Household Labor Supply Responses to Severe Health Shocks and the Benefits from Social Insurance

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Abstract

Analyzing administrative data on health and labor market outcomes, we study how individuals respond to spousal mortality and health shocks. We find a large increase in survivors' labor supply immediately following the death of their spouse, which is entirely driven by those who experience significant income losses due to the shock. In contrast, we find no economically significant spousal labor supply responses to non-fatal health shocks, consistent with the adequate insurance coverage for their associated income losses in our setting. We theoretically show that spousal labor supply responses have direct welfare implications for social insurance against mortality and health shocks and discuss efficient ways for targeting government transfers.

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1 Introduction

Severe illnesses and the subsequent deaths of primary earners are among the most devastating shocks that households face and are a major source of economic risk. The social insurance programs that protect households against the financial vulnerabilities imposed by these shocks – namely, survivors benefits and disability insurance – have become among the largest safety-net programs in most OECD countries in recent decades (OECD 2014).¹

In this paper we study how households respond to fatal and non-fatal severe health shocks and use that to draw implications for the design of social insurance. In the empirical component of the paper, we provide new and clear evidence on individuals’ labor supply responses to spousal mortality and health shocks and analyze the mechanisms that underlie these responses. Overall, we find significant increases in spousal labor supply when income losses are large and households lack adequate formal insurance, consistent with a self-insurance role of household members’ labor market behavior. Then, in a simple theoretical framework, we show that beyond their relevance for understanding households’ behavior over the life-cycle, these responses have direct welfare implications. We show that spousal labor supply responses to adverse events can be mapped into the household’s valuation of additional government transfers. Hence, household labor supply behavior can be used for assessing the benefits on the margin from the sizable social insurance programs that protect against income losses due to mortality and health shocks.

To recover the causal effects of these shocks we develop a quasi-experimental research design that constructs counterfactuals to affected households by using households that experience the same shock a few years in the future. We combine event studies for these two experimental groups and identify the immediate and longer-run treatment effects using a “dynamic” differences-in-differences estimator. The identification strategy that we offer relies on the assumption that the timing of the shock within a short period of time is as good as random. Therefore, it is applicable to the analysis of a wide range of other common economic shocks. We conduct the analysis by exploiting long panels of administrative data on the entire Danish population (from the years 1980-2011). These data provide comprehensive information on health-care utilization, income, wealth, and labor market behavior with spousal linkages, and are therefore ideal for our purposes.

Our empirical analysis focuses on the extreme shock of the death of a spouse, which can lead to significant and permanent income losses. Analyzing over 500,000 Danish households of married and cohabiting couples in which a member has died, we find an immediate and persistent increase in survivors’ labor supply following their spouse’s death. This response amounts to an average increase of 7.6% in survivors’ labor force participation and 6.8% in annual labor income by the fourth year after the shock.

The average effects that we find are entirely driven by households that experience substantial

¹For example, in 2014 the US government paid $93 billion to more than 6 million surviving spouses and $132 billion to 9 million disabled workers through the Old-Age, Survivors, and Disability Insurance program, compared to $846 billion paid in unemployment benefits (SSA 2015; White House 2015).
income shocks due to the loss of a spouse, and therefore have greater need for self-insurance through labor supply. In particular, we show that the mean increase in labor supply is attributable to survivors whose deceased spouses had earned a large share of the household’s income, who have less disposable income at the time of the shock, and who are less formally insured by government transfers. We also find that high-earning survivors decrease their labor supply, consistent with the conjecture that their high income is no longer necessary to support two people. Notably, widowers — who tend to be financially stable when losing their wives — decrease their labor supply, while widows — who tend to experience considerably larger income losses when losing their husbands — significantly increase their labor supply. By the fourth year after their husbands die, widows increase their participation by 11.3%, which translates into a 10.1% increase in their annual earnings.

We additionally analyze alternative hypotheses other than self-insurance for the mechanisms that may underlie the average increase in survivors’ labor supply. In particular, we find that the evidence is inconsistent with the conjecture that this response is driven by a lower cost of supplying labor (or a higher willingness to work) following the death of a spouse, e.g., due to loneliness and the desirability of social integration or because the survivor no longer has to care for an ill spouse.

In contrast to mortality shocks, we show that for shocks that are well-insured in our setting (through social and private insurance) and require no additional informal insurance, there are no economically significant spousal labor supply responses. Studying over 70,000 households in which a spouse experiences a non-fatal heart attack or stroke, we find that the earnings of the affected individuals drop by 19% after the shock, while the household’s post-transfer income declines by only 3.3%. Consistent with this lack of a significant income drop, there are no notable changes in the unaffected spouses’ participation with an economically small decline in labor earnings (of about 1%). The combination of our quasi-experimental design and rich administrative data allows us to precisely estimate this small response, which has proven difficult in previous studies (e.g., Coile 2004; Meyer and Mok 2013).

Following our empirical analysis, we highlight in a simple theoretical model the importance of studying the labor supply responses of spouses by showing they can inform the design of social insurance. Specifically, we show that these ex-post responses to shocks are an integral component of the assessment of social gains from additional government benefits and, thus, have direct welfare implications. The intuition of this theoretical result is that the extent to which households self-insure income losses using spousal labor supply is directly related to the degree to which they lack formal insurance. Hence, the relative changes in spousal labor supply in response to health and death shocks can reveal the scope for additional welfare-improving government benefits through the social insurance schemes that protect against them.

We conclude with a discussion on the qualitative welfare implications of our findings in light of the simple theoretical framework. First, our results show that the relative increase in survivors’ labor supply is substantially larger for older widows. Driven by the differential attachment to the labor force over the life-cycle, this finding suggests that survivors benefits should be age-dependent. Second, survivors’ labor supply is strongly increasing in the share of the household’s income that the
deceased had earned, which suggests that survivors benefits should be a function of the deceased spouse’s work history. Evidently, both of these features characterize the current large survivors benefits scheme within the Social Security system in the US.

This paper relates to several strands of the literature. First, a significant and active body of research studies the effects of adverse health on own labor market outcomes. This includes smaller-sample studies using survey data in the US (e.g., Charles 2003; Chung 2013; Meyer and Mok 2013) as well as recent large-scale studies in countries in which administrative data that link health and own labor market outcomes are available (e.g., Lundborg et al. 2011; Halla and Zweimüller 2013; Pohl et al. 2013; Gupta et al. 2015). Due to the unavailability of large-scale data that combine both administrative health-care utilization and labor market information and include household linkages, there is very little direct evidence on the effects of health shocks on household labor supply (e.g., Coile 2004 and Meyer and Mok 2013 who use survey data in the US). Our paper provides novel empirical results for the impact of health shocks on spousal labor supply using large-scale data with objective health measures, and to the best of our knowledge, is among the first papers to study labor supply responses to spousal death.

Second, numerous past empirical studies have analyzed spousal labor supply responses to wage and unemployment shocks in order to uncover the extent to which it is used as insurance (what is known as the “added worker effect”). However, while spousal labor supply is commonly modeled as an important self-insurance mechanism against adverse shocks to the household (e.g., Ashenfelter 1980; Heckman and Macurdy 1980; Lundberg 1985), this prior empirical work has been unable to find evidence of significant labor supply responses to temporary spousal unemployment (e.g., Heckman and Macurdy 1980, 1982; Lundberg 1985; Maloney 1987, 1991; Gruber and Cullen 1996; Spletzer 1997). The leading explanation for this lack of evidence has been that in the context of temporary unemployment income losses are small relative to the household’s lifetime income and are already sufficiently insured through formal social insurance (Heckman and Macurdy 1980; Cullen and Gruber 2000). Consistent with this explanation, in a carefully estimated life-cycle model that accounts for insurance from government transfers, Blundell et al. (2015) find that wives’ labor supply is an important consumption insurance device against permanent shocks to husbands’ wages, as opposed to (wealth-constant) transitory shocks. To uncover the self-insurance role of spousal labor supply using a different strategy, Cullen and Gruber (2000) study whether it is crowded out by unemployment insurance benefits and find a large crowd-out effect; and in recent work Autor et al. (2015) find similar crowd-out effects in the context of disability insurance. We take an alternative empirical approach in a new setting, different from unemployment shocks, and directly study the effects of severe health shocks with different degrees of income loss: mortality shocks, which impose large and permanent income losses that are only partially insured, and morbidity shocks, which are well-insured in our setting.

Third, prior related work on estimating welfare gains from social insurance has focused on studying its “consumption smoothing” effects, mostly in the context of disability insurance with
little direct work on the gains from survivors' benefits. Our conceptual framework offers an alternative approach that uses data from the labor market instead of consumption data, and studies smoothing of spousal labor supply. In practice, each approach has its comparative advantages which we discuss in the paper, and hence we view the analysis of fluctuations in consumption of goods and fluctuations in consumption of leisure as complementary methods. In our main context of mortality shocks, studying consumption would under-estimate the benefits from additional survivors' benefits: the large increase in widows' labor supply mitigates the consumption drop they would otherwise experience, but comes at a cost of reduced leisure which is accounted for in the analysis of labor supply. Additionally, to address the change in the household's composition following a spouse's death, consumption analysis would rely on estimates for adult equivalence scales (Blundell and Lewbel 1991) that account for economies of scale in the household. These estimates would be essential for translating changes in household expenditure into actual changes in survivors' individual consumption, in contrast to the analysis of labor supply behavior that can be directly assigned to individual household members.

Our theoretical analysis also relates to and builds on recent work on labor market methods for welfare analysis in the context of unemployment, which rely on the labor market behavior of the unemployed (Shimer and Werning 2007; Chetty 2008; Landais 2015). In the shocks that we consider, in which adverse health hurts individuals' ability to work, these methods cannot be applied. The directly affected individual may be unresponsive to economic incentives (or even deceased) and hence cannot reveal the household's preferences through labor market behavior. Exploiting the interplay between the labor supply decisions of household members, our approach uses only the responses of the indirectly affected spouse. As such, our analysis offers a labor market method in a household setting that is also applicable to other economic shocks in which the individual who is directly impacted may be unresponsive to economic incentives or at a corner solution (of either working full-time or not working at all). For example, relevant to the debate on the privatization of Social Security, the value of protecting against pension-wealth losses in the 401(k) account of a working individual can be assessed by the labor supply response of his or her spouse.

The paper is organized as follows. Prior to our empirical analysis, Section 2 describes the private and social institutional environment in Denmark and the data sources that we use. In Section 3 we develop our empirical research design for recovering the causal effects of adverse shocks. Our core empirical analysis is presented in Section 4. In this section we estimate individuals' labor supply responses to spousal mortality and health shocks and analyze the heterogeneity in these responses to study their underlying mechanisms. In Section 5 we provide a simple theoretical framework.

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2 This work includes reduced-form studies in the context of health shocks and the death of a spouse (e.g., Myers et al. 1987; Hurd and Wise 1989; Auerbach and Kotlikoff 1991; Cochrane 1991; Stephens 2001; Bernheim et al. 2003; Meyer and Mok 2013; Chung 2013; Ball and Low 2014; Dobkin et al. 2015) and studies that rely on structural economic modeling in the context of disability insurance and Social Security (e.g., İmrohoroğlu et al. 1995, 2003; Huang et al. 1997; Kotlikoff et al. 1999; Bound et al. 2004; Benitez-Silva et al. 2006; Nishiya and Smetters 2007; Chandra and Samwick 2009; Bound et al. 2010; Low and Pistaferri 2015; Autor et al. 2015).
that illustrates the normative relevance of our estimates. We briefly discuss the qualitative welfare implications of our findings in Section 6. Section 7 concludes.

2 Data and Institutional Background

To study labor supply responses to spousal mortality and severe health shocks we turn to the Danish institutional setting and its rich administrative data. The Danish setting is unique in providing data on both health and labor market outcomes, as well as household linkages, and is therefore ideal for our purposes. In this section, we describe the Danish insurance environment, both social and private, as it relates to sick individuals and surviving spouses, and list our data sources.

**Institutional Background.** It is useful to distinguish between two types of insurance: health insurance (coverage of medical care) and income insurance (insurance against income losses in different health states). Health insurance in Denmark is a universal scheme in which almost all costs are covered by the government, with a few exceptions such as dental care, chiropractic treatments, and prescription drugs that entail a limited degree of out-of-pocket expenses. Therefore, the Danish setting allows us to concentrate on (social and private) income insurance for losses that go beyond immediate medical expenses, as we describe below.

In Denmark, income insurance against severe health shocks and the death of a spouse consists of four main components that are typical of systems in developed countries: temporary sick-pay benefits, permanent Social Disability Insurance, privately purchased insurance policies, and other indirect social insurance programs (such as early retirement and old-age pensions).

During the first four weeks after a health shock occurs, workplaces are obliged to provide the sick employee with sick-pay benefits, which fully replace wages as long as the employee is ill within this period. Some common agreements and work contracts insure wage earnings against sicknesses of longer duration. For example, some blue-collar common agreements in the private sector provide wages during periods of sickness for up to one year. If the sick worker’s contract does not provide such a scheme, then the local government must provide flat-rate sick-pay benefits from the fifth up to the fifty-second week after the worker has stopped working. In 2000, for example, a sick worker received a fixed daily rate that added up to DKK 11,400 ($1,425) per month (the same as the prevailing unemployment benefit rate).

If the worker remains sick and is unable to work, he or she can apply at the municipality level for Social Disability Insurance (Social DI) benefits that will provide income permanently. For example, in 2000, subject to income-testing against overall household income, a successful application amounted to DKK 110,400 ($13,800) per year for married or cohabiting individuals and DKK 144,500 ($18,000) for single individuals.

Importantly for our analysis, the Danish Social DI program has a broad social insurance scope. It can be awarded for vaguely defined social reasons, to individuals who are deemed to be in need of government assistance. In 1984 the notion of “social reasons” came to replace a complex mix of programs, such as survivors benefits for women and special old-age pensions for single women (where
the motive behind this rule change was that the pre-1984 rules discriminated between genders). Therefore, Social DI is the effective social insurance mechanism for surviving spouses who are unable to maintain their standard of living after losing their partners. Indeed, we find sharp increases in the take-up rate of Social DI by survivors immediately after their spouses die. Hence, we refer to Social DI in the context of spousal mortality shocks as social survivors benefits.

While Social DI and its surviving benefits component are state-wide schemes, they are locally administered. Regional councils (in a total of 15 regions) decide whether to approve or reject an individual's application, and municipal caseworkers (in a total of 270 municipalities) administer the application and handle all aspects of each case—including any contact with the applicant, preparation of the application, and collection of financial and health status records. The local administration of the program, combined with the vague notion of awarding benefits for social reasons, has led to differential application processing behavior across municipalities. In turn, it has resulted in substantial variation in rejection rates—ranging from 7% to 30%—and thus in the mean receipts of the program's benefits across the different municipalities over time (Bengtsson 2002). We exploit this municipality-year variation in the awarding of the survivors benefits component of the program later in the paper.

