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LIABILITY, INSURANCE AND DEFENSIVE MEDICINE:
NEW EVIDENCE

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DP 03/04

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Liability, insurance and defensive medicine: new evidence[1]

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17 July 2004

Abstract

For the first time, we test for effects of liability on hospital care using measures of *current* perceptions of litigation risk at *hospital* level; in particular, the risk-sharing arrangements agreed between hospitals and their insurers. GMM and ML estimators are used to allow for possible endogeneity of risk-sharing arrangements. Our findings are consistent with the exercise of liability-induced discretion by hospitals, especially regarding use of costly diagnostic imaging. Hospitals facing higher expected litigation costs also use these tests more frequently, after controlling for activity levels, casemix and treatment outcome; the latter indicating that defensive medicine may be present. We also find evidence of fewer new claims against these hospitals, given adverse events, which may indicate the increased use of claims management processes by hospital managers concerned at the expected cost of litigation.

KEYWORDS: Medical malpractice, defensive care, insurance, litigation
JEL Classification: I18, K13

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1   Introduction

Health care providers in many countries can face significant costs arising from the need to compensate patients who have suffered from negligent care. The incentive to avoid these costs is arguably a means by which health care quality can be governed. At the same time, it is possible that providers will over-supply care to minimise the risk of successful claims. Were it to occur, such "defensive" behaviour would constitute a misallocation of scarce health resources. Understandably, policy makers have been exercised by this issue, most recently in the US and the UK.[2]

Empirical work by Kessler and McClellan (1996) notes that tort liability reform throughout the US in the '80s and '90s should have influenced treatment levels because of associated changes in physicians' exposure to litigation risk. Using data on heart treatments in 1984, 1987 and 1990, they estimate that reforms aimed at relaxing tort (e.g. damage caps, contingency fee caps, shifts to no-fault) decreased expenditure on heart treatments by between 5% and 9% over the period, without any significant impact on health outcomes. From this they infer that the expenditure incurred was unnecessary from the health care perspective and was therefore evidence of so-called "defensive medicine". Similarly, Dubay et al (1999, 2001) report evidence of "defensive" cesarian sections and prenatal care in response to malpractice fears, but of smaller magnitude, while results from an Office of Technology Assessment study, based on physician surveys about hypothetical clinical scenarios, found that approximately 8% of diagnostic testing was "consciously

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[2] For example: "When I first came to Washington, I wasn't sure if the proper role of the federal government was to get involved with medical liability reform. Then I saw what frivolous lawsuits and the defensive practice of medicine do to the federal budgets. They cost us a lot of money. And it's a national issue, therefore. And so Congress needs to pass medical liability reform -- not only to send a message that tort reform is vital, but also to help us control the cost of medicine…" (President Bush to Newspaper Association of America Annual Convention, April 21st, 2004). In the UK, see the Chief Medical Officer's recent report on reform options for medical malpractice (CMO, 2003).

defensive" (OTA, 1994). However, a Congressional Budget Office analysis failed to replicate Kessler and McClellan's findings when extended to other patient groups (Beider and Hagen, 2004).[3] More recently, Kessler and McClellan have extended their research by exploring the mechanisms by which tort reforms affect the behaviour of health care providers, and find that the main effect is on the reduction of claim frequency and cost (Kessler and McClellan, 2000). It seems that US health care providers responded to changes in "malpractice pressure" primarily through using more diagnostic procedures in order to manage claims rather than improving health outcomes.[4]

The premise underpinning this notion of defensive medicine is that more diagnostic procedures may help providers establish in court that sufficient care was taken in order to disprove claims of negligence, even where these procedures have no proven impact on treatment outcomes.[5] However, the incentive for providers to behave in this way could be diluted to the extent that they are covered by liability insurance, given that the insurer will bear (some of) the cost of each claim. This paper is concerned with the impact on defensive medicine of risk-sharing provisions imposed by liability insurers. The paper presents evidence on the effect of insurance deductibles (or "excesses") on the extent to which individual hospitals successfully manage the risk of litigation, and whether this is associated with any discernable impact on treatment outcomes and/or the utilization of diagnostic procedures.

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[3] Similar ambiguity also appears in earlier work on defensive medicine: see Localio et al (1993), Klingman et al (1996), Baldwin et al (1995) and Sloan et al (1997). For broader overviews of the area see Danzon (2000a) and (2000b), Weiler (1991) and Weiler et al (1993).

[4] Moreover, it could be argued that US health care providers were better able to pursue this strategy because of the predominance of fee-for-service ("indemnity") health insurance, and that the advent of managed care may remove some of the opportunities for undertaking diagnostic procedures which are not cost-justified from the perspective of the plan (Kessler and McClellan, 2002).

[5] This of course implies a failure of the courts to apply an appropriate test of the standard of care required – namely one which equated the marginal cost of care with its marginal benefit in terms of improved outcomes.

The paper makes two contributions. First, information on liability insurance excess levels provides a unique insight into the varying litigation risk to which individual providers are exposed. Previously, a number of variables have been used to proxy the extent of this risk: Kessler and McClellan's work uses state-level variations in tort regime; Localio et al. use area-wide variations in physician insurance premiums; Sloan et al. use previous claims experience. Each of these presents difficulties relating to the potential remoteness of the measure from current incentives for care. We believe that we are able to measure a hospital's perceived litigation risk more accurately than previous work because insurance deductibles (observed at hospital level) provide a direct link with the expected cost of litigation arising from a given claim. In addition, while insurance coverage decisions, claims experience and tort reforms are all potentially endogenous (see Sloan et al, 1997; Cummins et al, 2001), hospital level data are more likely to yield suitable instrumental variables as a means of addressing this problem convincingly, and our paper draws on this potential[6]

Our second contribution is to note that defensive behaviour in the face of tort risk may encompass managerial decisions, such as those identified as "informal dispute resolution" techniques by Farber and White (1991). In principle, the effects of insurance excesses on the hospital's investment in both clinical and managerial decisions will depend on whether these inputs are complements or substitutes: for example, does additional informal dispute resolution effort increase or decrease the need for treatment care? For the first time, we consider this empirically by examining the link between insurance excesses and claims experience (on the assumption that such managerial decisions are aimed at decreasing the likelihood of a claim arising for a given level of care).

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[6] Sloan et al (1997) test for endogeneity using instrumental variables, but these are drawn from county level data.

