clinic B)

Population groups	Total participants	All first timers	Procrastinators
		(Percent of participants in each category)	
Campus participants	382	33.4	10.5
Faculty	85	15.6	5.9
Staff	97	28.0	10.3
Students	139	45.9	10.1
U.C. spouse	68	33.3	16.2
Community participants	215	22.6	15.3
By priority group			
Adults 65 years of age or older	283	19.1	14.8
Under chronic medical conditions	191	22.8	15.2
Chronic aspirin therapy	48	15.9	12.5
Health-care worker	48	27.3	10.4
Out of home care giver	22	36.4	22.7
Any of the above	559	26.8	13.4

Source: Flu-shot survey, Fall 2004.

Table 7. Evidence on cooperation by campus members (Clinic A)

	Demand for flu vaccine			t-stat on
	Treatment 1	Treatment 2	Difference (%)	difference
Demand by category of campus population (in percentage of each category campus population)				
Faculty	8.8	6.1	-31.2	-1.26
Staff	4.8	3.2	-33.9	-0.95
Graduate students	0.9	0.6	-31.9	-1.20
Undergraduate students	0.9	0.5	-45.9	-2.51
In percentage of the campus population				
Total demand	1.8	1.1	-36.7	-2.26
Old timers	1.21	0.73	-39.6	-1.96
First-timers	0.48	0.38	-22.2	-0.71
Member of a priority group	0.78	0.42	-46.0	-1.85
Not member of a priority group	0.99	0.70	-29.4	-1.34

Source: Flu-shot survey, Fall 2004.

Table 8. Evidence on effective screening, legitimate service, exclusion errors, and inclusion errors (cheating)

	Effective screening: Non-priority not serviced	Legitimate service: Priority serviced	Exclusion error: Priority not serviced	Inclusion error: Non-priority serviced	Efficiency: Share of legitimate in total serviced
Criteria for definition of types					
Self-declared priority group	No	Yes	Yes	No	
Received flu vaccine	No	Yes	No	Yes	
	(Percent of participants in each category)				
Clinic A: categories of participants					
Community	2.9	92.5	0.00	4.6	95.3
Campus - Control	18.1	71.4	0.41	10.1	87.6
Campus - Treatment T1	36.8	43.5	0.41	19.3	69.3
Campus - Treatment T2	39.0	36.9	0.50	23.6	61.0
Clinic B: categories of participants					
Community	1.9	97.2	0.00	0.9	99.1
Campus	6.8	88.2	0.79	4.2	95.5
First timers					
Clinic A					
Community	7.1	89.3	0.00	3.6	96.2
Campus - Control	38.5	38.8	1.81	20.9	64.9
Campus - Treatment	54.4	19.5	1.12	25.1	43.7
Clinic B					
Community	4.4	91.1	0.00	4.4	95.4
Campus	13.2	76.9	0.83	9.1	89.4
Old timers					
Clinic A					
Community	2.4	92.9	0.00	4.7	95.2
Campus - Control	12.2	80.8	0.00	7.0	92.1
Campus - Treatment	27.4	53.6	0.40	18.6	74.3
Clinic B					
Community	0.7	99.4	0.00	0.0	100.0
Campus	3.3	94.6	0.83	1.2	98.7

Source: Flu-shot survey, Fall 2004.
Done Jan-10-2005

Table 9. Cheating by demographic category

First and second group	First group	Second group	p-value on difference
	(Percent of participants in each category)		
Clinic A			
Community vs. Campus control	4.6	10.1	0.04
Campus control vs. treatment	10.1	20.5	0.03
Male vs. female	10.7	20.0	0.08
First timers vs. old timers	22.2	13.7	0.25
Students vs. staff and faculty	16.5	18.3	0.70
Clinic B			
Community vs. Campus	0.9	4.2	0.03
Male vs. female	3.4	2.7	0.61
First timers vs. old timers	7.6	0.8	0.00
Students vs. staff and faculty	7.8	2.0	0.00

Source: Flu-shot survey, Fall 2004.
Standard errors clustered at the department*category level

Table 10. Number of patients by age: Observed peak at age 65 (both clinics)

	Clinic A			Clinic B	
Age group	Community	Campus Control	Campus non-weighted	Community	Campus
60-64 (*)	4.4	4.7	4.0	2.2	4.8
65	17	19	12	18	29
66-70 (*)	6.4	8.7	7.6	7.0	9.2
Ratio of 65 over					
60-64	3.9	4.1	3.0	8.2	6.0
66-70	2.7	2.2	1.6	2.6	3.2

(*) Average patients per age in relevant interval.
Source: Flu-shot survey, Fall 2004.

Table 11. Discontinuity analysis in demand around 65 years of age

Observed and predicted participation	Community	Clinic A Campus Control	Campus non-weighted	Clinic B Community	Campus
Observed at 65 years old	17	19	12	18	29
3rd degree polynomial					
Predicted at 65 years old	5.6	11.2	8.5	5.3	12.2
Standard error	1.91	2.16	1.89	1.61	1.60
1/(1+age)					
Predicted at 65 years old	7.9	9.1	7.8	8.6	9.3
Standard error	1.00	1.10	0.93	0.94	0.91

Best fit is shaded.
Source: Flu-shot survey, Fall 2004.