Another source of income to a household that experiences health shocks or in which a member dies is payments from an employer-based insurance policy, an element that is standard in labor-market pension plans. Since 1993, most sectors covered by common agreements (75% of the labor force) have mandatory pension savings, part of which consists of life insurance and insurance against specific health shocks. These pay out a lump-sum to the sick worker, as long as he or she is making contributions to the pension plan, or to the surviving spouse in case the plan member dies. The rates of these payouts are set by the individual pension funds. In addition, individuals can purchase private insurance policies of a similar structure.³

Lastly, there are old-age social insurance programs that can indirectly protect eligible survivors or households that experience other shocks, who can decide to take them up at different ages according to their financial needs. When crossing into their 60s and until they reach their old-age pension retirement age, individuals who have (voluntarily) been members of an unemployment fund for a sufficiently long period (10 years before 1992 and gradually increasing to 20 years thereafter) are

³Note that while the private market for life insurance is not negligible, there is a potentially important role for government intervention. Purchasing life-insurance products in Denmark requires answering a health status and behaviors questionnaire (and even undergoing medical exams) and, therefore, applications by unhealthy or older households are likely to be rejected. These rejections by the insurance companies can be explained by private information that is held by these rejected households (Hendren 2013). In addition, it is common that even when the life-insurance product is purchased by younger and healthy households (both in group and non-group markets) the coverage sharply declines with age, leaving older and unhealthy Danish households with no coverage through the private market against spousal death. A recent study by the Danish government suggests that approximately two thirds of the survivors surveyed received or expected to receive some transfer from a life insurance policy (see http://www.raadtilpenge.dk/~/media/PPP/Mister%20aestofaelle/Grafikrapport.pdf), consistent with the findings of Cavapozzi et al. (2013). In our sample, which spans 1980-2011, this coverage rate is likely smaller because life insurance holdings experienced a significant increase in the last decade due to the expansion of labor market pension schemes that sometimes include a life-insurance component.
eligible for the Voluntary Early Retirement Pension (VERP). Approximately 80% of the population is eligible for VERP, which provides a flat-rate annual income of roughly DKK 130,000 ($16,250). At the “full-retirement” age of 67 (or 65 for those born after July 1, 1939) all residents become eligible for the Old-Age Pension (OAP), which provides income-tested annuities of up to DKK 99,000 ($12,375) per year for singles and DKK 75,000 ($9,375) for coupled individuals (at 2000 rates). Note that the benefits to single survivors who qualify for social survivors benefits are reduced at age 67 (from $18,000 to $12,375) when the program transitions into the Old-Age Pension.4

Data Sources. We have merged data from several administrative registers to obtain annual information on Danish households of married and cohabiting couples from 1980 to 2011. We use the following registers: (1) the national patient register, which covers all hospitalization records (from both private and public hospitals), and from which we extract information on all the individuals that experienced a heart attack or a stroke; (2) the cause of death register, from which we identify death dates; (3) income registers, which include all sources of household income – e.g., labor income, capital income, annuity payouts, and government benefits from any program – as well as annual measures of gross wealth and liabilities;5 and (4) the Integrated Database for Labor Market Research, which includes demographic variables for the entire population as well as measures for full-time and part-time employment for individuals younger than 60. These measures are constructed using records of employees’ payments to the government-mandated ATP pension scheme. The mandatory level of payments into this program is a one-to-one function of employment status, where full-time employment is defined as working at least 30 hours per week all 12 months of the calendar year (“full-time full-year”), and part-time employment is defined as working at some point during the year but either fewer than 30 hours per week or fewer than 12 months within the calendar year.

All monetary values are reported in nominal Danish Kroner (DKK) deflated to 2000 prices using the consumer price index. In that year the exchange rate was approximately DKK 8 per US $1. We postpone describing the summary statistics of the analysis sample to the next section since they directly relate to the discussion on the advantages of our research design.

3 Research Design

The goal of our empirical analysis is to identify the causal (ex-post) effects of spousal mortality and health shocks on individuals’ labor supply. In this section we describe the empirical strategy that

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4 An additional small government-mandated pension scheme (for all wage earners in Denmark) that supplements the OAP is the ATP program. This program pays out a life annuity to individuals who reached full-retirement age, based on the number of years they contributed to the scheme. In 2003, for example, the average annual payout from the scheme amounted to DKK 4,900 ($612). Unlike the OAP, there is a life insurance element tied to this scheme, albeit negligible relative to the other labor-market based (as well as privately-purchased) life insurance policies. Until 2002 a surviving spouse was eligible for 30% of the capitalized value of the deceased spouse’s remaining benefits. Since 2002 survivors are instead eligible for a lump sum of DKK 40,000 ($5,000), taxed at 40%, if the deceased spouse is younger than 67 at death (which progressively reduces with the deceased’s age at death and entirely lapses if the spouse dies after age 70).

5 In our main analysis sample of spousal mortality shocks, the net assets of the median household amount to only DKK 13,236 ($1,655) while the median annual household-level income is DKK 239,922 ($29,990). Therefore, our analysis of labor supply responses focuses on income losses, and we use the wealth data in robustness checks.
we develop for overcoming the selection challenges inherent in the identification of these effects. We also report summary statistics of the analysis sample to display the comparability of our treatment and control groups.

3.1 Quasi-Experiment

The ideal experiment would randomly assign shocks to households and track labor supply responses over time. Therefore, we need to compare the responses to shocks of affected households to the counterfactual behavior of ex-ante similar unaffected households. This requires comparing households with same expectations over the distribution of future paths, but with different realizations, to isolate the “unanticipated” component of the shock. The access to over three decades of administrative panel data on the universe of Danish households allows us to develop a quasi-experimental research design that mimics this ideal experiment, by exploiting the potential randomness of the timing of a severe health shock or death within a short period of time.

To do so, we look only at households that have experienced the shocks that we consider at some point in our sample period, and identify the treatment effect from the timing at which the shock was realized. We construct counterfactuals to affected households using households that experience the same shock a few years in the future, and recover the treatment effect by performing event studies for these two experimental groups. Note that a simple event study, which analyzes the evolution of outcomes of a treated group around the time of a shock, is not appropriate for our application. Pure event studies identify short-run responses, while we are interested in identifying longer-run effects because of potential delays in adjustment (due to, e.g., labor market frictions). This necessitates a control group, as we construct in our design, that can account for complex life-cycle trends in the counterfactual behavior absent a shock (in, e.g., spousal labor force participation as depicted in Appendix Figure 1).

Before formally describing our research design, we illustrate with a concrete example its basic intuition of the similarity of households that experience shocks close in time.

Illustrative Example. Let us focus on a treatment group of individuals born between 1930 and 1950 who experienced a severe health shock, in particular, a heart attack or a stroke, in 1995. Consider studying the effect of the shock on some economic outcome of these individuals, e.g., their labor force participation. Panel A of Figure 1 plots the outcome for these households against the outcomes for households that have not experienced this shock in our sample period, and reveals very different life-cycle patterns across the two groups prior to 1995. This suggests that traditional matching estimators, which use these unaffected households as a control group, are inappropriate for our application as their validity will rely on the set of available controls and on the unconfoundedness assumption. Panel B of Figure 1 plots the outcome for the treatment group of households that experienced a shock in 1995 as well as for households that experienced the same shock in 2010 (15 years later), in 2005 (10 years later), in 2000 (5 years later), and in 1996 (1 year later). Studying the

\[\text{Note: This assumption requires that conditional on observed covariates there are no unobserved factors that are associated both with the treatment assignment and with potential outcomes (Imbens and Wooldridge 2009).}\]
behavior of households that experienced the shock in different years reveals increasingly comparable patterns to those of the treatment group’s behavior – in terms of trends before 1995 – the closer the year in which the individual experienced the shock was to 1995. These patterns confirm our intuition and suggest using households that experienced a shock in 1995 + Δ as a control group for households that experienced a shock in 1995. Panel D of Figure 1 displays a potential control group when we choose Δ = 5.

Our method generalizes this example by aggregating different calendar years. Simply put, our design conducts event studies for two experimental groups: a treatment group composed of households that experience a shock in year τ, and a matched control group composed of households from the same cohorts that experience the same shock in year τ + Δ. We identify the treatment effect purely from the trend in the difference in outcomes in each year across the two groups.

The trade-off in the choice of Δ, which captures the main weakness of our design, can be seen in Panel C of Figure 1. On the one hand, we would want to choose a smaller Δ such that the control group is more closely comparable to the treatment group, e.g., year 1996 which corresponds to Δ = 1. On the other hand, we would want to choose a larger Δ in order to be able to identify longer-run effects of the shock, up to period Δ − 1. For example, using those who experienced a shock in 2005 (Δ = 10) will allow us to estimate the effect of the shock for up to 9 years. However, this entails a potentially larger bias since the trend in the behavior of this group is not as tightly parallel to that of the treatment group. Our choice of Δ is five years, such that we can identify effects up to four years after the shock. We assessed the robustness of our analysis to this choice and found that local perturbations to Δ provide very similar results.

**Formal Description of the Design and Estimator.** Fix a group of cohorts, denoted by Ω, and consider estimating the treatment effect of a shock experienced at some point in the time interval [τ1, τ2] by individuals who belong to group Ω. We refer to these households as the treatment group and divide them into sub-groups indexed by the year in which they experienced the shock, τ ∈ [τ1, τ2]. We normalize the time of observation such that the time period, t, is measured with respect to the year of the shock – that is, t = year − τ, where year is the calendar year of the observation. As a control group, we match to each treated group τ the households among cohorts Ω that experienced the same shock but at τ + Δ for a given choice of Δ. For these households we assign a “placebo” shock at t = 0 by normalizing time in the same way as we do for the treatment group (t = year − τ).7

Denote the mean outcome of the treatment group at time t by \( y_t^T \) and the mean outcome of the control group at time t by \( y_t^C \) and choose a baseline period (or periods) prior to the shock (e.g., period \( t = -2 \)), which we denote by \( p \) (for “prior”). For any period \( n > 0 \), the treatment effect can be simply recovered by the differences-in-differences estimator

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\beta_n \equiv (y_n^T - y_n^C) - (y_p^T - y_p^C).
\]  

The treatment effect in period \( n \) is measured by the difference in outcomes between the treatment

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7 By construction, their actual shock occurs at \( t = \Delta \).
group and control group at time $n$, purged of the difference in their outcomes at the baseline period, $p$. Note that the choice of $\Delta$ puts an upper bound on $n$ such that $n < \Delta$.

The identifying assumption is that, absent the shock, the outcomes of the treatment and control groups would run parallel. In particular, in accordance with the differences-in-differences research design, there is no requirement regarding the levels of outcomes. The plausibility of this assumption relies on the notion that within the short window of time of length $\Delta$ the particular year at which the shock occurs is as good as random. To test the validity of our assumption, we accompany our empirical analysis with the treatment and control groups’ behavior in the five years prior to the shock year 0 in order to assess their co-movement in the pre-shock period. By showing that there are virtually no differential changes in the trends of the treatment and control groups before period 0, we alleviate concerns that the two groups may still differ by, e.g., their expectations over the particular year of the shock within our chosen five-year window of $\Delta$.8

Other papers that use similar identifying assumptions include earlier studies in the context of the long-run effects of job displacement (Ruhm 1991) and the effect of arrests on employment and earnings (Grogger 1995), as well as more recent studies such as that by Hilger (2014), who exploits variation in the timing of fathers’ layoffs in order to study the effect of parental income on college outcomes. Our quasi-experimental design can be applied to these shocks and to any other shock whose exact timing is random, which can be validated in any particular setting by studying the pre-trends of the experimental groups.

Estimating Equation. We use the simple “dynamic” differences-in-differences estimator of equation (1) to study the evolution of household responses in the graphical event studies that we conduct below. To quantify the mean treatment effects, we estimate the regression counterpart of this estimator, averaged over the years after the shock. In the regression results we also explicitly report statistical significance and account for controls as a robustness check. Our baseline estimating equation is of the form:

$$y_{i,t} = \beta_0 + \beta_1 \text{treat}_i + \beta_2 \text{post}_i \times \text{treat}_i + \beta_3 \Delta \text{treat}_i \times \text{post}_i + \beta_4 X_{i,t} + \alpha_i + \varepsilon_{i,t}.$$  \hspace{1cm} (2)

In this regression, $y_{i,t}$ denotes an outcome for household $i$ at time $t$; $\text{treat}_i$ denotes an indicator for whether a household belongs to the treatment group; $\text{post}_i$ denotes an indicator for whether the observation belongs to post-shock periods; $X_{i,t}$ denotes a vector of potential controls; and $\alpha_i$ is a household fixed effect. The parameter $\beta_3$ represents the average causal effect of spousal shocks on household outcomes.

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8Conceptually, as long as there is no perfect foresight we can use our strategy with the appropriate choice of $\Delta$. This choice is context dependent and requires empirical investigation, where any potential difference across the experimental groups would be included in the bias consideration in the choice of $\Delta$. Comparability is then an empirical question that can be investigated in several ways, such as: (1) analyzing sub-samples of shocks that are more likely to come as a surprise; (2) studying the robustness of the results to a rich set of controls; and the strategies we mentioned above: (3) testing for parallel trends in the pre-period; and (4) investigating the sensitivity of the results to the chosen control group by changing $\Delta$. We conduct this set of tests in our application and verify the robustness of our results in support of our underlying identifying assumption. The analysis of tests (1)-(3) appears in the paper, and the analysis of (4) is available from the authors on request.
3.2 Analysis Sample and Summary Statistics

Appendix Table 1 displays key summary statistics for the analysis sample. The sample of our main analysis includes households in which one spouse died between ages 45 and 80 and is comprised of 310,720 households in the treatment group and 409,190 households in the control group.

The table reveals the advantage of our research design—the comparability of the year of observation and the age of unaffected spouses across experimental groups. The average survivor in the treatment group loses his or her spouse in 1993 at age 62.86 and the average unaffected spouse in the control group experiences the placebo shock in year 1993 at age 62.27. The sub-sample of survivors under age 60, the age at which there is a large drop in labor force participation (due to eligibility for early retirement benefits as shown in Appendix Figure 1), displays even closer similarities. By construction, the research design nets out calendar year effects. However, due to the randomness of the exact timing of the shock (and without directly matching on age), it also effectively nets out life-cycle effects by comparing groups of almost identical ages.

The sample for our secondary analysis of severe health shocks includes households in which one spouse experienced a heart attack or a stroke (for the first time) and survived for at least three years. These shocks are among the leading causes of death in the developed world and their timing within a short period of time is likely unpredictable. Since the average age of spouses precisely at the time of these health shocks is just over 60 (60.67), we focus on households with both spouses under 60 to ensure that the results we document are driven only by the health shocks and not by eligibility for early retirement benefits.9 The sample consists of 37,432 households in the treatment group and 54,926 households in the control group. The unaffected spouse is on average 45.7 years old in the treatment group at the time of the shock and 45.3 years old in the control group, where the mean calendar year of the shock is around 1992 for both groups.10

4 Spousal Labor Supply Responses

In this section, we present our primary analysis of the impact of mortality and health shocks on spousal labor supply. We begin with the focus of our study, the extreme shock of spousal death. We present the average labor supply responses of survivors and then analyze the heterogeneity of these responses to uncover the mechanisms through which they may operate. In particular, we study how survivors’ behavior varies by the degree of income loss imposed by the death of their spouse and by the extent of coverage through survivors benefits to study the self-insurance role of spousal labor supply. We also analyze other potential mechanisms using a simple test that aims at assessing the extent to which survivors’ willingness to work may change in response to the shock. Then, we briefly study households’ labor supply responses to non-fatal severe health shocks—specifically,

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9 The results do not change, however, when we look at the unconstrained sample.
10 We also report the means of main labor supply outcomes in Appendix Table 1 for completeness. Note that participation and earnings are slightly higher for the control group, which poses no threat to the validity of the design since comparability requires similar trends and not similar levels.
heart attacks and strokes – for which the resulting labor income losses are well-insured in our setting.