The paper is structured as follows. Section 2 gives some basic theory. Section 3 reviews data available to us from UK hospitals, and the following section outlines the estimation methodology by which we test hypotheses concerning the effect of litigation risk on diagnostic procedures and treatment outcomes. Section 5 presents our results and a final section concludes.

2 Theory

Treatment failures (y) can be reduced if those involved take care (x) to avoid them. We assume that $y=y(x)$, and $y_x<0$, $y_{xx}>0$. However, to the extent that care is costly, health care providers may need to be given incentives to provide it. One natural incentive against insufficient care levels is to make the provider causing the harm (assuming causation can be determined) liable for the costs involved, if that provider fails to supply care beyond a sufficient threshold (i.e. behaves 'negligently'). In theory, for each treatment episode, the socially optimal level of care minimises total expected accident costs $x + p(x)D$, where D is the resulting damages, and $p(x)$ is the probability of a treatment failure, assumed to be decreasing in x, but at a decreasing rate. The socially optimal level of care solves $1 + p'(x^*)D = 0$: the marginal social benefit from an extra unit of care should equal its marginal social cost.[7] If courts are concerned with efficiency, they will set the legal standard of care at x^*. If a patient suffers a treatment failure, and it can be shown that the provider delivered care below x^*, it will be liable to pay D as compensation to the patient.

When the level of care is observable to all, and a claim for damages is made if $x<x^*$, it is straightforward to show that negligence liability would produce

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[7] See Miceli (1997) for more sophisticated models of liability rules.

socially optimal levels of care. Under these assumptions a risk neutral provider's care level solves

$$Min_x \begin{cases} x + p(x)D & \text{if} \quad x < x^* \\ x & \text{if} \quad x \geq x^* \end{cases} \qquad (1)$$

and the provider will clearly choose the efficient level of care x^*.[8] Conditional on this choice, informed patients will make no claims for negligence, although some treatment failures will remain: $y=y(x^*)$.

The informational assumptions required for this result are however substantial. On the one hand, patients may be uncertain about the provider's level of care, and this may influence the likelihood of a claim for damages. On the other hand the courts may also be uncertain about the provider's level of care, and this may influence the provider's view about what is necessary to avoid liability. For both these reasons, it is likely that the level of care chosen by providers under negligence liability may not be optimal, and this in turn will influence the frequency of treatment failures and subsequent claims.

Consider the possibility that both patients and courts observe the provider's level of care with error (u and v respectively). That is, for a given x, patients observe $x+u$, where $u \in [\underline{u}, \overline{u}]$ is a random variable drawn from the density $g(u)$, with $E(u)=0$. Similarly the court observes $x+v$, where $v \in [\underline{v}, \overline{v}]$ is a random variable drawn from the density $h(v)$, with $E(v)=0$. Hence the *ex ante* probability of a successful claim against the hospital by a patient receiving care x is[9]

$$\phi(x) \equiv p(x) \Pr(u \mid x + u < x^*) \Pr(v \mid x + v < x^*) \qquad (2)$$

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[8] This is guaranteed by the sharp increase in expected costs at care levels below x^*.
[9] Assuming u and v are independently distributed.

where $\Pr(u \mid x + u < x^*) = \int_{\underline{u}}^{x^*-x} g(u)du$ is the probability of a patient claim conditional on the occurrence of a treatment failure, and $\Pr(v \mid x + v < x^*) = \int_{\underline{v}}^{x^*-x} h(v)dv$ is the probability that the claim succeeds in court. It follows from the above assumptions that $\phi_x < 0$. The risk neutral provider's care level now solves

$$\underset{x}{Min}\, x + \phi(x)D \qquad\qquad\qquad (3)$$

Shavell (1987) shows that the care level that solves this problem with one source of uncertainty is greater than x^* provided that "the distribution of error is not too dispersed". It is possible to show that $x > x^*$ can still occur in the presence of our dual sources of uncertainty (see Appendix 1). In medical terms, this over-investment in care due to legal uncertainty is known as "defensive medicine".

Apart from demonstrating the potential for defensive medicine, the discussion so far raises two additional points. First, the above notion of defensiveness is of limited empirical value because it is difficult to operationalise: how does one judge when a level of care is greater than the (hard to measure) optimal level? Kessler and McClellan's (1996) solution is to identify as defensive that care which does not improve treatment outcomes. In our setting, this means that x is being applied despite the fact that $y(x)$ has flattened out. Second, an interesting corollary of the above result is that a provider faced with negligence liability has an incentive to control both the amount of care supplied (x) and the degree of error with which patients and courts observe the care level chosen (u and v). For a given level of care, improved information will result in fewer claims against the provider and a better chance of defending those that remain. It is for this reason that hospitals place considerable emphasis on accurate record-keeping and paper-trails, as well as

run a variety of complaints and mediation procedures in order to prevent treatment failures developing into legal claims (Farber and White, 1991). Activities of this nature are sometimes also discussed under the heading "defensive medicine", but we prefer to reserve that term for the (over) use of diagnostic or treatment procedures in response to the threat of litigation.[10] In the context of our model, the provision of such information will alter the distribution of court and patient errors and, potentially, change the provider's need to supply defensive levels of care. As claims management procedures are, like care, costly to operate, we would expect providers to use a combination of these measures in order to reduce their litigation risk.[11]

Another way in which health care providers can avoid this risk is by shifting it onto liability insurers, thereby possibly avoiding the incentives inherent in the negligence system – a moral hazard problem. In this case a range of measures is available for insurers to mitigate moral hazard, including experience-rated premiums and deductibles.[12] To show the effect of deductibles on provider behaviour, it is necessary to introduce uncertainty over the damages incurred by the patient. We assume that $D \in [\underline{D}, \overline{D}]$ is a random variable drawn from the density $f(D)$ (and cumulative distribution function $F(D)$) and denote claims management care as s. A provider who chooses a deductible of δ ($\underline{D} \leq \delta \leq \overline{D}$) is only liable for the first £δ of each claim, and therefore its care level decision solves

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[10] A better term for the use of procedures designed purely to reduce the incidence of successful claims contingent on treatment failure may be "claims management". Of course, some of the activities identified by Farber and White (1991) may be designed to reduce claims by providing patients with alternative remedies rather than improved information, but we abstract from this complication here.