Table 12. Declared reasons for being in the corresponding priority group among old timers (Clinic B)

	Declared reason in 2004	Would have been in 2003	% increase 2004 over 2003
	(% of population coming for vaccination)		
Adults 65 years of age or older	53.7	50.9	5.5
Women who will be pregnant during the flu season	1.8	1.1	63.6
On chronic aspirin therapy	9.4	7.5	25.3
Health-care worker	8.1	7.7	5.2
Out-of-home care giver	3.6	3.3	9.1
Contacts with infant	6.6	1.7	288.2
With chronic medical conditions	35.5	29.7	19.5
Average number of observations	394	362	

Source: Flu-shot survey, Fall 2004.

Table 13. Reasons for wanting to have a flu-shot among campus participants not member of priority groups

	Clinic A		
	C	T1 and T2	Clinic B
		(percent)	
Contact with children	10.3	9.5	4.3
Can't afford to miss work or study	60.9	53.5	73.9
Believe shortage is just temporary	8.5	1.7	–
Recently discovered the importance of flu shots	15.2	8.7	28.3
Concerned by shortage	19.6	14.9	17.4
Concerned by potential epidemic	12.7	16.2	19.6
Particularly exposed to others	–	–	58.7
Other reasons[1]	22.9	27.6	13.0
At least one of the above	88.7	88.0	91.3
Did not fill this part of questionnaire	11.3	12.0	8.7
Flu-shot was denied	64.2	63.3	56.5
Number of observations	67	120	46
Can't afford to miss work or study			
Among those to whom a flu shot was denied	72.3	61.8	76.9
Among those that were serviced	40.5	39.2	73.7

– means category was not available in the questionnaire.

[1] Mostly "living in dorms", "in contact with people", "don't want to be sick", "always had a shot", "travel abroad".

Source: Flu-shot survey, Fall 2004.

Table 14. Decomposition of the effects of scarcity, procrastination, cooperation and screening on the number of flushots distributed (based on clinic A)

	Change	**Number**
Projected normal population of candidates for flu vaccination, 2004*		100
Increase in demand due to response to scarcity: hoarding	12.3	112.3
Increase in demand due to strict deadlines reducing procrastination	35.4	147.8
Voluntary restraints due to appeals to cooperation	-54.2	93.6
Screening of intended cheaters by medical personnel	-36.5	57.1
Vaccinations given to individuals in priority groups (% of vaccination)		34.8 (61%)
Vaccinations given to cheaters (% of vaccination)		22.3 (39%)

* Assuming that the 2003 rate of new participants would have applied to 2004.