4.1 Labor Supply Responses to the Death of a Spouse

4.1.1 Mean Responses

Panels A and B of Figure 2 plot the average labor supply responses of individuals whose spouse died between ages 45 and 80. Panel A reveals an immediate increase in labor force participation (defined as having any positive level of annual earnings) following the death of a spouse. By the fourth year after the shock, the surviving spouses’ participation increases by 7.6% – an increase of 1.6 percentage points (pp) on a base of 20.6 pp. Panel B of Figure 2 shows that this response translates into a 6.8% increase in annual earnings (including zeros for those who do not work). Appendix Figure 2 repeats this analysis for survivors whose spouses experienced a heart attack or a stroke for the first time and died within the same year. This allows us to focus on deaths that are more likely to be “unexpected” and come as a surprise, and for which we have a sufficient number of observations. As seen in the figure, the pre-trends, levels, pattern of response, and response magnitudes are all very similar to those in the sample of deaths from any cause.\textsuperscript{11}

With significant disparities in baseline participation rates and labor income, men and women may face substantially different financial distress when they lose their spouse and, therefore, may respond differently to this shock. Indeed, Panels C and D of Figure 2 reveal clear differences in the responses of widowers and widows. While on average widowers do not change their labor force participation when their wife dies, widows immediately and significantly increase their labor force participation when they lose their husband. Four years after the shock, widows’ labor force participation increases by 2.2 pp from a baseline participation rate of 19.5 pp, which amounts to a large increase of 11.3% in their labor force participation.

This differential response suggests that female survivors have greater need to self-insure through labor supply and that they experience greater income losses when they lose their spouse as compared to their male counterparts. To test this conjecture, we plot the evolution of overall household income (from any source) around the death of a spouse, including earnings, capital income, annuity payouts, and benefits from social programs. We begin by plotting the household’s income in the absence of behavioral responses from the unaffected spouse in order to capture the income loss directly attributable to the loss of an earning spouse. To do so, we plot in Panel A of Appendix Figure 3 the household’s overall income, holding the unaffected spouse’s earnings and social benefits at their pre-shock level.\textsuperscript{12}

Before discussing this figure, it is useful to mention benchmarks for the changes that we observe in household income in order to interpret their magnitude. Following a spousal death, the household’s composition changes so that insuring the private consumption of surviving spouses does not require the entire 100% of the household pre-shock income. At the same time, potential economies of scale

\textsuperscript{11} Similar results were found for the small sample of “accidental” deaths. The analysis is available from the authors on request.

\textsuperscript{12} Specifically, we fix the surviving spouse’s labor income, Social Disability and Social Security benefits as well as sick-pay benefits at their level in \( t = -1 \).
within the household can make 50% of the household’s income before the shock insufficient for the survivors to maintain the same level of utility (see, e.g., Nelson 1988; Browning et al. 2013). The share of the household’s income that would keep individuals’ consumption utility at its pre-shock level is usually assumed to lie between 50% and 100% and is commonly referred to as the adult “equivalence scale”. Some commonly used scales are the modified OECD equivalence scale of 67% and the square-root scale of 71%. One would expect surviving spouses to broadly compensate for income losses with respect to this general benchmark, such that declines in household income on the order of 29%-33% would not require self-insurance through labor supply. Note that we merely mention this benchmark to gauge magnitudes. Our analysis of income losses compares relative losses across gender sub-groups, and does not rely on assumptions regarding the exactly appropriate compensation level. 

Panel A of Appendix Figure 3 shows that widowers, who do not change their labor supply on average, experience an overall decline of 32% in household income. However, as expected by their different labor supply responses, widows experience a significant relative loss of 8 pp compared to widowers, so that the potential decrease in household income is 25% larger for female survivors. To study the actual change in household income, Panel B of Appendix Figure 3 takes into account the surviving spouses’ labor supply responses and any change in the benefits they may receive from social or private insurance. The figure shows that widows experience an actual decline of 31% and that widows manage to decrease their additional potential loss – through the increase in labor supply and higher take-up of social insurance – to incur an actual decline of 35%. Overall, widows’ labor supply responses account for 22% of the 5 pp shrinkage in their potential income loss (from 40% to 35%). Note that surviving spouses do not fully compensate for a loss in household income (to 100%) since as singles they do not need the full pre-shock level of income.

Younger Households. The baseline labor supply behavior of individuals below and above age 60 substantially differ. At age 60 there is a sharp drop in participation when 80% of the labor force becomes eligible for early retirement benefits. This implies that surviving spouses under age 60 have a much stronger attachment to the labor force and significantly higher labor earnings and are, therefore, implicitly more financially resilient after the loss of an earning spouse. Consistent with this view, Panels A and B of Figure 3 reveal that widows under 60 exhibit a much smaller relative increase in labor supply compared to the universe of widows. Their “shock elasticities” amount to a mere increase of 3.3% in participation and 3.2% in annual earnings. Interestingly, widowers under 60 respond with a decrease in their labor supply, which amounts to a 4.1% decline in their annual earnings. The majority of these widowers (74%) earned more than their deceased wives and, compared to widows, they have significantly larger baseline participation rates (0.78 vs. 0.715) and

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13 The implicit equivalence scale in the Danish Social DI is approximately 0.65 and is 0.66 in the Old-Age Pension (see Section 2). The relevant equivalence scales that we mention here are for adults because the median age of the youngest child of our treated individuals born after 1930 (for whom we have data on children) is 30, with only 10% having a youngest child under 18.

14 Indeed, as we mentioned in the introduction, the difficulty of knowing the correct benchmark for full compensation is one of the issues that make the analysis of consumption fluctuations (relying on changes in income flows) challenging for welfare evaluations in the context of spousal mortality.
average labor income (DKK 227,560 vs. DKK 138,232). Therefore, their behavior is consistent
with the notion that they no longer support two people in the household and that, as singles, they
may not require the entire amount of their high labor income to meet their consumption needs.
Put together, the behavior of younger households suggests that their higher participation rates and
annual earnings effectively insure them better against losing an earning spouse. We further test this
hypothesis directly in Section 4.1.2, where we analyze heterogeneity in survivors’ responses by the
level of their own pre-shock earnings.

For younger survivors, the registers additionally consist of administrative measures for full-time
and part-time employment as defined in the data section. This allows us to further investigate
the dynamics of spousal labor supply behavior and to distinguish between extensive and intensive
margin responses. As we show in Figure 4, in periods 0 and 1 there are temporary transitions to
part-time work, consistent with spending time with the dying spouse and mourning his or her loss.
These transitions stabilize thereafter such that the active decision margin becomes full-time work
vs. non-participation.

For completeness, we report in Appendix Table 2 estimates for the regression counterparts of
the main figures that we presented so far by using the specification of equation (2). To account for
the full-time/part-time dynamic responses that we documented above, \( post_{it} \) assumes the value 1
for periods 2 to 4 (when the response stabilizes on the full-time margin). We present in the table the
average treatment effects and their statistical significance, and verify the robustness of our results
to the inclusion of year, age, and household fixed effects.

4.1.2 Heterogeneity in Responses by Income Losses and Degree of Insurance

We continue with further investigation of the heterogeneity in the survivors’ labor supply re-
sponses across different subgroups to provide evidence that is consistent with the insurance mecha-
nism hypothesis. Importantly, using different strategies we show that the responses are proportional
to the loss of income that survivors experience when their spouse dies, and depend on the survivors’
degree of financial stability and level of insurance.

Within-Gender Analysis of Heterogeneity by Income Loss. We begin by studying the effect of
the death of a spouse on labor force participation by the degree of income loss for each gender
separately. To this end, for each household we calculate the potential income loss due to the shock
in the following way.

First, similarly to Panel A of Appendix Figure 3, we calculate for each household the overall
income (from any source) holding the unaffected spouse’s earnings and social benefits at their pre-
shock level (in \( t = -1 \)). Second, we calculate the ratio of this “potential income” measure in \( t = 1 \)
to the household’s income in \( t = -1 \). Third, we normalize this ratio for the treated households by
the mean ratio of the control households in order to purge life-cycle and time effects. This leaves
us with a measure of the potential income replacement rate for each treated household, which we
denote by \( r_{rr} \), that captures the change in household income directly attributed to (and only to) the
loss of a spouse. This measure is smaller whenever the deceased spouse’s relative contribution to
the household’s income was larger. Notably, it accounts for the deceased spouse’s income from any source: labor earnings, private or social retirement income, and benefits from government programs. Therefore, as required for our analysis, it also captures the income loss imposed by the death of older non-working individuals who receive income from sources other than the labor market.

To study the heterogeneity in labor supply responses by the income replacement rate (rr
), we augment the baseline differences-in-differences model of equation (2) and estimate the following specification:

\[
l_{i,t} = \beta_0 + \beta_1 \text{treat}_i + \beta_2 \text{post}_i,t + \beta_3 i \times \text{treat}_i + \beta_4 X_{i,t} + \alpha_i + \varepsilon_{i,t},
\]

where

\[
\beta_3 = \beta_{30} + \beta_{31} \text{rr}_i + \beta_{32} Z_{i,t}.
\]

In this regression \( l_{i,t} \) denotes an indicator for the labor force participation of the unaffected spouse in household \( i \) at time \( t \). We adjust the basic differences-in-differences design by allowing the treatment effect, \( \beta_{3i} \), to vary across households and model it as a function of the household’s potential replacement rate \( \text{rr}_i \). Our parameter of interest is \( \beta_{31} \), which captures the extent to which the surviving spouse’s labor supply response correlates with the income loss he or she experiences. Since \( \beta_{31} \) can capture other dimensions of heterogeneity beyond the income replacement rate, we let the treatment effect vary with additional household-level characteristics, \( Z_{i,t} \), such that \( \beta_{31} \) further isolates the treatment effect’s partial correlation with the loss of household income.\(^{15}\)

Table 1 reports the results of estimating (3) separately for each gender, with and without \( Z_{i,t} \), for the entire sample of surviving spouses and for only the sub-sample of survivors under age 60. The results consistently show throughout the specifications the strong correlation between labor supply responses and income losses: survivors in households with lower potential income replacement rates (lower \( \text{rr}_i \)), who experience larger income losses, are much more likely to increase their labor force participation in response to the shock. Specifically, it implies larger increases in spousal labor supply among households in which the deceased had earned a larger share of the household’s income. Since controlling for the additional interactions with \( Z_{i,t} \) does not change the results much, the evidence suggests that the heterogeneous responses are indeed driven by differential income replacement rates.

In addition, the estimation results reveal very similar sensitivity to income losses across genders; so that re-weighting the female and male sub-samples using the regression in (3) to match on pre-shock own and spousal income would lead to similar average responses across genders. This strengthens the conjecture that unobserved gender differences (e.g., in preferences) do not drive the differential average labor supply responses across female and male survivors, but rather their divergent income losses.

**Responses by Own Earnings.** The heterogeneity in responses with respect to the loss in household income that we have analyzed so far has focused on income changes **relative** to pre-shock flows.

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\(^{15}\)The variables we include in \( Z_{i,t} \) are age dummies for the surviving spouse, dummies for the age of the deceased at the year of death, year dummies, indicators for the number of children in the household as well as the surviving spouse’s months of education (and its square). The results are also robust to the inclusion of a quadratic in the household’s net wealth. Note that \( X_{i,t} \) always includes the variables in \( Z_{i,t} \) as well as their interaction with \( \text{treat}_i \) and \( \text{post}_i,t \).
An additional strategy for studying this sort of heterogeneity focuses on the levels of the surviving spouses’ disposable income available at the time of the shock. To do this, we turn to analyze how labor supply responses of surviving spouses may vary with their own level of earnings when their spouses die, since higher-earning survivors have more disposable income and are therefore effectively better insured.

We constrain the sample in the following way. First, we exclude surviving spouses whose average labor income before the shock (in periods -5 to -2) was lower than that of their experimental-group-specific 20th percentile. Then, for each household we calculate the pre-shock labor income share of the deceased spouse out of the household’s overall labor income and include only households in which both spouses were sufficiently attached to the labor force. Specifically, we keep households for whom the average share was between 0.20 and 0.80. These restrictions allow us to focus on households in which there has been some loss of income due to the death of a spouse and in which the surviving spouse earned non-negligible labor income both in levels and as a share within the household.16

We divide the remaining sample into five equal-sized groups according to the survivors’ pre-shock level of earnings, and plot in Panel A of Figure 5 the average labor income response (as well as its 95-percent confidence interval) against the pre-shock mean earnings for each group.17 The figure reveals a strong gradient of labor supply responses with respect to the survivors’ own level of earnings when the shock occurs. Survivors at the bottom of the income distribution increase their annual earnings by 7.79% in order to meet their consumption needs, while those at the top decrease their earnings by 2.93%. As for widowers younger than 60, the behavior of the high-earning survivors is consistent with the notion that their high income is no longer necessary to support two people and that they may find lower levels of income sufficient for their consumption needs as singles.

Since the household’s pre-shock labor income is composed of two earners, we need to account for the pre-shock earnings of the dying spouse. Hence, we divide the sample into two groups – households in which the dying spouse’s pre-shock labor income fell within the bottom three quintiles of its group-specific distribution, to which we refer as “low earners”, and households in which the dying spouse’s pre-shock labor income fell within the top two quintiles, to which we refer as “high earners”. Panels B and C of Figure 5 reveal that the gradient prevails in both sub-samples, such that surviving spouses with lower earnings are much more likely to increase their labor supply when their spouse dies, regardless of whether their spouse was a high or low earner. Panel A of Appendix Table 3 shows that this relationship is robust to the inclusion of dummy variables for age and year (as well as to the inclusion of a quadratic in the household’s net wealth) by separately estimating the corresponding differences-in-differences equation for each surviving spouses’ quintile. Note that merely analyzing the average earnings response in this sample would have masked the substantial

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16 These restrictions also imply that the results below for this sub-sample are mainly driven by intensive-margin responses.
17 Note that pre-shock earnings of a survivor is calculated as average earnings in periods -5 to -2. This measure smooths out transitory wage shocks and excludes periods just before the spouse’s death so that potential responses in anticipation of it do not affect this measure.
heterogeneity we documented. Panel B of Appendix Table 3 shows that the average labor income increase for this sub-sample is DKK 585 (0.39%) and is not statistically different from zero.

Spatial Variation in Social Insurance over Time. Lastly, we take advantage of spatial variation in the administration of social survivors benefits to study survivors’ labor supply responses by the generosity of social insurance. This allows us to test the hypothesis that the self-insurance mechanism underlies spousal labor supply responses using variation in the household’s income that is plausibly exogenous. It also allows us to analyze whether better social insurance crowds out labor supply increases in response to shocks. Consistent with our heterogeneity analysis so far, we find that the increase in survivors’ participation due to the shock declines in the formal insurance they receive from the government which mitigates their income loss.

For this analysis, we constrain the sample to survivors under 67 (the age at which the program transitions into the Old-Age Pension) and to the period prior to 1994 due to a data break in the reporting method of survivors benefits received through Social DI. In addition, since for this sample the increase in the take-up of the program following the shock is attributable to females, we focus the analysis on widows. Inclusion of widowers does not change the qualitative results. Panel A of Appendix Figure 4 clearly displays the insurance role of Social DI for widows, whose take-up of the program increases by more than 50% in the year that their husbands die.

Recall that while Social Survivors Benefits is a state-wide program, it is locally administered so that regional councils decide whether to approve or reject an application and municipal caseworkers (in a total of 270 municipalities) administer the application and handle all aspects of each case. Since this structure and the vague definitions for eligibility criteria have led to substantial variation in rejection rates across municipalities, it has created significant variation in the mean receipts of the program’s benefits across the different municipalities over time (Bengtsson 2002).