[11] Formally, calling claims management care s, the provider solves $\text{Min}_{x,s} \; x + s + \phi(x, s)D$. An interior solution requires $\phi_x, \phi_s < 0$ so that claims management care reduces the probability of a successful claim by lowering the probability of claimant and court error. Interactions between x and s will depend on the sign of ϕ_{xs}. This may be positive or negative depending on how changes in x and s affect $g(\bullet)$ and $h(\bullet)$.

[12] The insurer may also seek to monitor its policyholders' behaviour but the transactions costs of doing this may be prohibitive or damaging to the efficiency of the underlying liability rule.

$$\underset{x,s}{Min}\ x + s + \phi(x,s)E(D\mid\delta) \tag{4}$$

where

$$E(D\mid\delta) = \int_{\underline{D}}^{\delta} Df(D)dD + [1 - F(\delta)]\delta \tag{5}$$

While one might expect providers facing a larger share of their liability risk as a consequence of a large deductible to increase both treatment and claims management care, the effects of δ on x and s are generally ambiguous, depending on the sign of ϕ_{xs}. In Appendix 2, a necessary condition for δ to increase both care levels is shown to be $\phi_{xs} < \max\{\phi_{xx}, \phi_{ss}\}$: the care levels are complements or 'moderate' substitutes. An intuitive (if extreme) example of a failure to meet this condition would be the case where claims management is so effective that claims rarely proceed, rendering treatment care relatively redundant. In this case, the latter may not need to increase with the risk of litigation.

To summarise our discussion, providers facing a litigation risk may take a number of steps to reduce this. In the presence of patient and court error in the observation of care levels, these are likely to include the defensive over-supply of treatment as well as investment in a variety of claims management processes (including detailed record keeping). Such activities seek to reduce the impact of uncertainty on the likelihood of facing a claim and, conditional on such a claim, on the likelihood of losing the case. We would typically (though not necessarily) expect providers who face a higher litigation risk (say, through a high deductible) to supply more care and to take more measures to reduce claims. These predictions are, in themselves, of considerable interest as they make clear that providers can adopt a variety of costly responses to changes in their risk of litigation. Accordingly, it is important to take all of these into account when assessing the effects of such changes in risk. Further,

to the extent that any extra treatment care supplied does not affect treatment outcomes, there may be evidence of defensive medicine. Below, we describe the data and methods we use to test these predictions, and the results.

3   Data

3.1   Excess levels

All hospitals in the UK face the same system of civil law, and the basis of liability has remained unchanged for centuries. However, it hospitals have not all faced the same expected cost of litigation. Since 1990, the health service in the UK has been decentralised to a significant degree such that individual hospitals have acquired considerable financial autonomy and have adopted commercial accounting practices. Over the same period, moreover, the responsibility for compensating injured patients has, almost unnoticed, shifted first from the individual clinician to the hospital[13], and now finally to the National Health Service Litigation Authority (NHSLA) as the central agency set up to pool litigation risks through what is known as the Clinical Negligence Scheme for Trusts (CNST). The NHSLA has, from April 2002, taken financial responsibility for 100% of all claims against NHS hospitals. Prior to this date, under the terms of the CNST, hospitals had to retain part of the cost through choosing an "excess" level (i.e. a deductible), below which they were responsible for the patient's claim. Thus, each hospital until recently has chosen an excess level under the pooling scheme (the CNST), and this determines the subsequent exposure to liability risk. The payment for CNST cover varies depending on the hospital's casemix, the excess level

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[13] So called "NHS indemnity" was introduced in 1990; in effect, the NHS accepted vicarious liability for negligent errors made by its employees and clinicians. In a broader context, it is this focussing of liability on the organization rather than the individual that has come to be known as "enterprise liability".

chosen, and, to a limited degree, the risk management standards applied and the claims experience observed over previous years.[14] Hospitals with low excess levels faced a lower expected cost from litigation than those with high excess levels. Consequently we have a unique opportunity to test whether this variation in liability risk had an impact on claim frequency, treatment failures and the use of diagnostic tests. Table 1 shows the variation in CNST excess levels across all English hospitals in the scheme:

Table 1 here

One fundamental issue for the subsequent analysis of these data is the potential endogeneity of the chosen excess level. It is quite plausible that the perception of liability risk is an important consideration when hospital management decides upon the appropriate CNST excess level to choose, with a consequent risk of simultaneity bias in the estimates.[15] For this reason in what follows we have tested for and, where necessary, used appropriate estimators in order to allow for the endogeneity of this variable.

3.2   Claims experience

Claims experience can be measured in a number of ways. For a sample of English hospitals in the CNST, we obtained data on the number of opened claims, the number of paid claims, and the number of claims currently outstanding (Fenn et al, 2001). Of these, the number of CNST claims newly opened is likely to be the best reflection of current care levels, given the long

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[14] Discounts of up to 25% of assessed contributions are given to hospitals who can demonstrate that they have in place certain risk management procedures. Contributions may also be varied by +/- 10% if there is evidence that their recent claims experience is substantially different from what was expected based on their casemix.
[15] Hospitals which feel they are at high risk of litigation, and who believe they can do little about this, may optimally choose low deductibles. Hospitals which believe they have taken effective action to control the risk of litigation may optimally choose high deductibles. For both these reasons, the measures we investigate below (claims, treatment failures, diagnostic tests) may be simultaneously determined with the excess level.

delay between claim initiation and claim payment for many medical malpractice claims. Figure 1 below shows the distribution of the number of new claims in 2001 for those hospitals that responded to our survey:

Figure 1 here

3.3 Care

The level of care taken by individual clinicians and health care providers is not generally observable. However, the Department of Health (DoH) does collect data from all hospitals on the numbers of certain types of diagnostic procedures – in particular the various types of imaging and scanning procedures which are available for diagnostic purposes.[16] These vary numerically from the very frequent and routine use of radio-graphs ("X-rays") and obstetric ultrasound scans, to the less common but growing techniques such as MRI scans and fluoroscopy. Table 2 shows descriptive statistics for these procedures.

Table 2 here

3.4 Treatment failures

Direct measures of the number of treatment failures arising from activity in each hospital are not available in the UK. However, as part of its emphasis on performance measurement at hospital level, the DoH routinely publishes data for each hospital on a range of outcome measures, such as 30-day mortality rates following specific types of admission. In addition they also publish the numbers of 28-day emergency readmissions following discharge. For our purpose this is a candidate proxy measure for the number of treatment failures

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[16] Department of Health Form KH12: "Imaging and radiodiagnostic examinations and tests".

in each hospital. Figure 2 below shows the distribution of readmissions in 2001 for all English hospital trusts.