Source: Flu-shot survey , Fall 2004

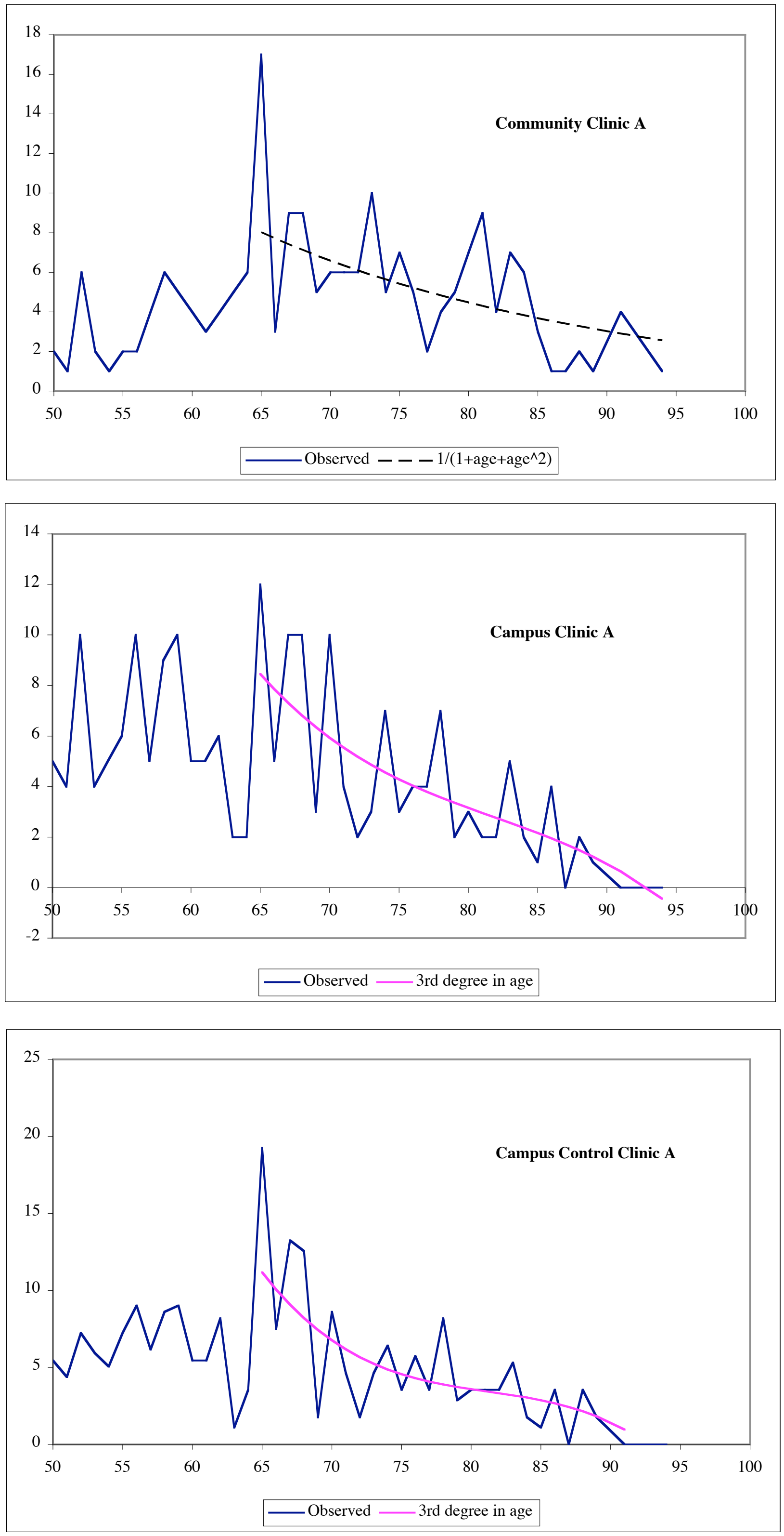
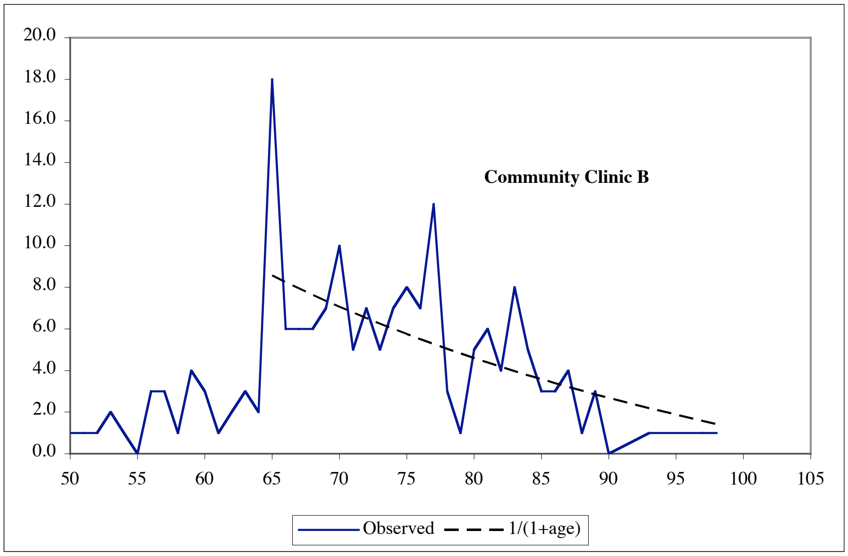


Figure 1. Age profile and discontinuity analysis (Clinic A)



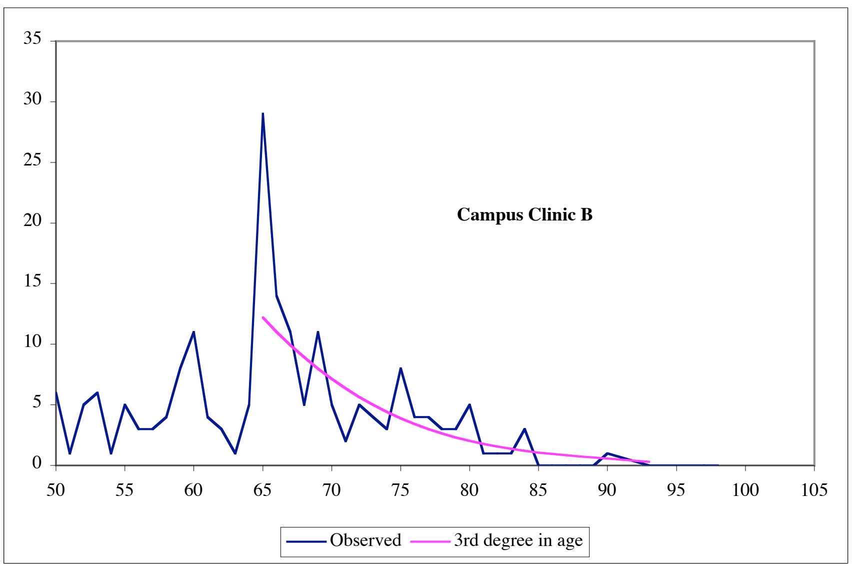


Figure 2. Age profile and discontinuity analysis (Clinic B)