We use these year-by-municipality average receipts as an instrument for actual receipts. In particular, we calculate for each municipality the average survivors benefits received by non-working surviving spouses through Social DI in each year. Then, we assign to each widow of household $i$ in the treatment group the respective mean in municipality $m$ at time $t$ excluding her own benefits (the “leave-one-out” mean), denoted by $\overline{SB}_{-i,t,m}.^{18}$ We estimate the following augmented differences-in-differences regression:

$$l_{i,t} = \beta_0 + \beta_1 \text{treat}_i + \beta_2 \text{post}_{i,t} + \beta_3 \text{treat}_i \times \text{post}_{i,t} + \beta_4 X_{i,t} + \epsilon_{i,t}, \quad (4)$$

where

$$\beta_3 = \beta_30 + \beta_31 SB_{i,t}.$$ 

In this regression, $l_{i,t}$ denotes the participation of the unaffected female spouse of household $i$ at time $t$, and $X_{i,t}$ includes municipality $m$’s unemployment rate and average earnings (and their interaction with $\text{treat}_i$, $\text{post}_{i,t}$, and $\text{treat}_i \times \text{post}_{i,t}$), as well as age, year, and municipality fixed effects. $SB_{i,t}$ are actual social survivors benefits receipts, measured in annual DKK 1,000 ($\text{DKK}125$) terms, for which we instrument using $\overline{SB}_{-i,t,m}$ (where the F-statistic on the excluded instrument in the first stage is

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18 The variation in this instrument is displayed in Panel B of Appendix Figure 4.
24.3). The identifying assumption is that, given our set of controls, the average of social survivors benefits transferred to other widows in a municipality in a given year affects a widow’s participation only through its influence on her own survivors benefits receipts. Note that the source of variation we use is within municipalities over time since we include municipality and calendar year fixed effects as controls.

The two-stage least squares results are presented in Table 2. The estimate for our parameter of interest, $\beta_{31}$, is -0.057. With an average of DKK 23,262 ($2,908) in actual survivors benefits receipts by widows in the analysis sample (including zeros for those not on the program) and a participation rate of 0.5054, this estimate translates to a participation elasticity with respect to social benefits of -0.26 for widows under 67.\textsuperscript{19} This implies that formal social insurance crowds out labor supply responses which otherwise provide an informal self-insurance mechanism against loss of income following the death of a spouse.

In summary, the results reveal a clear pattern: there are significant average increases in labor supply in response to losing a spouse, which are entirely driven by households that experience large income losses due to this shock. At the same time, survivors whose pre-shock earnings were high and represented a large share of the household’s income decrease their labor supply, consistent with the change in the household’s composition so that they no longer financially support their spouse. Put together, the results provide strong evidence of the self-insurance role of spousal labor supply in the extreme case of the death of a spouse, which translates into large and permanent income losses for most households in our setting due to incomplete insurance of spousal mortality.

4.1.3 Alternative Mechanisms: Survivors’ Labor Disutility State Dependence

Besides income losses, there are other important ways in which households can be directly affected by mortality shocks that can drive our results. For example, potential changes in the unaffected spouse’s labor disutility (or willingness to work) can directly lead to spousal labor supply responses even when households are well-insured. We are specifically interested in testing the hypothesis that the increase in survivors’ labor supply can be attributable to lower costs of supplying labor following the death of a spouse, due to loneliness and the desirability of social integration or because the survivor no longer has to care for an ill spouse. In this section, we briefly discuss a simple strategy to test this conjecture.

Consider widows, for whom we find an increase in participation in response to spousal death, who did not work before the shock in a model where time is divided between labor and leisure (or any other use of “time at home”). Widows in households in which the deceased spouse did not work before his death experience smaller income losses (taking into account the deceased’s income from any source including government transfers), but consumed more joint leisure and hence may be more likely to experience loneliness. Similarly, if the deceased spouses in these households did not work because they were potentially ill in the years preceding their death, their widows are also more likely

\textsuperscript{19}For a sense of scale, estimates for the net-of-tax participation elasticity are on the order of 0.25 (see, e.g., Chetty 2012).
to have taken care of them, thereby having more time available for market work when their husbands die. Overall, survivors in these households are more likely to experience a decrease in the utility cost of labor supply. In contrast, widows in households in which the deceased spouse worked before his death consumed less joint leisure (or care-giving time), but experience larger income losses. The social integration (or “loneliness”) hypothesis and the hypothesis of decreased care-giving time are consistent with spouses in the first group of households increasing their labor supply more than spouses in the latter group do, while the self-insurance hypothesis is consistent with the opposite pattern.

In Table 3 we first verify the differential level of income losses across the two groups of widows (column (3)). Studying their labor supply, we find that the increase in the labor force participation of survivors in households in which the deceased worked is much larger (by 4.61 pp), with a negligible effect for survivors in households in which the deceased did not work (0.78 pp). Moreover, among households in which the deceased did not work and received low levels of income, there was no increase in the widows’ labor supply. Hence, the evidence is inconsistent with the conjecture that the mean increase in the surviving spouses’ labor supply is driven by lower cost of labor following the shock, so that the analysis consistently supports the view that this increase is driven by self-insurance of large income losses.  

4.2 Labor Supply Responses to Spousal Health Shocks

As a complementary analysis, we study in this section households’ labor supply responses to non-fatal severe health shocks. Recall that our analysis sample for this shock consists of households in which a spouse experienced a heart attack or a stroke (for the first time) and survived for at least four years (until $t = 3$), and in which both spouses were under age 60.

Panel A of Figure 6 shows that within three years of the shock, the affected spouses’ participation sharply falls, which translates into a large loss of annual earnings. Appendix Table 4 quantifies these effects by estimating a differences-in-differences regression, in which we allow for differential treatment effects in the “short run” (periods 1 and 2) and the “medium run” (period 3), to account for the gradual responses documented in Panel A of Figure 6.  

Columns 2 and 4 of Appendix Table 4 reveal that by the third year after the shock the labor force participation rate of the sick spouses drops by 12 pp – about 17% – and that annual earnings drop by DKK 36,015 ($4,500) – a significant drop of 19%.

However, while there is a significant drop in the sick spouses’ earnings, Columns 5 and 6 of Appendix Table 4 show that the actual loss of income that these households experience is much smaller and amounts to only 3.3% of overall household income. That is, taking into account the entire

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20 In Fadion and Nielsen (2015) we develop a complementary test that leads to similar conclusions.

21 We estimate the following specification

$$y_{i,t} = \beta_0 + \beta_1 \text{treat}_{i,t} + \beta_{2a} \text{post}_{t}^{a} + \beta_{2b} \text{treat}_{i,t} \times \text{post}_{t}^{b} + \beta_{3a} \text{treat}_{i,t} \times \text{post}_{t}^{a} + \beta_{3b} \text{treat}_{i,t} \times \text{post}_{t}^{b} + \alpha_i + \epsilon_{i,t},$$

where $y_{i,t}$ denotes an outcome for household $i$ at time $t$, $\text{post}_{i,t}^{a} = 1$ in periods 1 and 2 and zero otherwise, and $\text{post}_{i,t}^{b} = 1$ in period 3 and zero otherwise. Therefore, $\beta_{3a}$ captures the “short run” effect, and $\beta_{3b}$ captures the “medium run” effect.
household income, including any transfers from social or private sources (particularly Disability Insurance), reveals that these shocks are very well-insured in our Danish setting. Consistent with this lack of a notable income drop, there are no economically significant labor supply responses among unaffected spouses (as shown in Panel B of Figure 6 and Columns 7 to 10 of Appendix Table 4) as there is no significant need to self-insure.\textsuperscript{22} In line with our previous findings, this behavior is consistent with self-insurance being the driving mechanism of spousal labor supply responses to shocks, here in a context where this form of informal insurance is not exercised since households are formally well-insured.

Note that the rich data and our research design allow for a precise estimation of these economically insignificant spousal responses to shocks.\textsuperscript{23} In particular, our results imply a small but positive degree of complementarity in spouses’ labor supply in response to health shocks, with an estimate of 0.065 for the unaffected spouse’s earnings elasticity with respect to the affected spouse’s earnings. Since the household’s income is not perfectly insured, this response likely implies some degree of health-state dependence of the household’s utility. Intuitively, the fact that given a small loss of income due to the shock the unaffected spouses’ decrease in labor supply involves an additional (very small) loss (through their lower earnings) is consistent with two main state dependence channels. First, it is consistent with households in the bad state valuing income less than do households in the good state — i.e., a consumption utility state dependence. Second, it is consistent with an increase in the unaffected spouses’ utility loss from time spent away from home either because they would like to take care of their sick spouse or due to preferences for joint leisure — i.e., a labor disutility state dependence. With no additional assumptions, one can only reach conclusions about the ratio of these two types of potential state dependence (see Fadlon and Nielsen 2015 for a formal analysis).

5 Theory: Welfare Implications of Spousal Labor Supply Responses

Having studied households’ labor supply responses to mortality and severe health shocks, we now move on to their conceptual interpretation. In this section, we analyze a simple static unitary model of household extensive labor supply decisions. The purpose of this analysis is to show that the degree to which spouses respond to shocks is an integral component of the assessment of the welfare benefits from social insurance. We show that the relative change in spousal labor force participation in response to shocks can reveal the extent to which households lack formal insurance and need to self-insure, because the magnitude of this response increases with the degree of income loss. Hence, spousal labor supply responses can inform us of the scope for additional welfare-improving government transfers through more generous social insurance.

\textsuperscript{22} As for spousal mortality shocks, we find a strong correlation between spousal labor supply responses and income losses (expressed in household income replacement rates) in the context of health shocks using a specification similar to equation (3). The results are reported in Appendix Table 5.

\textsuperscript{23} Note that Meyer and Mok (2013) similarly find that the typical disabled individual in the US loses about 21% in earnings but only 6.75% in post-transfer household income by the fourth year after the shock.
The model that we study here is the simplest possible model that delivers our results. However, our qualitative arguments extend to much more general settings. In particular, in the context of social insurance over the life-cycle, it is important to consider households’ self-insurance through ex-ante mechanisms such as precautionary savings. In Online Appendix A, we analyze a fully-dynamic life-cycle model that allows for endogenous savings, as well as private and informal insurance arrangements, and can incorporate a general class of arbitrary choice variables (such as time investment in home production). In Online Appendix B, we introduce state dependence in preferences and allow for flexible consumption-leisure complementarities. In Online Appendix C, we analyze an intensive-margin version of our model.24

5.1 A Model of Household Labor Supply

Setup. We study labor force participation decisions of a two-person household, which consists of individuals 1 and 2. Our focus is on the extensive margin rather than work intensity to allow for labor market frictions, such as hour requirements set by employers, which can limit employees’ ability to optimize on the intensive margin.25

We consider a world with two states of nature: a “good” state, state g, in which member 1 is in good health and works; and a “bad” state, state b, in which member 1 experiences a shock and drops out of the labor force. Households spend a share of $\mu^g$ of their adult life in state g and a share of $\mu^b$ in state b (with $\mu^g + \mu^b = 1$). In what follows, the subscript $i \in \{1, 2\}$ refers to the household member and the superscript $s \in \{g, b\}$ refers to the state of nature.

Household Preferences. Let $U(c^s; l^s_1, l^s_2)$ represent the household’s utility as a function of aggregate consumption, $c^s$, and the household members’ labor force participation, $l^s_1$ and $l^s_2$, in state $s$. Since we study extensive margin behavior, $l^s_i = 1$ if $i$ works and $l^s_i = 0$ otherwise. For simplicity, we assume that $U(c^s; l^s_1, l^s_2) = u(c^s) - v_1 \times l^s_1 - v_2 \times l^s_2$, where $u(c^s)$ is the household’s utility from consumption, and $v_i$ represents each member $i$’s disutility from labor (including the utility value of direct work costs and the opportunity costs of lost home production). To let the model incorporate both the case in which the bad state is when member 1 is sick and the case in which member 1 is deceased, we set $u(c^s) = Q(c^s)$ when both spouses are alive and $u(c^s) = q(c^s)$ when member 1 does not survive.26 The couple’s disutilities from labor $(v_1, v_2)$ are drawn from a continuous distribution defined over $[0, \infty) \times [0, \infty)$. We denote the marginal probability density function of $v_2$ by $f(v_2)$ and

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24 In Online Appendix C we also show that the results extend to models of the household other than the unitary framework by using the collective approach to household behavior (Chappori 1988, 1992; Apps and Rees 1988). Additional extensions, details, and discussions are available in the NBER working paper version of this paper (Fadlon and Nielen 2015).

25 Evidence for such frictions in the Danish context is found in Chetty et al. (2011). Note that the choice of the appropriate model for welfare analysis should depend on the context. In our specific context, we saw empirically that survivors’ responses were concentrated on the participation margin. However, other applications, such as studying a sub-population with full employment before a shock occurs, would call for the intensive-margin model because work intensity is expected to be the operative margin. The simple participation model of this section is most closely related to Kleven et al. (2009) and Immervoll et al. (2011), who study optimal taxation of couples with extensive-margin labor supply responses.

26 We assume that these functions are well-behaved – i.e., that $Q'(c^s) > 0$, $Q''(c^s) < 0$, $q'(c^s) > 0$, and $q''(c^s) < 0$ – which implies that $u'(c^s) > 0$ and $u''(c^s) < 0$ in each scenario.
its cumulative distribution function by \( F(v_2) \).

**Household Budget Constraint.** Each choice of individual 2’s employment determines the household’s overall income in state \( s \), \( y^s(l_2^s) \), such that \( y^s(l_2^s) = A^s + \bar{z}_i^s \times l_1^s + \bar{w}_s \times l_2^s + B^s(l_2^s) \), where \( A^s \) is the household’s state-contingent wealth and non-labor income (including life insurance payouts, transfers from any other source of individually-purchased or employer-provided private insurance, transfers from relatives, and medical expenses), and \( \bar{z}_i^s \) is \( i \)’s net-of-tax labor income in state \( s \). \( B^s(l_2^s) \) represents transfers from the government in state \( s \), which we allow to depend on 2’s participation, so that transfers can be state-dependent as well as earnings-tested at the household level.\(^\text{27}\)

**Household Behavior.** The household consumes its entire disposable income in each state of nature and in each of member 2’s employment statuses, so that \( c^s(l_2^s) = y^s(l_2^s) \). There are no savings decisions involved in the baseline static model, which we introduce in the dynamic extension to the model. Hence, in the current setting, the household’s choices reduce to the labor force participation decision of the unaffected spouse (member 2) in each state \( s: l_2^s \). The unaffected spouse works in state \( s \) if and only if

\[
v_2 < \bar{v}_2^s \equiv u(y^s(1)) - u(y^s(0)). \tag{6}
\]

That is, the spouse works if the household’s valuation of the additional consumption of his or her labor income compensates for his or her utility loss from working.