Figure 2 here

3.5   Exposure

As far as factors potentially influencing inter-hospital variations in claims, treatment failures and diagnostic tests are concerned, the most important of these relate to the size and type of the hospital – direct measures of exposure to litigation risk in the absence of liability insurance. Clearly, raw activity level measures such as the number of admissions or treatment episodes at a particular hospital will be a factor determining the number of procedures and treatment failures, and therefore the number of claims made by patients. In addition, the nature of the treatment episodes will presumably influence the frequency and cost of claims: maternity hospitals, and those with a large proportion of acute beds, may be more open to litigation than others, for instance. Table 3 summarises the data we have in relation to hospital size (measured by the number of "finished consultant episodes" or FCEs) and type.

Table 3 here

In what follows we use the broad casemix variables summarised here as one way of proxying the risk type of individual hospitals – that is, their exposure to litigation. However, these represent a very rough classification of risk, and an alternative possibility arises from the way the NHSLA calculates the CNST contributions for each hospital in the scheme. In practice, this involves each hospital submitting a breakdown of its whole-time equivalent staff by specialty area, and then allocating a weight to each of these specialty groups based on prior evidence on the litigation risk of each group. This gives the base

contribution, which prior to April 2002 was reduced in relation to the hospital's chosen deductible/excess. This provides us with an alternative way of proxying risk type: we ran a regression of assessed contributions against a measure of hospital size and its excess, and used the residual from this regression as a means of revealing the NHSLA's assessment of risk.[17]

4 Estimation

4.1 New claims

For a given hospital, the process over time by which observed data are generated on the numbers of new claims could be characterised as a Poisson process with a constant rate of occurrence, μ. The observed number of claims would clearly depend on the population exposed to risk – such as the number of treatment episodes in a given year, N. Consequently, the expected number of new claims occurring in a given year at a given hospital would be the product $N\pi$, where π represents the mean probability of a treatment episode resulting in a claim. Given an assumed Poisson process, this would imply that the observed number of events (y) in a hospital in a given year is distributed with density

$$f(y; N, \pi) = \frac{e^{-N\pi}(N\pi)^y}{y!} \tag{6}$$

While we can observe N for each hospital, the parameter π is a latent variable, which can nevertheless be modelled as a function of observed covariates and unobserved random variables. With a conventional loglinear specification of

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[17] The relevant OLS regression was: Contribution (£000) = 38.08[4.27] + 0.0055[33.78].FCEs - 0.0011[4.55].excess. The R^2 was 0.81 and the t-statistics are in square parentheses.

this function, we have

$$\pi = \exp(\beta_1 N + \beta_2 d + \beta_3'\varrho + \varepsilon) \tag{7}$$

where d measures the expected cost of subsequent litigation (i.e. the deductible) and ρ is a vector of measures proxying the hospital's risk type[18]; β_1, β_2 and β_3 are the associated coefficients. The error term ε measures the impact of unobserved heterogeneity in the underlying risk across hospitals. Incorporating (7) into (6) leads to overdispersion of the Poisson distribution. A mixed distribution can be obtained once an assumption is made about the distribution of $\exp(\varepsilon)$. A common assumption for the heterogeneity is the gamma distribution, and the resulting Poisson/gamma mixture can be shown to generate a negative binomial distribution for y:

$$f(y; N, \pi, \alpha) = \frac{\Gamma(\alpha^{-1} + y)}{\Gamma(\alpha^{-1})\Gamma(y + 1)} \left(\frac{\alpha^{-1}}{\alpha^{-1} + N\pi} \right)^{\alpha^{-1}} \left(\frac{N\pi}{N\pi + \alpha^{-1}} \right)^y \tag{8}$$

where α defines the one-parameter gamma distribution for the heterogeneity variable $\exp(\varepsilon)$. If the distributional assumptions explicit in the above are correct, estimation of the parameters α, β_1, β_2 and β_3 by maximum likelihood is straightforward.

As pointed out in section 3.1, we believe that d is a potentially endogenous regressor. To test for this in relation to new claims we use a method suggested by Wooldridge (1997) for count data models with endogenous explanatory variables along similar lines to those suggested in other limited dependent variable contexts by Smith and Blundell (1986) and Rivers and Vuong (1988).

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[18] The exposure measure N is included as a regressor to capture the possibility that the per-episode risk of an event is sensitive to the level of exposure (i.e. the size of the hospital).

For a given explanatory variable *d* which is potentially endogenous, it is possible to estimate a reduced form regression equation of the form

$$d = \boldsymbol{z}'\boldsymbol{\theta} + \nu \tag{9}$$

where $\boldsymbol{z}$ represents a vector of exogenous variables including at least one not included in $\boldsymbol{\rho}$ for identification purposes, $\boldsymbol{\theta}$ is the corresponding vector of reduced form coefficients and ν is the reduced form error term for the i'th hospital. If it is possible to obtain $\hat{\boldsymbol{\theta}}$ as a consistent estimator for $\boldsymbol{\theta}$, Wooldridge shows that the residuals $\hat{\nu}$ defined by $\hat{\nu} = d - \boldsymbol{z}'\hat{\boldsymbol{\theta}}$ can be included as an additional covariate in a maximum likelihood estimator for the count data model, and that a significant coefficient on this covariate in the augmented regression is a robust test of the endogeneity of *d*. If the null of exogeneity cannot be rejected on the basis of a t-test on the relevant coefficient, the efficient estimator is the (non-augmented) negative binomial regression.

4.2 Diagnostic tests and readmissions

While the data available to us on diagnostic tests and readmissions, as summarized in section 3 above, are also in principle generated by a count data process, the frequency of counts across hospitals in these cases is relatively high. Because the conditional means of these variables are correspondingly high, it is likely that the standard linear IV estimator in the face of endogeneity is available to us, and would be robust to alternative distributional forms. However, because the underlying count data process has an intrinsic heteroskedasticity, and because the standard linear IV estimator is inconsistent in the presence of endogeneity together with heteroskedasticity of uncertain origin, we prefer to begin with a more general estimator such as linear GMM,

which is fully robust and asymptotically efficient (Baum et al, 2003).