**Spousal Labor Supply as Insurance.** At this point it is easy to see the self-insurance role of spousal labor supply responses to shocks, our outcome of interest. Define \( y_{s-2}^s \) as the household’s resources excluding those directly attributed to 2’s labor supply decision – i.e., \( y_{s-2}^s \equiv A^s + \bar{z}_i^s \times l_1^s \) – such that the income loss from the shock is \( L \equiv y_{s-2}^s - y_{s-2}^s \). In addition, for each state \( s \), denote the spouse’s probability of participation (or the participation rate of unaffected spouses in the population) by \( e^s_2 \equiv F(\bar{v}_2^s) \). In each state the unaffected spouse’s probability of participation decreases in his or her unearned income:

\[
\frac{\partial e^s_2}{\partial y_{s-2}^s} = f(\bar{v}_2^s)[u'(y^s(1)) - u'(y^s(0))] < 0. \tag{7}
\]

This implies that we should expect a relative increase in spousal labor force participation, \( \frac{e^h_2}{e^s_2} > 0 \), whenever there is some income loss that is not fully insured, \( L > 0 \). That is, income shocks lead to self-insurance through the unaffected spouse’s labor force participation. Furthermore, the unaffected spouse’s labor supply response to the shock \( \frac{\partial e^h_2}{\partial L} \) increases in the income loss \( L \):

\[
\frac{\partial \left( \frac{e^h_2}{e^s_2} \right)}{\partial L} = f(\bar{v}_2^s) \frac{u'(y^h(0)) - u'(y^h(1))}{F(\bar{v}_2^s)} > 0, \tag{8}
\]

so that the extent of spousal self-insurance increases in the degree of income loss imposed by the shock. These comparative statics are no more than simple income effects at the household level.

\(^{27}\) It is also straightforward to include economies of scale in the household’s resource constraint (using a general transformation of income into consumption as in Browning et al. 2013) as well as differential tax rules for joint filing.
which are a direct implication of the concavity of $u(c^s)$.

5.2 Social Insurance

Having illustrated the self-insurance role of spousal labor supply, we now turn to analyze the planner’s problem in order to show that spousal labor supply responses can have important welfare implications. We do so by mapping how individuals respond to spousal shocks into predictions about the welfare gains from providing more generous social insurance.

Policy Tools. The planner observes the state of nature as well as the employment status of each spouse. Since some spouses work and earn more than others do, the optimal policy is dependent on whether the spouse is employed. We denote the tax on spouse $i$’s labor income in state $g$ by $T_i^g$ and the monetary benefits given to non-working spouses in state $g$ by $m^g$. In state $b$, households receive transfers of the amount $M^b$, with additional benefits of the amount $m^b$ to lower-income households in which the unaffected member 2 does not work. This tax-and-benefit structure allows for the analysis of flexible policy designs and mimics features of existing social insurance programs in most developed countries (such as income-testing that characterizes the Supplemental Security Income program within the Old-Age, Survivors and Disability Insurance in the US and the Social Disability Insurance in Denmark).\(^\text{28}\) We denote taxes by $T \equiv (T_1^g, T_2^g)$ and benefits by $B \equiv (m^g, M^b, m^b)$.

Planner’s Problem. Let $W^s(v_2)$ denote the household’s value function in state $s$ such that

$$W^s(v_2) = \begin{cases} u(y^s(1)) - v_1 \times t_1^s - v_2 & \text{if } v_2 < \bar{v}_2^s \\ u(y^s(0)) - v_1 \times t_1^s & \text{if } v_2 \geq \bar{v}_2^s. \end{cases}$$

Therefore, the household’s expected utility is $J(B, T) \equiv \mu^g \int_0^\infty W^g(v_2)f(v_2)dv_2 + \mu^b\int_0^\infty W^b(v_2)f(v_2)dv_2$. The social planner’s objective is to choose the tax-and-benefit system that maximizes the household’s expected utility subject to the requirement that expected benefits paid, $\mu^g(1 - e_2^g)m^g + \mu^b(M^b + (1 - e_2^b)m^b)$, equal expected taxes collected, $\mu^g(T_1^g + e_2^gT_2^g)$. Hence, the planner chooses the benefit levels $B$ and taxes $T$ that solve

$$\max_{B,T} J(B, T) \quad \text{s.t. } \mu^g(1 - e_2^g)m^g + \mu^b(M^b + (1 - e_2^b)m^b) = \mu^g(T_1^g + e_2^gT_2^g). \quad (9)$$

Welfare Benefits from Social Insurance. What is the welfare gain from providing more generous benefits if the bad state occurs? To answer this question, consider transferring resources from the good state $g$ to the bad state $b$, by a small decrease in the benefit $m^g$ to finance a corresponding balanced-budget increase in $m^b$.\(^\text{29}\)

The social gain from this perturbation consists of the household’s valuation of additional insurance. To construct a measure for this valuation, consider first the household’s utility loss from a $1$ reduction in $m^g$ to finance the additional insurance. This loss is captured by $\frac{\partial J(T, B)}{\partial m^g}$.

\(^{28}\)The exact way in which we model transfers simplifies the analysis and is not necessary for our results. Any system that conditions transfers on the state of nature and employment, as well as on age in the dynamic model, can be analyzed within our framework.

\(^{29}\)In the simple model, this perturbation concerns the distribution of transfers to low-income households across different health states. Other perturbations to the system will follow the steps of the analysis conducted below. We focus on this particular aspect of the policy since it captures the essence of insuring households against shocks in a mathematically simple way.
\[ \mu^g > \frac{\partial}{\partial m} (\int_0^\infty W^g(v_2)f(v_2)dv_2) = \mu^g(1 - e^g_2)u'(c^g(0)), \] since every dollar taken produced a value of \( u'(c^g(0)) \) and was transferred to the household with probability \( \mu^g(1 - e^g_2) \). Partially differentiating the government’s budget, this reduction in \( m^g \) allows a balanced-budget increase in \( m^b \) of the amount \( \left| \frac{\partial m^b}{\partial m^g} \right| = \frac{\mu^g(1 - e^g_2)}{\mu^b(1 - e^b_2)} \). The household’s valuation per $1 increase in \( m^b \) is given by

\[ \frac{\partial J(T,B)}{\partial m^b} = \frac{\partial}{\partial m^b} \left( \int_0^\infty W^b(v_2)f(v_2)dv_2 \right) = \mu^b(1 - e^b_2)u'(c^b(0)), \] as it produces a value of \( u'(c^b(0)) \) with probability \( \mu^b(1 - e^b_2) \). The overall utility gain from the increase in benefits when the shift occurs is, therefore, \( \frac{\partial J(T,B)}{\partial m^b} \times \left| \frac{\partial m^b}{\partial m^g} \right| \).

Put together, the welfare benefits from a (balanced-budget) increase in \( m^b \) financed by a $1 decrease in \( m^g \) is \( \frac{\partial J(T,B)}{\partial m^b} \times \left| \frac{\partial m^b}{\partial m^g} \right| - \frac{\partial J(T,B)}{\partial m^g} \). To gain cardinal interpretation for this expression, we follow the recent social insurance literature and normalize it by the baseline welfare gain from a $1 transfer through \( m^b \) (Chetty and Finkelstein 2013). That is, the normalized welfare benefit from our policy change is

\[ MB \equiv \frac{\partial J(T,B)}{\partial m^b} \times \left| \frac{\partial m^b}{\partial m^g} \right| - \frac{\partial J(T,B)}{\partial m^g} = \frac{u'(c^b(0)) - u'(c^g(0))}{u'(c^g(0))} = \frac{u'(c^b(0))}{u'(c^g(0))} - 1. \tag{10} \]

The marginal benefit from a balanced-budget increase in \( m^b \) is captured by the insurance value of transferring resources from the good to the bad state, which is measured by the gap in marginal utilities of consumption across the two states. This “rate of return” on shifting funds, which is zero in the first-best allocation in which marginal utilities are smoothed across states of nature, measures market inefficiency and quantifies the potential benefit from government intervention. This expression in exactly the benefit side of Baily’s (1978) and Chetty’s (2006a) formula for the optimal level of social insurance applied to our setting.

**Consumption-Based Method for Identifying Welfare Benefits.** The main reduced-form approach for directly assessing the welfare gains from social insurance in (10) is the method that was developed by Baily (1978) and Chetty (2006a) and was first implemented by Gruber (1997) in the context of unemployment insurance. To provide a simple description of it here, consider the case in which the household’s consumption utility exhibits constant relative risk aversion, so that \( u(c) = \frac{c^{1+\gamma}}{1+\gamma} \) with \( \gamma > 0 \) and \( \gamma \neq 1 \). In this case, we can express (10) by \( MB = \left( \frac{u'(c^b(0))}{u'(c^g(0))} \right) \times \left( \frac{c^b(0)}{c^g(0)} \right) - 1 \equiv \gamma \times \left( \frac{c^g(0) - c^b(0)}{c^g(0)} \right) \) (where the latter approximation follows from a Taylor expansion). This formula

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30 Our analysis resembles the derivation of individuals’ willingness to pay for additional unemployment insurance in Hendren (2015). Deriving these benefits can be also achieved by characterizing the first-order conditions of the planner’s problem as in Chetty (2006a), Chetty and Finkelstein (2013), and Fadlon and Nielsen (2015) (see also our analyses of the dynamic model and the intensive margin model in the online appendix).

31 When contemplating a policy change, the planner must weigh this benefit against the associated cost. The cost of transferring $1 across states is due to within-state behavioral responses, which lead to fiscal externalities that households impose on the government budget when changing their participation decisions. For example, in our case the government’s revenue could decrease since more generous social insurance will lead to fewer spouses choosing to work in the bad state (see Fadlon and Nielsen 2015 for details). Identifying marginal costs is conceptually straightforward and much of the social insurance literature has focused on their estimation in different contexts. Therefore, we abstract from their analysis in this paper.
evaluates fluctuations in the consumption of goods across states, \( \frac{\epsilon^b_0}{\epsilon^a_0} \), with the relative rate of change in the utility from marginal dollars, captured by the curvature of the utility function (measured either with \( u''(\epsilon^a(0)) \) or \( \gamma \)). Put differently, the benefits from insurance can be evaluated by the analysis of “quantity” fluctuations in consumption, which are then “priced” in utility terms.

**Labor Supply Representation of Welfare Benefits.** We show next that simple implications of the household’s labor supply decisions allow us to rewrite the marginal benefit in (10) in terms of the unaffected spouse’s labor supply. By doing so, we show that the gains from additional insurance can be alternatively measured by evaluating changes in the consumption of the spouse’s leisure instead of changes in the household’s consumption of goods. The following proposition summarizes this welfare result. We provide a simple proof and then discuss the intuition behind the welfare formula.

**Proposition 1.** The marginal benefit from raising \( m^b \) through a balanced-budget decrease in \( m^a \) is

\[
MB = \Phi \times \left( \frac{e^b_2}{e^a_2} \right) - 1, \tag{11}
\]

where \( \Phi \equiv \phi^b / \phi^a \), \( \phi^a \equiv \frac{|\epsilon^a_2(m^a)|}{m^a \times f(e^a_2)} \), and \( \epsilon(e^a_2, m^a) \) is the unaffected spouse’s participation elasticity with respect to the policy tool \( m^a \).

**Proof.** Recall that the unaffected spouse works when the value of additional consumption from his or her labor income, \( \bar{v}^a \equiv u(y^a(1)) - u(y^a(0)) \), outweighs his or her disutility from labor, \( v_2 \). This decision rule reveals the household’s consumption value of an additional dollar, \( u'(y^a(0)) \), through the change in the critical labor-disutility threshold below which the spouse works (\( \bar{v}^a \)) in response to an increase in benefits, since \( \left| \frac{\partial \bar{v}^a}{\partial m^a} \right| = u'(y^a(0)). \)32 Hence, we can rewrite the marginal benefit from social insurance using the change in the marginal entrant’s disutility of labor, and to represent \( MB \) with labor supply responses of the unaffected spouse using the equalities \( e^a_2 = F(\bar{v}^a_2) \) and their semi-elasticities, \( \epsilon(e^a_2, m^a) / m^a = f(e^a_2) \frac{\partial v^a_2}{f(e^a_2) \partial m^a} \). Conceptually, the proof shows that extensive margin responses can be used for welfare analysis of marginal policy changes for the following reason: extensive margin responses are governed by the labor disutility of the marginal entrant; and the labor disutility of the marginal entrant can be mapped into consumption preferences through the household’s optimization. Within a state, marginal entrants are always indifferent regarding whether to work or not; it is the cross-state analysis that entails information on the benefits from additional insurance.33

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32 This is isomorphic to differentiating the first-order condition for the spouse’s search effort in a search model of labor force participation (see Online Appendix A).

33 In our simple model with one-dimensional heterogeneity over labor disutility, the marginal entrant identifies consumption preferences for infra-marginal households (by extrapolation). With multi-dimensional heterogeneity, so that households also differ by consumption preferences, identification requires having marginal households for each “type” of consumption preferences. The average marginal utility of consumption is then assessed using the average participation responses taken over all households. This is equivalent to having all types at an interior solution in search or intensive margin models (such as in Chetty 2008 or in Online Appendices A and C). See Chetty (2008) and Hendren (2013) for such aggregations of private williness to pay for social insurance. In addition, for other applications in which the identification of household preferences and welfare evaluations rely on discrete choices similar to labor force participation responses see Chetty (2006b) and Chetty (2009).
Intuition. This formula shows that the marginal net benefit from social insurance can be expressed using different moments of the unaffected spouse’s labor supply. The leading term, \( \Phi \times \frac{\epsilon_{e_2}^b}{e_2^2} \), which captures the gross marginal benefit, has two parts: \( \frac{\epsilon_{e_2}^b}{e_2^2} \) that consists of a cross-state response; and \( \Phi \) that consists of within-state responses. This leading term essentially expresses the relative gain from additional consumption of goods in the bad state by using its mirror image of the relative gain from additional consumption of leisure in the bad state, due to less need to compensate for the income loss associated with the shock through spousal labor supply. Put differently, the formula assesses the benefits of incrementally smoothing labor supply across states as a result of additional formal social insurance that reduces costly self-insurance.

Similar to the consumption representation, our formula evaluates benefits by multiplying the change in the “quantity” of spousal labor supply in response to shocks, \( \frac{\epsilon_{e_2}^b}{e_2^2} \), by the change in the relative “price” of labor force participation across the two states, \( \Phi \). In the comparative statics of our model in equation (8) we saw that this “quantity” term increases with income losses and captures the self-insurance role of spousal labor supply. Intuitively, the welfare benefits from additional transfers are higher whenever this quantity is larger, since stronger need to self-insure implies lack of adequate formal insurance and a greater scope for welfare-improving social insurance.

To see how \( \Phi \) captures the relative price, or utility cost, of spousal labor supply, let us consider its components. Within a state \( s \), the extent to which spousal labor force participation responds to a policy variation in the benefits \( m^s \) is captured by \( \epsilon(e_{e_2}^s, m^s)/m^s \), the percent change in within-state participation. This measure is proportional to \( \frac{\partial e_{e_2}^s}{\partial m^s} \), the change in the labor disutility of the marginal entrant, which identifies the cost of additional labor supply on the margin in the extensive margin model. Hence, \( \epsilon(e_{e_2}^s, m^s)/m^s \) reveals information on the social marginal cost of survivors’ labor supply in each state. However, this semi-elasticity is also proportional to the share of marginal households, \( f(\bar{v}_e^s) \). Therefore, we must normalize it by \( f(\bar{v}_e^s) \) to achieve a within-state “price” change attributable to preferences only, which yields the within-state measure \( \phi^s \equiv \left| \frac{\epsilon(e_{e_2}^s, m^s)}{m^s \times f(\bar{v}_e^s)} \right| \). The relative change in prices across states of nature, required for evaluating cross-state transfers, is then \( \Phi \equiv \phi^b/\phi^g \).