We have grounds to believe that both issues may be relevant here. In particular, as discussed above, there is good reason to suspect that the deductible chosen by the hospital management is chosen with full knowledge of the litigation risks faced, and the actions planned to deal with these risks. Moreover, in addition to the intrinsic heteroskedasticity referred to above, the hospitals in our sample vary considerably in size and diversity, so arbitrary heteroskedasticity is likely. For these reasons we take the following approach to estimation: first, we estimate a GMM model for each event. Simultaneously, we test for heteroskedasticity and endogeneity in order to determine whether GMM is indicated. If neither endogeneity nor heteroskedasticity is present, we consider an alternative OLS estimator in order to improve the small sample estimation performance.

5   Results

5.1   Instrumental variables

To begin with, it is necessary to find ways of testing for the potential endogeneity of the deductible. To do this, some instruments are needed which fulfil the usual requirements of relevance and exogeneity. Fortunately, possibilities exist as a legacy of the initial regulations governing the choice of deductible. When the CNST was first brought into existence in 1995, restrictions were put in place on the minimum deductible permitted for different classes of hospital. For instance very large acute hospitals were initially not permitted to choose a deductible lower than £100,000[19], which in effect meant that they were exposed to the risk of paying for the great

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[19] £1 = \$1.8 (May 2004)

majority of claims. However, as the scheme matured over the following six years, the rules were relaxed, and by 2001 most hospitals were permitted to choose deductibles as low as £10,000. Nevertheless, through natural inertia and administrative delay, some hospitals decided to leave their deductible where it stood, rather than enter into financial calculations as to the optimal deductible for their particular risk profile. For this reason, the deductibles in place in our year of analysis (2001) were correlated with the class of hospital for reasons which were independent of the hospital's inherent risk type. To demonstrate the relevance of these instruments, Table 4 shows the results of a reduced form OLS regression explaining variations in the CNST excess level across NHS trusts in terms of the hospitals' DoH classification, and their casemix (proxied in two different ways). This regression shows a strong influence of hospital class on the excess level, and the F-test of the joint significance of the four class indicator variables is high.

Table 4 here

Having established the relevance of the candidate instruments, these are now used to test for the endogeneity of the deductible in regressions explaining the inter-hospital variation in litigation-related events: new claims, diagnostic tests, and treatment failures.

5.2   New claims

We now consider whether providers respond to litigation risk by seeking to reduce the likelihood of facing claims (perhaps through the provision of information in an informal dispute resolution system, as described by Farber and White, 1991). Table 5 presents the results of negative binomial ML regressions for the number of new claims as they vary across hospitals; again

two models are estimated corresponding to two different ways of proxying casemix.

Table 5 here

In columns (1) and (3) of the Table, the results are given for a regression augmented with the residuals from the relevant reduced form regression estimators. In both cases, the null of exogeneity cannot be rejected on the basis of a t-test. Consequently our preferred specifications are the non-augmented models, as reported in columns (2) and (4). The exposure variable (FCEs) is highly significant and positive as expected, and the coefficients on the deductible are significantly negative in both models, implying that a high exposure to the expected cost of litigation is correlated with a lower frequency of new claims.

5.3   Diagnostic tests

Next, we explore whether there is a link between exposure to litigation risk (as measured by the hospital's deductible) and the supply of care. Tables 6 and 7 present GMM estimates for regressions on the numbers of diagnostic imaging procedures of various kinds (as described above). Model 1 (in Table 6) uses three casemix measures to proxy risk type; model 2 (in Table 7) uses the residual from a regression of CNST contributions on hospital size and its deductible as a proxy for risk type. The test statistics show, respectively, the F-test for the overall fit of the regressions; the Pagan-Hall χ^2 test for heteroskedasticity; the Wu-Hausman F-test for the endogeneity of the deductible; and Hansen's J-test of overidentifying restrictions (a test of instrument exogeneity). The null of exogeneity of the deductible is rejected strongly in five of the seven regressions in model 1 and six of the seven in

model 2. In all but one case where exogeneity is rejected, the J-test of overidentifying restrictions does not allow us to reject the null of instrument orthogonality, which confirms the instrument set as both relevant and exogenous. Moreover, the null of homoskedasticity is strongly rejected in four of the seven regressions in model 2, indicating that standard IV regressions would not be suitable for all these data.

Tables 6 and 7 here

The results seem to suggest a separation of diagnostic imaging tests into two groups. First, those which are routinely undertaken in large numbers, such as ultrasound scans (both obstetric and non-obstetric) and radiographs; second those which are undertaken far less frequently on a less routine basis, such as CT/MRI imaging, and fluoroscopy. The latter group consistently have positive and significant coefficients on the hospital's deductible, implying that a greater exposure to potentially costly litigation encourages more of these tests to be undertaken (after taking account of the endogenous nature of the deductible in this context). With the former group, the coefficients on the deductible are much weaker, although generally positive. These tests are strongly determined by activity levels and casemix, and not apparently by fear of litigation.

These results provide insight into hospital reactions to litigation risk. They may also provide evidence of defensive medicine: hospitals appear to supply more discretionary types of care when their litigation risk is higher. In order to consider this possibility further, we end by exploring Kessler and McClellan's (1996) suggestion that genuinely defensive care will not impact upon treatment outcomes.

5.4   Treatment failures

Table 8 shows the results for GMM and OLS regressions on the number of emergency readmissions within 28 days of discharge. The statistics at the end of the GMM results show, as before, tests for overall fit, heteroskedasticity, endogeneity of the deductible, and instrument exogeneity. Both GMM models are significant overall, but it is not possible in either model to reject the null hypotheses that the deductible is exogenous and the disturbances are homoskedastic. In effect this means that GMM carries no advantages as an estimator, and OLS is preferred as a result of an improved small sample performance. Here the results are dominated by a strong impact of the exposure measure, and little else. In practice, the number of readmissions varies across hospitals only in relation to the number of patients admitted to treatment. There is not even a significant impact of hospital risk type (i.e. casemix).

Table 8 here

It appears from these results that the high incidence of diagnostic procedures in hospitals facing high litigation costs is not matched by a corresponding improvement in treatment outcomes, insofar as these can be measured by readmission rates. Whilst it is important to recognise that the lack of a correspondence between the use of diagnostic procedures and readmission rates does not rule out a relationship with other, longer term health outcomes, these results are consistent with the increased use of diagnostic procedures being "excessive", and designed only to reduce the likelihood of successful litigation.