Note that the cross-state term \( \frac{\epsilon_{e_2}^b}{e_2^2} \) is not policy specific and is present whenever the planner considers additional insurance by transferring resources from the good to the bad state. However, the price term, \( \Phi \), adjusts according to the policy change and involves within-state semi-elasticities with respect to the specific policy tools that the planner considers changing.

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Note the comparison to the intensive-margin version of our model in Online Appendix C. In the model here, the marginal entrant, \( \bar{v}_e^s \), reveals the cost of labor supply on the margin, and the change in the marginal entrant’s disutility, \( \frac{\partial e_{e_2}^s}{\partial m^s} \), evaluates the relative cost of labor supply across states of nature. In an intensive-margin model in which \( v(l_2^s) \) is the spouse’s labor disutility function and \( l_2^s \) is the choice of work intensity, it is the cost of the marginal hour of work, \( v'(l_2^s) \), that reveals the cost of labor supply on the margin, and the change in the cost of the marginal hour, \( v''(l_2^s) \) (or \( \varphi \equiv \frac{v''(l_2^s)}{v'(l_2^s)} \)), is used to evaluate the cross-state labor supply responses. This is equivalent to the use of \( u''(e^s) \) (or \( \gamma \)) in the consumption-based approach. In the appendix, we show that for general utility functions \( MB \equiv \gamma \times \left( \frac{e^s - e^b}{e^s} \right) \equiv \varphi \times \left( \frac{1 - \frac{\epsilon_{e_2}^b}{e_2^2}}{\frac{\epsilon_{e_2}^b}{e_2^2}} \right) \). As in the extensive-margin formula, the intensive-margin formula consists of the “quantity” of spousal labor supply responses to shocks \( \left( \frac{1 - \frac{\epsilon_{e_2}^b}{e_2^2}}{\frac{\epsilon_{e_2}^b}{e_2^2}} \right) \), evaluated in utility terms using \( \varphi \), which can be estimated using within-state elasticities (similar to the estimation of risk aversion in Chetty 2006b).
Comparison of Methods. The two methods, which are equivalent in the simple model, have practical comparative advantages in different settings. The main advantage of analyzing welfare benefits by assessing the utility cost of consumption fluctuations is that it aims at directly estimating the gap in marginal utilities of consumption. As such, it does not require that households’ optimization leads them to an “interior” solution in other choice variables which, in our case, means that the threshold value of the marginal entrant’s labor disutility is within the support of the labor disutility distribution (see Finkelstein et al. 2015 for a related discussion). The main limitations of this approach are twofold: accurate longitudinal data on overall consumption expenditure across health states is largely uncommon (Chetty and Finkelstein 2013; Bee et al. 2013; Pistaferri 2015); and welfare calculations are sensitive to the value of risk aversion, for which there is a wide range of context-dependent estimates (Chetty and Szeidl 2007; Chetty and Finkelstein 2013; Low and Pistaferri 2015).35 The important advantage of evaluating benefits by studying labor supply responses is the wide availability of large-scale accurate data from the labor market, and the use of directly-estimated changes in participation rates and labor supply elasticities. However, this approach relies on the presence of marginal households in the participation model. That is, identification would not be achieved for sub-populations in which all unaffected spouses never work (e.g., due to significant labor market frictions) or work full-time prior to the shock. Additionally, for some policy changes, such as the simple one that we analyze here, full identification of benefits would require additional calibrations of the labor disutility distribution.36

In summary, we have shown using a simple model that the ex-post causal effects of mortality and health shocks on spousal labor supply, \( \hat{\beta}_w \), have direct welfare implications. Even in the dynamic extension to our model, where ex-ante responses are explicitly accounted for, ex-post responses to a shock (rather than in expectation of it) assess the gain from additional conditional benefits. The intuition behind this conceptual result is as follows: when forward-looking households make adjustments in anticipation of shocks (according to their expectations), their responses after the shock is experienced recover its residual uninsured risk. This leftover risk assesses the insurance gap that the government can efficiently fill. Empirically, when ex-ante responses are possible, one

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35 There have been recent important advances in the analysis of consumption which deal with some of these data limitations, both by using survey data that cover a wide set of non-durable and services expenditure (Blundell et al. 2015; Low and Pistaferri 2015), and by creating consumption measures from income and wealth registers (Browning and Leth-Petersen 2003; De Giorgi et al. 2012; Kojien et al. 2014; Autor et al. 2015; Kolsrud et al. 2015).

36 Specifically, in our case, since \( \Phi \) involves the ratio \( \frac{\mu_0^w}{\mu_0^b} \), full identification of welfare benefits would require calibrating this ratio. This can be done in different ways. In our application, the empirical analysis of spousal participation across states of nature is consistent with \( \hat{\mu}_0^w \) and \( \hat{\mu}_0^b \) being within a small region of the support \( [0, \infty) \). Hence, one can plausibly invoke a locally linear approximation of \( F \) in the threshold region \( (\hat{\mu}_0^w, \hat{\mu}_0^b) \), so that \( \frac{\mu_0^w}{\mu_0^b} \approx 1 \). Note that this approximation is isomorphic to a second-order approximation of the search effort function in a search model of participation that we analyze in Online Appendix A. However, if one wishes to avoid approximations, one can accompany the analysis with assumptions regarding the family of distributions to which \( F \) belongs, and then calibrate its parameters with the participation rates observed in the data. For example, in our analysis of mortality shocks, assuming that \( F \) is log-normally distributed and normalizing its mean and standard deviation to 0 and 1, respectively, implies that \( \frac{\mu_0^w}{\mu_0^b} = 0.99 \).
has to carefully choose research designs that cleanly recover the causal impact of shocks, which are required for identifying households’ willingness to pay for benefits (see discussions on these issues in Chetty 2008 and Hendren 2015). Identifying these exact responses was the goal of our empirical analysis.

6 Welfare Implications of Empirical Results

We have illustrated within our simple model that the gains from providing additional insurance are higher when spousal relative labor supply responses to shocks are larger. In this section, we rely on this comparative statics to discuss the qualitative welfare implications of our empirical findings. Quantitatively assessing the welfare gains from additional benefits requires identifying the components in $\Phi$ which is not a part of our analysis.$^{37}$

The heterogeneity analysis of survivors’ labor supply revealed two noteworthy patterns. First, studying the behavior of widows below and above 60, the age at which there is a sharp decline in labor force participation, we found a significantly smaller relative increase in labor supply for younger survivors. Appendix Figure 5 explicitly compares the relative change in participation for widows below and above 60. It shows that younger widows increase their labor force participation by 3.3%, while older widows increase their participation by 45.4%. This result suggests that the differential attachment to the labor force over the life-cycle, which reduces the financial vulnerability of younger survivors, may justify age-dependent social insurance for spousal mortality shocks.

Second, we found that increases in the surviving spouse’s labor supply are strongly correlated with the share of the household’s income the deceased had earned. This suggests that it may be welfare improving to let survivors benefits increase in the deceased spouse’s pre-shock share of annual household earnings. A similar pattern of heterogeneity in responses was found for non-fatal spousal health shocks, so that disability benefits may also be more efficiently distributed if dependent on the disabled spouse’s work history.$^{38}$

It is worth noting that all of these features characterize the American system. Survivors in the US are eligible for benefits through their deceased spouse’s Social Security entitlement only after age 60. These benefits are a function of the deceased’s work history and are therefore increasing in the labor income the deceased had earned. The case is similar for disability benefits, that are based on the disabled worker pre-shock average earnings.

Overall, our findings revealed significant heterogeneity in responses across different pre-shock dimensions of household characteristics, which suggests that enriching the policy tools to condition transfers on these observable characteristics may be welfare improving. Of course, any policy consideration that conditions transfers on pre-shock characteristics should take into account potential ex-ante behavioral responses with respect to these margins.

$^{37}$We refer the interested reader to Fadlon and Nielsen (2015) for suggestive calibrations.

$^{38}$There may be countervailing arguments when distributional considerations are involved. Here we focus on efficiently targeting benefits for the purpose of insuring households against the income loss imposed directly by mortality and health shocks.
7 Conclusion

This paper provides new evidence on households’ labor supply responses to fatal and non-fatal severe health shocks and uses these responses to draw implications for the design of social insurance. Studying the critical event of the death of a spouse, we find large increases in the surviving spouses' labor supply driven by households for whom this event imposes significant income losses. Analyzing households in which an individual has experienced a severe health shock but survived, for whom income losses are well-insured, we find no significant spousal labor supply responses. Together, the results provide strong support for self-insurance against large and persistent income losses as the mechanism that underlies spousal labor supply responses to shocks. They also point to a potential explanation for the elusiveness of the insurance role of spousal labor supply in previous literature. In support of the hypotheses raised by Heckman and MaCurdy (1980) and Cullen and Gruber (2000), we find that spousal labor supply plays a significant self-insurance role when the income loss incurred by the shock is large relative to the household’s lifetime income – as in the death of a spouse – and is irrelevant when the loss is sufficiently insured through formal social insurance – as in spousal health shocks.

We show the importance of studying spousal labor supply behavior in response to shocks for its welfare implications. The degree to which households self-insure through spousal labor supply reveals their lack of formal insurance and, hence, the scope for more generous social insurance. Based on this result, we discuss the implications of our findings for potentially improving efficiency in the distribution of government benefits. The significant heterogeneity in responses that we find across different pre-determined dimensions of household characteristics imply that richer policy tools that condition transfers on these observable characteristics may be welfare improving.

More broadly, our quasi-experimental design for identifying the effect of shocks as well as our method for welfare analysis can be applied to other important economic questions. Our research design, which relies on comparing households that are affected only a few years apart, can be applied to estimating the effect of a shock in any setting in which its particular timing is likely to be random. When large-scale labor market data are readily available, our welfare analysis, which relies on spousal labor supply, can be used to assess the gains from social insurance in settings in which the directly affected individual may be at a corner solution. For example, in the debate on the privatization of Social Security, the value of protecting against pension-wealth losses in the 401(k) account of a working individual can be recovered by the labor supply response of his or her spouse. Spousal labor supply can also be used to evaluate the welfare losses caused by the discontinuation of an employee’s compensation, such as health insurance, as well as the value of unemployment insurance for the long-term unemployed (whose long durations of unemployment significantly harm their employment prospects).39

39See Kroft, Lange and Notowidigdo (2013) on the adverse effect of longer unemployment spells.
References


Figure 1:
Illustration of the Empirical Research Design

A. Health Shocks in Year 1995 vs. No Shock

B. Health Shocks in Different Years and No Shock

C. Health Shocks in Years 1995, 1996, and 2005

D. Research Design with Δ=5

Notes: These figures compare the labor force participation of a treatment group of individuals who were born between 1930 and 1950 and experienced a heart attack or a stroke in 1995 to that of potential control groups. Panel A compares the treatment group to those who belong to the same cohorts but did not experience a shock in our data window, years between 1980 and 2011, and shows that the pre-1995 patterns of these groups are far from parallel. Panel B adds the behavior of households that experienced the same shock but in different years, and shows that the groups are becoming increasingly comparable to the treatment group – in terms of parallel trends before 1995 – the closer the year in which the individual experienced the shock was to the year the treatment group experienced the shock (1995). The figures suggest using households that experienced a shock in year 1995+Δ as a control group for households that experienced a shock in 1995. The trade-off in the choice of Δ is presented in Panel C. On the one hand, we would want to choose a smaller Δ such that the control group would be more closely comparable to the treatment group, e.g., year 1996 which corresponds to Δ=1. On the other hand, we would want to choose a larger Δ in order to be able to identify longer-run effects of the shock, up to period Δ-1. Using those that experienced a shock in 2005, which corresponds to Δ=10, will allow us to estimate up to the 9-year effect of the shock. However, this entails a potentially greater bias since the trend in the behavior of this group prior to 1995 is not as tightly parallel to that of the treatment group. Panel D displays the potential control group for this example when we choose Δ=5. Our research design generalizes this example by aggregating different calendar years.
Figure 2:
Survivors’ Labor Supply Responses to the Death of Their Spouse

A. Labor Force Participation

B. Annual Earnings

C. Labor Force Participation by Gender
Widowers (wife dies)  Widows (husband dies)

D. Annual Earnings by Gender
Widowers (wife dies)  Widows (husband dies)

Notes: These figures plot the labor supply responses of survivors to the death of their spouse. The sample includes individuals whose spouses died between ages 45 and 80 from 1980 to 2011. Panels A and B depict the behavior of labor force participation and annual earnings, respectively, for the entire sample. Panels C and D break down these average responses by the gender of the surviving spouse. The x-axis denotes time with respect to the shock, normalized to period 0. For the treatment group, period 0 is when the actual shock occurs; for the control group period 0 is when a “placebo shock” occurs (while their actual shock occurs in period 5). The dashed gray line plots the behavior of the control group. To ease the comparison of trends, we normalize the level of the control group’s outcome to the pre-shock level of the treatment group’s outcome. This normalized counterfactual is displayed by the blue line and squares. The red line and circles plot the behavior of the treatment group.
Figure 3:
Labor Supply Responses of Survivors under Age 60 to the Death of Their Spouse by Gender

A. Labor Force Participation
Widowers (wife dies)                     Widows (husband dies)

B. Annual Earnings
Widowers (wife dies)                     Widows (husband dies)

Notes: These figures plot the labor supply responses of survivors under age 60 to the death of their spouse by the gender of the surviving spouse. The sample includes individuals under 60 whose spouses died between ages 45 and 80 from 1980 to 2011. Panel A depicts the behavior of labor force participation, and Panel B depicts the behavior of annual earnings. The lines in each graph are constructed as described in the notes of Figure 2.
Figure 4:
Labor Supply Responses of Survivors under Age 60 to the Death of Their Spouse:
Full-Time/Part-Time Employment

A. Labor Force Participation

B. Full-Time Employment

C. Part-Time Employment

Notes: These figures plot labor supply responses of survivors under age 60 to the death of their spouse. The sample includes individuals under 60 whose spouses died between ages 45 and 80 from 1980 to 2011. Panel A depicts labor force participation; Panels B and C depict the fraction of surviving spouses who are employed full time and part time, respectively. The pictures are constructed from ATP data available for workers under 60. Full-time employment is defined as working at least 30 hours per week all 12 months of the calendar year (“full-time full-year”); part-time employment is defined as working at some point during the year, but either fewer than 30 hours per week or fewer than 12 months within the calendar year. The lines in each graph are constructed as described in the notes of Figure 2.
Figure 5:
Survivors’ Annual Earnings Responses to the Death of Their Spouse by the Level of their Own Pre-Shock Earnings

A. All Households

B. Households with Low-Earning Deceased Spouses

C. Households with High-Earning Deceased Spouses

Notes: These figures include individuals whose spouses died between ages 45 and 80 from 1980 to 2011, where we constrain the sample in the following way. First, we exclude surviving spouses whose average labor income before the shock (in periods -5 to -2) was lower than their experimental-group-specific 20th percentile. Then, we calculate for each household the pre-shock labor income share of the deceased spouse out of the household’s overall labor income and include only households in which both spouses were sufficiently attached to the labor force; specifically, we keep households for whom the average share was between 0.20 and 0.80. These restrictions allow us to focus on households for which there has been some loss of income due to the death of a spouse and in which the surviving spouse earned non-negligible labor income both in levels and as a share within the household. In addition, to guarantee that our results are not driven by outliers, we exclude households with dying spouses whose mean pre-shock earnings did not fall within their group-specific 5th and 95th percentiles as well as households with unaffected spouses whose mean pre-shock earnings were higher than those of their group-specific 95th percentile. We divide the remaining sample into five equal-sized groups by their pre-shock level of earnings and plot the average labor income response as well as its 95-percent confidence interval (where standard errors are calculated using the Delta method) against the pre-shock mean earnings for each group. Panel A includes all households; Panel B includes households in which the dying spouse’s pre-shock labor income fell within the bottom three quintiles of its group-specific distribution, to which we refer as “low-earners”; Panel C includes households in which the dying spouse’s pre-shock labor income fell within the top two quintiles, to which we refer as “high-earners”. The pre-shock periods include periods -5 to -3. The post-shock periods include periods 2 to 4.
Figure 6:
Household Labor Supply Responses to Non-Fatal Severe Health Shocks

A. Affected Spouse

Labor Force Participation

Annual Earnings

Time to Shock

Panel A depicts the labor force participation and annual earnings of the individual that experienced the shock. Panel B depicts the labor force participation and annual earnings of the unaffected spouse. The lines in each graph are constructed as described in the notes of Figure 2.