5.5   Elasticities

Our findings can best be summarised by inspection of the following table of elasticities derived from the results reported in the previous sub-sections. The table shows the sensitivity of claims, various diagnostic procedures and readmissions to the relevant measures of activity and the insurance deductible respectively. The elasticities with respect to activity levels are indicators of the extent to which the adverse events considered here are simply driven by variations in the number of patients treated. The elasticities with respect to the deductible are indicators of the extent to which the events are driven by the expected cost of litigation, after controlling for hospital activity levels and casemix.

Table 9 here

As might be expected, both claims and readmissions are broadly proportional to the hospital's activity level: that is, a 10% increase in a hospital's treatment episodes results in an 11-12% increase in its emergency readmissions and negligence claims respectively. In the case of claims, there is some evidence that this would be supplemented by a 2% reduction in new claims conditional on a 10% increase in the deductible. By contrast there is no evidence of any significant impact of the deductible on the level of readmissions.

As far as diagnostic imaging procedures are concerned, the relatively infrequent, non-routine procedures are highly sensitive to the deductible, and presumably, therefore, to the litigation threat. The most sensitive tests are MRI/CT scans, radio-isotopes and fluoroscopy. The results suggest, for example, that a hospital with a £100,000 CNST excess used in the region of 50% more CT scans than hospitals with a £50,000 excess, after controlling for activity levels and casemix. By contrast the more routine procedures such as

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ultrasound scans and radiographs are mainly driven by the underlying activity levels rather than by the expected cost of litigation.

6   Conclusion

Under negligence liability, hospitals face the prospect of paying for harm caused to patients unless they can show that they (managers and clinicians) behaved reasonably in taking care to avoid the harm. Unfortunately, the courts' interpretation of reasonable care is not always easy to predict, and the uncertainty over the standard of care required is one explanation for the claimed existence of so-called "defensive medicine" and for administrative expenditures devoted purely to the management of patient claims.

The recent past has opened up a unique opportunity for research on this topic using UK NHS hospital data. A combination of financial autonomy at hospital level and risk-sharing arrangements in the years from 1995 to 2002 means that data exist on the extent to which different hospitals faced differing expected litigation costs arising from their mistakes. Evidently, we would expect hospitals facing greater litigation risks to be more likely to take action to minimise these risks. Such hospitals could take more care, which would include both increased monitoring of clinical practice and increased use of diagnostic tests designed to ensure that appropriate decisions are made. Depending on the underlying technology, this increase in care may or may not have a significant impact on health outcomes at the margin. Hospitals faced with higher expected litigation costs may also engage in activities to minimise the number and success rate of claims consistent with a given level of care.

The results reported in this paper are consistent with the exercise of litigation-induced discretion in relation to the use of costly advances in certain types of

diagnostic imaging. Those hospitals which faced a higher expected cost of litigation were those which used these tests more frequently. The fact that these additional tests did not apparently translate into a lower readmission rate may suggest that they were being used "defensively". That is, driven by uncertainty over the legal standard of care, providers have extended the use of such tests beyond the point at which they have significant benefits to patients.[20] Moreover, the finding that hospitals facing higher expected litigation costs reduced the number of new claims in spite of the absence of any impact on readmission rates may indicate the presence of a "Farber and White" effect, by which claims are "managed" through improved patient communication and informal dispute resolution measures.

To conclude, this paper has shown rigorously using unique hospital-level data that the threat of litigation has an impact on both clinical and managerial discretion. Our results suggest that this impact may extend to the supply of defensive levels of treatment care, with associated wasteful expenditures. Of course, the policy implications of these results need careful thought. For example, we believe it is unwise to ignore the possible incentive effects of liability rules on clinical practice and hospital management. The fact that we have identified hospitals responding to liability-induced incentives for increased care suggests that tort rules can be a powerful force for improvements in patient safety, even when they are filtered through liability insurance arrangements. Such insights need to be borne in mind when evaluating alternative mechanisms for compensating medical injuries.

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[20] It is of course possible that diagnostic tests have an impact on securing the most suitable intervention for patients, with better long term outcomes, and that this does not show up in data on acute, short term emergency responses to treatment failures.

Appendix 1

In this Appendix we confirm that defensive medicine may arise in the presence of two sources of uncertainty (in contrast to the single source in Shavell (1987). As out purpose is only to demonstrate this possibility, we use an example.

For simplicity, assume that $g(u)$ and $h(v)$ are identical uniform distributions on $[a, b]$ and denote $\Delta \equiv b - a$. (Shavell (1987) notes that the uniform distribution will support his result.) Also, let $p(x) = 1/x$. In the absence of any uncertainty, optimal care is $x^* = \sqrt{D}$. Given these assumptions, consider the problem in (2) in the text. We shall show that the provider's objective function can be decreasing in x when evaluated at x^*: i.e. a higher value of x minimises the function.

The derivative of the objective function in (2) is

$$1 + p'(x)[G(x^*-x)H(x^*-x)]D - p[g(x^*-x)H(x^*-x) + G(x^*-x)h(x^*-x)]D$$

Substituting for the distributions, and noting our simplifying assumption that G and H are the same, this expression becomes

$$1 + p'(x)\left(\frac{x^*-x-a}{\Delta}\right)^2 D - 2p(x)\left[\frac{x^*-x-a}{\Delta^2}\right]D$$

Evaluating this at $x = x^*$ yields

$$1 - \frac{a^2}{\Delta^2} + \frac{2a}{\Delta^2}\sqrt{D}$$

Since the distributions are centred on 0, $\Delta = 2|a|$ and the above expression simplifies to

$$\frac{3}{4} + \frac{1}{2a}\sqrt{D}$$

As $a < 0$, there are combinations of a and D that will make this expression negative.

Appendix 2

In this Appendix we provide a simple analysis of how the relationship between treatment care and claims management will influence the effect of insurance excesses.

Denote treatment care by x and claims management effort by s. The (composite) probability of a claim arising is now $\phi(x, s)$; we shall consider the signs of the partial (and cross-partial) derivatives of this below. The hospital solves

$$\underset{x,s}{Min}\ x + s + \phi(x,s)E(D\,|\,\delta)$$

Using subscripts to denote partial derivatives, the first-order conditions are

$$1 + \phi_x E(D\,|\,\delta) = 1 + \phi_s E(D\,|\,\delta) = 0$$

Note that a necessary condition for an interior solution to these equations is $\phi_x = \phi_s = -1/E(D\,|\,\delta) \equiv \phi' < 0$.

Using the first-order conditions, the effects of a change in δ are

$$\begin{bmatrix} \phi_{xx}E & \phi_{xs}E \\ \phi_{sx}E & \phi_{ss}E \end{bmatrix}\begin{bmatrix} dx \\ ds \end{bmatrix} = \begin{bmatrix} \phi'E_\delta d\delta \\ \phi'E_\delta d\delta \end{bmatrix}$$

where $E \equiv E(D|\delta)$, $E_\delta > 0$ and the first matrix is the Hessian (which we denote Δ below) and a sufficient second-order condition for a minimum requires $|\Delta| > 0$. Therefore

$$\frac{dx}{d\delta} = \frac{E_\delta E\phi'}{|\Delta|}(\phi_{xs} - \phi_{ss})$$

$$\frac{ds}{d\delta} = \frac{E_\delta E\phi'}{|\Delta|}(-\phi_{xx} + \phi_{sx})$$

The sufficient second-order conditions for a minimum give $\phi_{xx} > 0$ and $\phi_{ss} > 0$, and the results reported in Section 2 follow directly from this.

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Tables

Table 1: Excess levels for NHS hospitals, 2001

Excess (£)	Freq.	Percent
10000	159	44.54
25000	125	35.01
50000	46	12.61
100000	27	7.56
Total	357	100.00

Table 2: Diagnostic imaging procedures in NHS hospitals, 2001

Variable	Obs	Mean	Std. Dev.	Min	Max
CT scans	156	7681	5873	9	48845
MRI scans	140	3603	3098	1	20960
Obst u/s scans	152	10453	5815	20	37273
Other u/s scans	174	15909	11717	269	100045
R-isotopes	132	3127	2495	1	16710
R-graphs	176	89457	54837	597	363409
Fluoroscopy	165	5959	4256	35	25635

Table 3: Treatment episodes and casemix variables, NHS hospitals 2001

Variable	Obs	Mean	Std. Dev.	Min	Max
Finished Consultant Episodes	304	39451	37857	3	207764
Propn acute beds	357	.434	.377	0	1
Propn general beds	357	.137	.178	0	1
Propn maternity beds	357	.028	.047	0	.525

Table 4: Reduced form estimates for CNST excess levels, NHS hospitals 2001

	(1) CNST excess	(2) CNST excess
Small/medium acute hospital	741	2,392
	(0.22)	(0.87)
Large acute hospital	6,367	7,784
	(2.04)	(2.93)
Very large acute hospital	19,464	20,555
	(4.47)	(5.59)
Acute teaching hospital	50,530	52,137
	(5.80)	(6.07)
Proportion maternity beds	29.341	
	(0.19)	
Proportion acute beds	42.231	
	(1.16)	
Proportion general beds	-3.326	
	(0.08)	
Contribution residual		-10.666
		(0.49)
Observations	356	303
R-squared	0.34	0.34
F stat ($\beta_1=\beta_2=\beta_3=\beta_4=0$)	13.59	16.71
Prob>F	0.00	0.00

Table 5: Negative binomial regression estimates and endogeneity tests for new claims, NHS hospitals 2001

	(1)	(2)	(3)	(4)
	New claims	New claims	New claims	New claims
FCEs 2001	0.000036	0.000033	0.000033	0.000031
	(7.12)	(7.93)	(4.75)	(5.43)
CNST excess	-0.000019	-0.000008	-0.000012	-0.000006
	(2.12)	(2.50)	(1.23)	(2.00)
Excess residual	0.000013		0.000007	
	(1.24)		(0.58)	
Proportion maternity beds	0.020950	0.023870		
	(1.97)	(1.81)		
Proportion acute beds	-0.000803	-0.001221		
	(0.12)	(0.19)		
Proportion general beds	-0.020361	-0.018879		
	(1.75)	(1.64)		
Contribution residual			0.000620	0.000707
			(0.61)	(0.71)
Observations	112	112	112	112
Wald test	107.95	109.37	42.13	39.54
Pr>Chi2	0.00	0.00	0.00	0.00
alpha	0.71	0.72	0.78	0.78

Table 6: GMM estimates and tests for diagnostic imaging procedures (Model 1), NHS hospitals 2001

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	CT scans	MRI scans	Obst scans	Other scans	R-isotopes	R-graphs	Fluoros
CNST excess	0.104	0.075	0.008	0.073	0.053	0.024	0.109
	(2.49)	(2.77)	(0.26)	(1.33)	(1.68)	(0.12)	(3.18)
FCEs 2001	0.043	0.009	0.108	0.233	0.019	1.467	0.049
	(1.71)	(0.50)	(6.42)	(7.45)	(1.25)	(14.39)	(2.72)
Proportion maternity beds	-31.576	-154.175	563.666	176.949	-29.226	-620.329	-38.150
	(0.22)	(1.47)	(6.56)	(2.69)	(0.38)	(2.80)	(1.10)
Proportion acute beds	46.969	30.414	0.582	7.469	2.632	132.982	28.250
	(2.91)	(2.39)	(0.04)	(0.36)	(0.26)	(2.08)	(2.31)
Proportion general beds	24.306	20.296	3.623	71.740	-1.469	72.329	34.669
	(0.84)	(0.86)	(0.15)	(1.49)	(0.07)	(0.65)	(1.40)
Observations	153	137	149	171	129	173	162
F test	15.58	6.19	60.67	57.82	5.25	171.66	24.45
Pr>F	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Wu-Hausman F test	14.93	30.93	0.50	11.25	33.22	0.51	53.50
Pr>F [H0: chosenxs is exogenous]	0.00	0.00	0.48	0.00	0.00	0.47	0.00
Pagan-Hall Chi2 test	47.20	18.62	39.76	49.85	23.79	46.10	22.06
Pr>Chi2 [H0: disturbance is homoskedastic]	0.07	0.99	0.23	0.04	0.90	0.08	0.94
Hansen's J test	2.85	6.79	2.14	2.64	2.66	4.53	2.85
Pr>Chi2 [H0: instruments are orthogonal]	0.42	0.08	0.54	0.45	0.45	0.21	0.42