B. Unaffected Spouse

Labor Force Participation

Annual Earnings

Time to Shock

Notes: These figures plot the labor supply responses of households in which an individual experienced a heart attack or a stroke between 1980 and 2011 and survived for at least three years. The sample includes households in which both spouses were under age 60. Panel A depicts the labor force participation and annual earnings of the individual that experienced the shock. Panel B depicts the labor force participation and annual earnings of the unaffected spouse. The lines in each graph are constructed as described in the notes of Figure 2.
Table 1: Survivors’ Labor Force Participation Responses to the Death of Their Spouse by the Degree of Income Loss

A. Surviving Spouses of All Ages

<table>
<thead>
<tr>
<th>1. Baseline Regression</th>
<th>Both Genders</th>
<th>Widowers</th>
<th>Widows</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
</tr>
<tr>
<td>Treat × Post</td>
<td>0.1265***</td>
<td>0.1220***</td>
<td>0.1170***</td>
</tr>
<tr>
<td></td>
<td>(0.0023)</td>
<td>(0.0042)</td>
<td>(0.0027)</td>
</tr>
<tr>
<td>Treat × Post ×</td>
<td>-0.1889***</td>
<td>-0.1894***</td>
<td>-0.1744***</td>
</tr>
<tr>
<td>Replacement Rate</td>
<td>(.0035)</td>
<td>(.0061)</td>
<td>(.0044)</td>
</tr>
<tr>
<td>Number of Obs.</td>
<td>4,288,621</td>
<td>1,387,615</td>
<td>2,901,006</td>
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<tr>
<td>Number of Households</td>
<td>714,892</td>
<td>231,318</td>
<td>483,574</td>
</tr>
</tbody>
</table>

2. Regression with Interactions

<table>
<thead>
<tr>
<th>Both Genders</th>
<th>Widowers</th>
<th>Widows</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1)</td>
<td>(2)</td>
</tr>
<tr>
<td>Treat × Post</td>
<td>-0.1989***</td>
<td>-0.2021***</td>
</tr>
<tr>
<td>Replacement Rate</td>
<td>(.0045)</td>
<td>(.0081)</td>
</tr>
<tr>
<td>Number of Obs.</td>
<td>2,741,690</td>
<td>821,742</td>
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<tr>
<td>Number of Households</td>
<td>459,622</td>
<td>137,724</td>
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Regression 1 for Sub-Sample of Regression 2

<table>
<thead>
<tr>
<th>Both Genders</th>
<th>Widowers</th>
<th>Widows</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1)</td>
<td>(2)</td>
</tr>
<tr>
<td>Treat × Post</td>
<td>-0.1923***</td>
<td>-0.1918***</td>
</tr>
<tr>
<td>Replacement Rate</td>
<td>(.0043)</td>
<td>(.0077)</td>
</tr>
</tbody>
</table>

B. Surviving Spouses under 60

1. Baseline Regression

<table>
<thead>
<tr>
<th>Both Genders</th>
<th>Widowers</th>
<th>Widows</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1)</td>
<td>(2)</td>
</tr>
<tr>
<td>Treat × Post</td>
<td>0.0883***</td>
<td>0.0652***</td>
</tr>
<tr>
<td>Replacement Rate</td>
<td>(.0054)</td>
<td>(.0125)</td>
</tr>
<tr>
<td>Number of Obs.</td>
<td>803,158</td>
<td>201,487</td>
</tr>
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<td>Number of Households</td>
<td>134,199</td>
<td>33,720</td>
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2. Regression with Interactions

<table>
<thead>
<tr>
<th>Both Genders</th>
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<th>Widows</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1)</td>
<td>(2)</td>
</tr>
<tr>
<td>Treat × Post</td>
<td>-0.1481***</td>
<td>-0.1375***</td>
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<tr>
<td>Replacement Rate</td>
<td>(.0091)</td>
<td>(.0186)</td>
</tr>
<tr>
<td>Number of Obs.</td>
<td>704,370</td>
<td>173,620</td>
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<td>Number of Households</td>
<td>118,812</td>
<td>29,288</td>
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Regression 1 for Sub-Sample of Regression 2

<table>
<thead>
<tr>
<th>Both Genders</th>
<th>Widowers</th>
<th>Widows</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1)</td>
<td>(2)</td>
</tr>
<tr>
<td>Treat × Post</td>
<td>-0.1377***</td>
<td>-0.1236***</td>
</tr>
<tr>
<td>Replacement Rate</td>
<td>(.0088)</td>
<td>(.0184)</td>
</tr>
</tbody>
</table>

Notes: This table reports the interaction of the treatment effect of the death of a spouse with the household’s post-shock income replacement rate (equation (3)). The sample includes individuals whose spouses died between ages 45 and 80 from 1980 to 2011. The treatment group comprises households that experienced the shock in different years, to which we match households that experienced the same shock five years later as a control group (Δ=5). Panel A reports estimates for the sample of all survivors by gender; Panel B reports estimates for the sample of survivors under age 60 by gender. In each panel, we report estimates of two specifications. Specification 1 in each panel estimates a baseline differences-in-differences specification which interacts the treatment effect with the replacement rate variable. This replacement rate is calculated as follows. First, we fix the surviving spouse’s labor income, Social Disability and Social Security benefits as well as sick-pay benefits at their pre-shock levels in period -1. Then, we calculate the ratio of this adjusted household income in period 1 (post-shock) to that in period -1 (pre-shock), and normalize it by the average ratio for the control group in order to account for calendar year trends as well as for life-cycle effects. Specification 2 in each panel extends specification 1 to include interactions of the treatment effect with additional household characteristics: age dummies for the surviving spouse, dummies for the age of the deceased at the year of death, year dummies, indicators for the number of children in the household as well as the surviving spouse’s months of education (and its square). The results are also robust to the inclusion of a quadratic in the household’s net wealth. All the variables that are interacted with “Treat × Post” are interacted with “Treat” and “Post” and enter the regressions separately as well. Since there are households with missing values for some of the controls (that are therefore included in the estimation of specification 1 but not 2), we show the robustness of our estimate of interest (“Treat × Post × Replacement Rate”) to the inclusion of this set of controls by reporting estimates for specification 1 for the sub-sample of households that are included in the estimation of specification 2. All specifications include year, age, and household fixed effects. The pre-shock periods include periods -5 to -3. The post-shock periods include periods 2 to 4. Robust standard errors clustered at the household level are reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1.
Table 2: Widows’ Labor Force Participation Responses to the Death of Their Spouse by Social Survivors Benefits

<table>
<thead>
<tr>
<th>Dependent Variable:</th>
<th>Widows’ Participation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treat × Post × Survivors Benefits</td>
<td>-0.0057***</td>
</tr>
<tr>
<td>Average Treatment Effect</td>
<td>1.8 pp</td>
</tr>
<tr>
<td>Counterfactual Participation</td>
<td>48.7 pp</td>
</tr>
<tr>
<td>Number of Obs.</td>
<td>364,100</td>
</tr>
<tr>
<td>Number of Clusters</td>
<td>268</td>
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</tbody>
</table>

Notes: This table reports the interaction of the treatment effect of the death of a spouse with the actual survivors benefits widows received through the Social Disability Insurance (Social DI) program (equation (4)). The regression is estimated by two-stage least squares, where the instrument for actual benefits is constructed as follows. In each year we calculate for each municipality the average benefits received by non-working surviving spouses through Social DI. Then, we assign to each widow in the treatment group her respective municipality-year leave-one-out mean. The sample includes widows under age 67 (the age at which the program transitions into the Old-Age Pension) in years prior to 1994 (when there is a data break in the reporting method of survivors benefits received through Social DI). The controls included in the estimation are municipality unemployment rate and average earnings (and their interaction with “Treat”, “Post”, and “Treat × Post”) as well as age, year, and municipality fixed effects. The identifying assumption is that, given our set of controls, the average social survivors benefits transferred to widows in a municipality in a given year affects a widow’s participation only through its influence on her own survivors benefits receipts. Note that the source of variation we use is within municipalities over time since we include municipality and calendar year fixed effects as controls. The pre-shock periods include periods -5 to -3. The post-shock periods include periods 2 to 4. Robust standard errors clustered at the municipality level are reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table 3: Labor Force Participation Responses of Widows Who Did Not Work before the Shock

<table>
<thead>
<tr>
<th>Mean Spousal Labor Force Participation</th>
<th>Spousal Participation by the Deceased’s Employment History</th>
<th>Overall Household Income by the Deceased’s Employment History</th>
<th>Deceased Did Not Work</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
<td></td>
</tr>
<tr>
<td>Treat × Post</td>
<td>0.0132***</td>
<td>-72,326***</td>
<td>0.0018</td>
</tr>
<tr>
<td>(0.0005)</td>
<td>(841)</td>
<td>(4)</td>
<td>(0.0012)</td>
</tr>
<tr>
<td>Treat × Post × Deceased Worked</td>
<td>0.0461***</td>
<td>-59,208***</td>
<td>0.0021</td>
</tr>
<tr>
<td>(0.0027)</td>
<td>(6.438)</td>
<td>(5)</td>
<td>(0.0018)</td>
</tr>
<tr>
<td>Number of Obs.</td>
<td>1,320,908</td>
<td>1,320,908</td>
<td>114,851</td>
</tr>
<tr>
<td>Number of Households</td>
<td>220,270</td>
<td>220,270</td>
<td>19,160</td>
</tr>
<tr>
<td>Number of Treated Households with Non-Working Deceased</td>
<td>90,686</td>
<td>90,686</td>
<td>90,686</td>
</tr>
<tr>
<td>Number of Treated Households with Working Deceased</td>
<td>11,257</td>
<td>11,257</td>
<td>11,257</td>
</tr>
</tbody>
</table>

Notes: This table reports the differences-in-differences estimates of the labor force participation responses of widows who did not work during the five-year period preceding their spouse’s death. The sample includes households in which the husband died between ages 45 and 80 from 1980 to 2011 and in which he either worked throughout the entire five-year period preceding his death (periods -5 to -1) or did not work altogether during this period. The treatment group comprises households that experienced the shock in different years, to which we match households that experienced the same shock five years later as a control group (Δ=5). Column 1 reports the simple differences-in-differences estimate in a regression in which the outcome variable is spousal labor force participation. Column 2 adds an interaction of the treatment effect with an indicator for whether the husband worked before his death. Column 3 runs the same specification as in Column 2 but where the outcome variable is the household’s overall income. Columns 4 and 5 report the spousal labor force participation effect for sub-samples of the households in which the husband did not work before his death. Column 4 reports the treatment effect for households in which the non-working deceased’s overall income before the shock (periods -3 to -1), including any transfer from government programs, was lower than the 10th percentile of this sample’s income distribution; Column 5 reports the treatment effect for households in which the non-working deceased’s overall income before the shock was lower than the 5th percentile. All specifications include year, age, and household fixed effects. The pre-shock periods include periods -5 to -3. The post-shock periods include periods 2 to 4. Robust standard errors clustered at the household level are reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1.
Appendix Figure 1:
Life-Cycle Labor Force Participation of the Unaffected Spouses in the Death Event Sample

Notes: This figure displays the life-cycle labor force participation of the unaffected spouses that are included in the death event sample (i.e., individuals whose spouses died between ages 45 and 80 from 1985 to 2011). The observations include the pre-shock periods (specifically, periods -5 to -2). The sharp drop at age 60 corresponds to eligibility for the Voluntary Early Retirement Pension (VERP). The figure shows the complex life-cycle trends in labor supply and illustrates why an extrapolation based on behavior in previous years is a poor predictor of future behavior.

Appendix Figure 2:
Survivors’ Labor Supply Responses to the Death of Their Spouse: Fatal Heart Attacks and Strokes

These figures plot the labor supply responses of survivors to the death of their spouse. The sample includes households in which an individual experienced a heart attack or a stroke between 1980 and 2011 and died in the same year. The panel on the left depicts the behavior of labor force participation, and the panel on the right depicts the behavior of annual earnings. The lines in each graph are constructed as described in the notes of Figure 2.
Appendix Figure 3:
Household Income around the Death of a Spouse

A. Potential Household Income

B. Actual Household Income

C. Potential Household Income of Survivors under Age 60

Notes: These figures plot different measures of household-level income around the death of a spouse by the gender of the surviving spouse. The sample includes individuals whose spouses died between ages 45 and 80 from 1980 to 2011. Panel A plots an adjusted measure of household income. Specifically, we fix the surviving spouse's labor income, Social Disability and Social Security benefits as well as sick-pay benefits at their pre-shock levels (in period -1). Hence, this measure captures the income loss that is directly attributed to the loss of a spouse. Panel B plots the actual household income that is observed in the data, which takes into account the surviving spouse’s behavioral responses. Panel C plots the adjusted measure from Panel A for survivors under age 60. The lines in each graph are constructed as described in the notes of Figure 2.
Appendix Figure 4:
Social Survivors Benefits for Widows under Age 67

A. Take-Up of Social Survivors Benefits

B. Distribution of Average Survivors Benefits

Notes: These figures include widows younger than 67 (the age at which the Social Disability Insurance transitions into the Old-Age Pension) in years prior to 1994 (when there is a data break in the reporting method of benefits received through Social Disability Insurance). Panel A plots these widows’ take-up of survivors benefits through the Social Disability Insurance program around the death of their spouse. Panel B displays the distribution of the instrument that we use in estimation of equation (4). These are the year-by-municipality average benefits received by non-working survivors through Social DI.