Table 7: GMM estimates and tests for diagnostic imaging procedures (Model 2), NHS hospitals 2001

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	CT scans	MRI scans	Obst scans	Other scans	R-isotopes	R-graphs	Flouros
CNST excess	0.090	0.064	-0.045	0.045	0.047	0.013	0.100
	(2.66)	(3.17)	(1.21)	(1.17)	(1.77)	(0.07)	(3.35)
FCEs 2001	0.060	0.018	0.145	0.254	0.021	1.502	0.059
	(3.04)	(1.22)	(10.47)	(12.82)	(1.74)	(17.47)	(4.00)
Contribution residual	12.703	7.480	28.594	24.758	4.924	70.271	2.847
	(3.06)	(2.70)	(6.55)	(4.76)	(1.59)	(3.00)	(0.77)
Observations	153	137	149	171	129	173	162
F test	21.98	10.74	72.88	112.10	10.09	239.60	32.20
Pr>F	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Wu-Hausman F test	11.40	21.95	7.00	5.56	27.88	0.00	50.69
Pr>F [H0: chosenxs is exogenous]	0.00	0.00	0.01	0.02	0.00	0.99	0.00
Pagan-Hall Chi2 test	34.51	22.35	66.26	57.57	19.79	63.66	21.75
Pr>Chi2 [H0: disturbance is homoskedastic]	0.01	0.17	0.00	0.00	0.28	0.00	0.19
Hansen's J test	5.30	13.48	4.27	1.13	4.68	2.54	3.68
Pr>Chi2 [H0: instruments are orthogonal]	0.15	0.00	0.23	0.77	0.20	0.47	0.30

Table 8: Regression estimates and associated diagnostic tests for readmissions, NHS hospitals 2001

	(GMM)	(OLS)	(GMM)	(OLS)
	Readms	Readms	Readms	Readms
CNST excess	0.001315	-0.000475	0.001897	-0.000494
	(0.36)	(0.27)	(0.57)	(0.28)
Admissions 2001	0.063378	0.065228	0.062912	0.065383
	(24.96)	(31.06)	(25.02)	(32.35)
Proportion maternity beds	-22.907771	-20.354383		
	(1.34)	(1.14)		
Proportion acute beds	2.708149	2.772787		
	(0.87)	(0.88)		
Proportion general beds	4.069535	2.291333		
	(0.86)	(0.57)		
Contribution residual			-0.400460	-0.299287
			(1.07)	(0.83)
Observations	154	154	154	154
F test	235.91		347.79	
Pr>F	0.00		0.00	
Wu-Hausman F test	1.30		2.33	
Pr>F [H0: chosenxs is exogenous]	0.26		0.13	
Pagan-Hall Chi2 test	38.29		32.58	
Pr>Chi2 [H0: disturbance is homoskedastic]	0.12		0.00	
Hansen's J test	3.14		3.51	
Pr>Chi2 [H0: instruments are orthogonal]	0.21		0.17	
R-squared		0.92		0.92

Table 9: Elasticities of event numbers with respect to activity and excess levels, NHS hospitals 2001

	Model 1		Model 2	
	Activity	Excess	Activity	Excess
New claims	1.235	-0.219	1.164	-0.170
CT scans	0.350	0.529	0.508	0.472
MRI scans	0.161	0.830	0.349	0.758
Obst u/s scans	0.614	0.027	0.826	-0.153
Other u/s scans	0.809	0.164	0.880	0.102
R-isotopes	0.379	0.653	0.427	0.585
R-graphs	0.877	0.009	0.899	0.005
Fluoroscopy	0.476	0.678	0.576	0.621
Readmissions	1.091	-0.006	1.093	-0.006

Figures

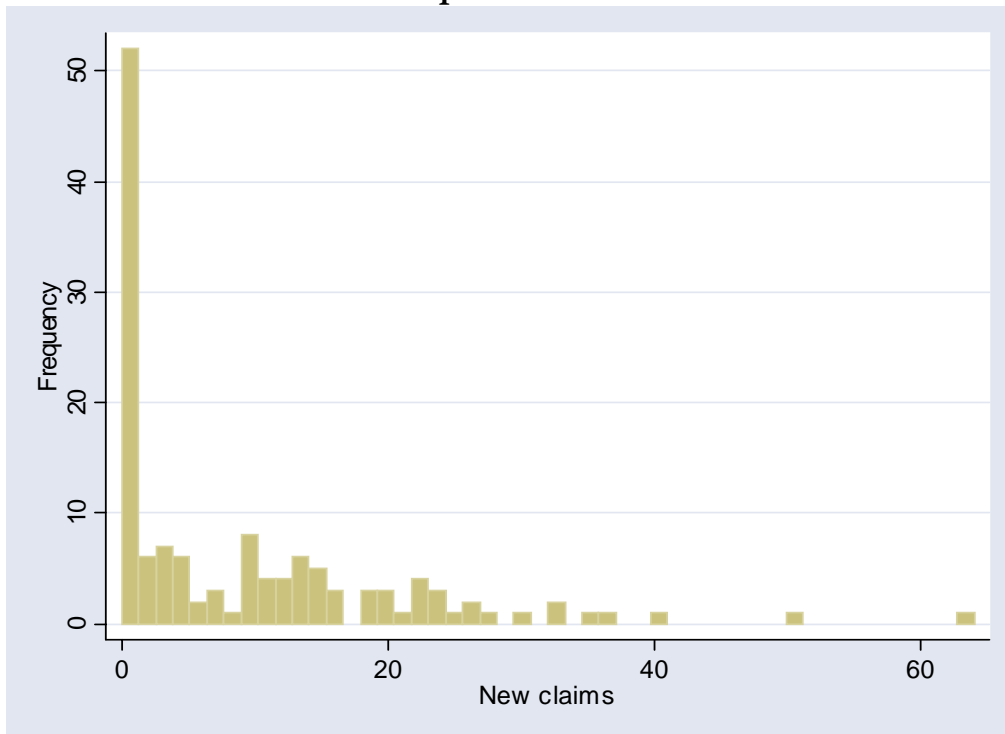## Figure 1: Frequency of new clinical negligence claims, NHS hospitals 2001

Figure 2: Frequency of emergency readmission within 28 days of discharge, NHS hospitals, 2001