Appendix Figure 5:
Widows’ Labor Force Participation Responses to the Death of Their Spouse by Age

Widows under Age 60
Widows over Age 60

Notes: These figures plot the labor force participation responses of widows to the death of their spouse. The sample includes individuals whose spouses died between ages 45 and 80 from 1980 to 2011. The panel on the left depicts the behavior of widows younger than 60, the age at which there is a sharp decline in labor force participation due to eligibility for early retirement benefits, and the panel on the right depicts the behavior of widows older than 60. The lines in each graph are constructed as described in the notes of Figure 2.
Appendix Table 1:
Summary Statistics of Analysis Sample

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>All Ages</th>
<th>Under 60 (1)</th>
<th>Under 60 (2)</th>
<th>Under 60 (3)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Treatment</td>
<td>Control</td>
<td>Treatment</td>
<td>Control</td>
</tr>
<tr>
<td>Unaffected Spouse</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age</td>
<td>62.86</td>
<td>62.27</td>
<td>47.60</td>
<td>47.48</td>
</tr>
<tr>
<td>Education (months)</td>
<td>118.66</td>
<td>119.94</td>
<td>129.19</td>
<td>129.38</td>
</tr>
<tr>
<td>Percent female</td>
<td>0.6937</td>
<td>0.6632</td>
<td>0.7485</td>
<td>0.7485</td>
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<tr>
<td>Affected Spouse</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age</td>
<td>64.84</td>
<td>64.01</td>
<td>52.51</td>
<td>52.14</td>
</tr>
<tr>
<td>Education (months)</td>
<td>123.57</td>
<td>124.05</td>
<td>131.80</td>
<td>132.22</td>
</tr>
</tbody>
</table>

Outcomes

| Unaffected Spouse       | Participation | 0.3474 | 0.3719 | 0.7389 | 0.7445 | 0.7709 | 0.7820 |
|                        | Earnings (DKK) | 62.455 | 67.452 | 160.799 | 162.094 | 163.336 | 168.311 |
| Affected Spouse        | Participation | 0.2723 | 0.3211 | 0.6033 | 0.6560 | 0.7621 | 0.7790 |
|                        | Earnings (DKK) | 51.579 | 61.791 | 143.118 | 158.447 | 198.723 | 204.191 |

Number of Households

|              | 310,720 | 409,190 | 55,103 | 80,578 | 37,432 | 54,926 |

Notes: This table presents means of key variables in our analysis sample. All monetary values are reported in nominal Danish Kroner (DKK) deflated to 2000 prices using the consumer price index. In this year the exchange rate was approximately DKK 8 per US $1. For each event, the treatment group comprises households that experienced a shock in different years, to which we match households that experienced the same shock five years later as a control group (Δ=5). Columns 1 and 2 report statistics for the death event sample of households in which a spouse died of any cause between ages 45 and 80 from 1980 to 2011. Column 1 reports statistics for the entire sample, and Column 2 reports statistics for the sub-sample of surviving spouses under age 60. Column 3 reports statistics for the health event sample. It includes households in which one spouse experienced a heart attack or a stroke between 1980 and 2011 and survived for at least three years, and in which both spouses were under age 60. The values reported in the table are based on data from two periods before the shock occurred (period t = -2).

Appendix Table 2:
Survivors’ Labor Supply Responses to the Death of Their Spouse

A. Surviving Spouses of All Ages

<table>
<thead>
<tr>
<th>Dependent variable:</th>
<th>Widowers</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Treatment × Post</td>
<td>Participation (1)</td>
<td>Participation (2)</td>
<td>Earnings (3)</td>
<td>Earnings (4)</td>
<td>Participation (5)</td>
<td>Participation (6)</td>
</tr>
<tr>
<td>Treat × Post</td>
<td>-.0016**</td>
<td>-.0017</td>
<td>-.939**</td>
<td>-.906**</td>
<td>.0188***</td>
<td>.0164***</td>
<td>2.957***</td>
</tr>
<tr>
<td>Household FE</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Year and Age FE</td>
<td></td>
<td>X</td>
<td></td>
<td>X</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Number of Obs.</td>
<td>1,397,030</td>
<td>1,397,030</td>
<td>1,397,030</td>
<td>1,397,030</td>
<td>2,919,946</td>
<td>2,919,946</td>
<td>2,919,946</td>
</tr>
<tr>
<td>Number of Households</td>
<td>232,973</td>
<td>232,973</td>
<td>232,973</td>
<td>232,973</td>
<td>486,890</td>
<td>486,890</td>
<td>486,890</td>
</tr>
</tbody>
</table>

B. Surviving Spouses under 60

<table>
<thead>
<tr>
<th>Dependent variable:</th>
<th>Widowers</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Treatment × Post</td>
<td>Participation (1)</td>
<td>Participation (2)</td>
<td>Earnings (3)</td>
<td>Earnings (4)</td>
<td>Participation (5)</td>
<td>Participation (6)</td>
</tr>
<tr>
<td>Treat × Post</td>
<td>-.0075***</td>
<td>-.0071**</td>
<td>-.792***</td>
<td>-.730***</td>
<td>.0207***</td>
<td>.0219***</td>
<td>4.093***</td>
</tr>
<tr>
<td>Household FE</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Year and Age FE</td>
<td></td>
<td>X</td>
<td></td>
<td>X</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Number of Obs.</td>
<td>203,569</td>
<td>203,569</td>
<td>204,438</td>
<td>204,438</td>
<td>607,437</td>
<td>607,437</td>
<td>608,742</td>
</tr>
<tr>
<td>Number of Households</td>
<td>34,104</td>
<td>34,104</td>
<td>34,118</td>
<td>34,118</td>
<td>101,529</td>
<td>101,529</td>
<td>101,562</td>
</tr>
</tbody>
</table>

Notes: This table reports the differences-in-differences estimates of the surviving spouses’ labor supply responses (equation (2)). The sample includes individuals whose spouses died between ages 45 and 80 from 1980 to 2011. The treatment group comprises households that experienced the shock in different years, to which we match households that experienced the same shock five years later as a control group (Δ=5). Panel A reports the responses of all survivors by gender, where widowers are those who lost their wives and widows are those who lost their husbands. Panel B reports the responses of survivors under 60 by gender. The pre-shock periods include periods -5 to -3. The post-shock periods include periods 2 to 4. Robust standard errors clustered at the household level are reported in parentheses.

*** p<0.01, ** p<0.05, * p<0.1.
### Appendix Table 3: Survivors’ Annual Earnings Responses to the Death of Their Spouse

#### A. Mean Responses by Quintiles of Own Pre-Shock Earnings

<table>
<thead>
<tr>
<th>Quintile</th>
<th>All Survivors</th>
<th>Low-Earning Deceased</th>
<th>High-Earning Deceased</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Treat × Post</td>
<td>Mean Earnings (1)</td>
<td>Mean Earnings (1)</td>
</tr>
<tr>
<td>Quintile 1</td>
<td>6,062*** (1,211)</td>
<td>7,237*** (2,194)</td>
<td>5,105*** (1,481)</td>
</tr>
<tr>
<td></td>
<td>8,847*** (978)</td>
<td>9,034*** (1,784)</td>
<td>8,565*** (1,199)</td>
</tr>
<tr>
<td>Quintile 2</td>
<td>5,946*** (1,348)</td>
<td>7,012*** (2,530)</td>
<td>4,919*** (1,641)</td>
</tr>
<tr>
<td></td>
<td>7,283*** (1,070)</td>
<td>7,120*** (2,014)</td>
<td>6,860*** (1,313)</td>
</tr>
<tr>
<td>Quintile 3</td>
<td>1,154 (1,369)</td>
<td>-667 (2,505)</td>
<td>1,370 (1,674)</td>
</tr>
<tr>
<td></td>
<td>3,744*** (1,049)</td>
<td>2,341 (1,893)</td>
<td>3,919*** (1,305)</td>
</tr>
<tr>
<td>Quintile 4</td>
<td>-2,203 (1,495)</td>
<td>-2,224 (2,746)</td>
<td>-2,644 (1,818)</td>
</tr>
<tr>
<td></td>
<td>-934 (1,157)</td>
<td>-986 (2,095)</td>
<td>-1,484 (1,416)</td>
</tr>
<tr>
<td>Quintile 5</td>
<td>-7,494*** (1,765)</td>
<td>-4,872 (3,211)</td>
<td>-8,877*** (2,170)</td>
</tr>
<tr>
<td></td>
<td>-5,846*** (1,399)</td>
<td>-3,703 (2,498)</td>
<td>-7,466*** (1,718)</td>
</tr>
</tbody>
</table>

#### B. Mean Responses by Gender

<table>
<thead>
<tr>
<th></th>
<th>Both Genders</th>
<th>Widowers</th>
<th>Widows</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treat × Post</td>
<td>585 (667)</td>
<td>-6,623*** (1,342)</td>
<td>3,405*** (729)</td>
</tr>
<tr>
<td>Counterfactual Earnings</td>
<td>150,994</td>
<td>163,010</td>
<td>145,969</td>
</tr>
<tr>
<td>Household FE</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Number of Obs.</td>
<td>686,521</td>
<td>220,125</td>
<td>466,392</td>
</tr>
<tr>
<td>Number of Households</td>
<td>114,462</td>
<td>36,705</td>
<td>77,756</td>
</tr>
</tbody>
</table>

Notes: This table reports the differences-in-differences estimates of the surviving spouses’ annual earnings by the level of their own earnings when their spouses died. The sample includes individuals whose spouses died between ages 45 and 80 from 1980 to 2011, where we constrain the sample in the following way. First, we exclude surviving spouses whose average labor income before the shock (in periods -5 to -2) was lower than their experimental-group-specific 20th percentile. Then, we calculate for each household the pre-shock labor income share of the deceased spouse out of the household’s overall labor income and include only households in which both spouses were sufficiently attached to the labor force; specifically, we keep households for whom the average share was between 0.20 and 0.80. These restrictions allow us to focus on households for which there has been some loss of income due to the death of a spouse and in which the surviving spouse earned non-negligible labor income both in levels and as a share within the household. In addition, to guarantee that our results are not driven by outliers, we exclude households with dying spouses whose mean pre-shock earnings did not fall within their group-specific 5th and 95th percentiles or households with unaffected spouses whose mean pre-shock earnings were higher than their group-specific 95th percentile. We divide the remaining sample into five equal-sized groups by their pre-shock level of earnings. Panel A separately estimates a differences-in-differences specification for each surviving spouses’ quintile. Column 1 includes all surviving spouses; Column 2 includes households in which the dying spouses’ pre-shock labor income fell within the bottom three quintiles of its group-specific distribution, to which we refer as “low-earners”; Column 3 includes households in which the dying spouses’ pre-shock labor income fell within the top two quintiles, to which we refer as “high-earners”. The gradient of survivors’ labor supply responses with respect to their own level of pre-shock earnings is also robust to the inclusion of a quadratic in the household’s net wealth. Panel B reports the average treatment effect for this sample. The second row reports the counterfactual outcome based on the differences-in-differences estimation. The pre-shock periods include periods -5 to -3. The post-shock periods include periods 2 to 4. Robust standard errors clustered at the household level are reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1.
Appendix Table 4:
Household Responses to Non-Fatal Severe Health Shocks

<table>
<thead>
<tr>
<th>Dependent variable:</th>
<th>Affected Spouse</th>
<th>Household Income</th>
<th>Unaffected Spouse</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Participation</td>
<td>Earnings</td>
<td>Participation</td>
</tr>
<tr>
<td>Treat × Post</td>
<td>Short Run</td>
<td>Medium Run</td>
<td>Short Run</td>
</tr>
<tr>
<td></td>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
</tr>
<tr>
<td></td>
<td>(5)</td>
<td>(6)</td>
<td>(7)</td>
</tr>
<tr>
<td></td>
<td>(9)</td>
<td>(10)</td>
<td></td>
</tr>
<tr>
<td>Treat × Post ×</td>
<td>-0.0861***</td>
<td>-0.1212***</td>
<td>-29.012***</td>
</tr>
<tr>
<td></td>
<td>(0.0023)</td>
<td>(0.0027)</td>
<td>(741)</td>
</tr>
<tr>
<td>Household FE</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Counterfactual Post-Shock Mean of Dependent Var.</td>
<td>0.7328</td>
<td>0.7147</td>
<td>195.433</td>
</tr>
<tr>
<td>Percent Change</td>
<td>-12%</td>
<td>-17%</td>
<td>-15%</td>
</tr>
<tr>
<td>Percent Change Excluding the Unaffected Spouse’s Responses</td>
<td>-2.1%</td>
<td>-3.3%</td>
<td></td>
</tr>
<tr>
<td>Number of Obs.</td>
<td>644,699</td>
<td>646,272</td>
<td>645,817</td>
</tr>
<tr>
<td>Number of Households</td>
<td>92,349</td>
<td>92,358</td>
<td>92,356</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Notes: This table reports the differences-in-differences estimates of household labor supply responses to severe health shocks in which the affected spouse survived and the effect of these shocks on overall household income (equation (5) in footnote 20). The sample includes households in which one spouse experienced a heart attack or a stroke and survived for at least three years, and in which both spouses were under age 60. The treatment group comprises households that experienced the shock in different years, to which we match households that experienced the same shock five years later as a control group ($\Delta=5$). We allow for differential treatment effects for the “short run” – periods 1 and 2 – and the “medium run” – period 3, to account for the gradual responses documented in Table VII. The pre-shock periods include periods -5 to -2. Household income (Columns 5 and 6) includes income from any source – including earnings, capital income, annuity payouts, and benefits from any social program. The third row reports the counterfactual outcome based on the differences-in-differences estimation. Robust standard errors clustered at the household level are reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Appendix Table 5:
Spousal Participation Responses to Non-Fatal Severe Health Shocks by the Degree of Income Loss

<table>
<thead>
<tr>
<th>A. Baseline Regression</th>
<th>Participation (1)</th>
<th>Participation (2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treat × Post</td>
<td>0.3423***</td>
<td>0.3327***</td>
</tr>
<tr>
<td></td>
<td>(0.0147)</td>
<td>(0.0147)</td>
</tr>
<tr>
<td>Treat × Post × Replacement Rate</td>
<td>-0.3529***</td>
<td>-0.3692</td>
</tr>
<tr>
<td></td>
<td>(0.0149)</td>
<td>(0.0152)</td>
</tr>
<tr>
<td>Treat × Post × Affected Spouse</td>
<td>0.0420***</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.0048)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>B. Regression with Interactions</th>
<th>Participation (1)</th>
<th>Participation (2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treat × Post</td>
<td>-0.3603***</td>
<td>-0.3720***</td>
</tr>
<tr>
<td></td>
<td>(0.0151)</td>
<td>(0.0153)</td>
</tr>
<tr>
<td>Replacement Rate</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.0050)</td>
<td></td>
</tr>
<tr>
<td>Affected Spouse Works</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of Obs.</td>
<td>236,897</td>
<td>236,897</td>
</tr>
<tr>
<td>Number of Households</td>
<td>47,459</td>
<td>47,459</td>
</tr>
</tbody>
</table>

Notes: This table reports the interaction of the treatment effect of non-fatal spousal health shocks with the household’s post-shock income replacement rate (similar to equation (3)). The sample includes households in which one spouse experienced a heart attack or a stroke and survived for at least three years, and in which both spouses were under age 60. The treatment group comprises households that experienced the shock in different years, to which we match households that experienced the same shock five years later as a control group ($\Delta=5$). Column (1) in Panel A estimates a baseline differences-in-differences specification which interacts the treatment effect with the replacement rate variable. This replacement rate is calculated as follows. First, we fix the surviving spouse’s labor income, Social Disability and Social Security benefits as well as sick-pay benefits at their pre-shock levels (in period -1). Then, we calculate the ratio of this adjusted household income in period 1 (post-shock) to that in period -1 (pre-shock), and normalize it by the average ratio for the control group in order to account for calendar year trends as well as for life-cycle effects. Column (1) in Panel B extends this specification to include interactions of the treatment effect with additional household characteristics: age dummies for both spouses, year dummies, indicators for the number of children in the household, the healthy spouse’s months of education (and its square), and a quadratic in the household’s net wealth. All the variables that are interacted with “Treat × Post” are interacted with “Treat” and “Post” and enter the regressions separately as well. Column (2) in Panels A and B replicates column (1) in Panels A and B, respectively, but adds interactions with an indicator for the sick spouse’s labor force participation. All specifications include year, age, and household fixed effects. The pre-shock periods include periods -5 to -3. The post-shock periods include periods 2 and 3. Robust standard errors clustered at the household level are reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1.