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Optimism and Death: Predicting the Course and Consequences of Depression Trajectories in Response to Heart Attack

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Abstract
The course of depression in relation to myocardial infarction (MI), commonly known as heart attack, and the consequences for mortality are not well characterized. Further, optimism may predict both the effects of MI on depression as well as mortality secondary to MI. In the current study, we utilized a large population-based prospective sample of older adults (*N* = 2,147) to identify heterogeneous trajectories of depression from 6 years prior to their first-reported MI to 4 years after. Findings indicated that individuals were at significantly increased risk for mortality when depression emerged after their first-reported MI, compared with resilient individuals who had no significant post-MI elevation in depression symptomatology. Individuals with chronic depression and those demonstrating pre-event depression followed by recovery after MI were not at increased risk. Further, optimism, measured before MI, prospectively differentiated all depressed individuals from participants who were resilient.

Keywords
optimism, depression, resilience, myocardial infarction, mortality, latent growth mixture modeling, heart attack

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Both depression and myocardial infarction (MI), or heart attack, independently carry a significant disease burden (Mathers & Loncar, 2006; Murray & Lopez, 1997). Moreover, both provide reciprocal risk, as depression is an independent risk factor for MI, and MI is an independent risk factor for depression (Van Melle et al., 2004). Finally, depression following MI is a significant independent risk factor for mortality (Frasure-Smith, Lespérance, & Talajic, 1993). However, closer evaluation of the evidence indicates that the complex longitudinal relationship between depression and MI is not well understood. Much of the research in this domain employs subjects only identified following MI (Frasure-Smith et al., 1993; Wulsin & Singal, 2003). Additionally, studies comparing the risks associated with new-onset depression have utilized retrospective self-reports to determine past depression incidence (Dickens et al., 2008; Spijkerman et al., 2005), which may confound findings, as memory biases associated with depression influence beliefs and cognitions about past depression (Watkins, 2002). Finally, although several truly prospective studies have assessed depression as a risk factor for later MI as well as mortality, these studies have not determined whether the course of depression in response to MI increases risk for mortality (Anda et al., 1993). To our knowledge, no studies have prospectively identified depression trajectories in response to MI or examined whether these trajectories differentially predict mortality.

Disentangling the relationship between depression and MI is important, as evidence indicates that individuals with new-onset depression following heart disease are saddled with significantly worse clinical prognoses (Zuidersma, Thombs, & de Jonge, 2011) and significantly elevated risk of mortality (Dickens et al., 2008), compared with individuals who do not develop depression.

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Explanations for increased mortality in the former group include poor adherence to the post-MI medication regimen (Glassman, Bigger, & Gaffney, 2009) and biological consequences of MI that are also risk factors for depression, such as activation of inflammatory pathways (Ziegelstein, 2013).

Optimism, an individual attitude about the social or material future that is biased toward one's advantage (Peterson, 2000) or a generalized favorable expectation about the future (Carver, Scheier, & Segerstrom, 2010), may predict decreased risk for depression following a significant stressor, such as MI. Optimism predicts positive health outcomes generally (Rasmussen, Scheier, & Greenhouse, 2009) and following MI specifically (Scheier et al., 1999). Optimism reduces the risk for both MI and MI-related mortality (Giltay, Geleijnse, Zitman, Hoekstra, & Schouten, 2004; Giltay, Kamphuis, Kalmijn, Zitman, & Kromhout, 2006; Kubzansky, Koenen, Spiro, Vokonas, & Sparrow, 2007). Further, optimism prospectively predicts risk for later depressive symptoms (Giltay, Zitman, & Kromhout, 2006). However, no previous research has determined that optimism prospectively predicts the course of depression in relation to MI or has a distal impact on mortality.

Disentangling the relationship between MI, depression, and optimism requires consideration of heterogeneity in the course of depression responses to stressful life events. Other prospective studies of depression in response to life stressors, such as bereavement, have shown that people do not respond homogeneously, but instead follow typical patterns (Bonanno, 2004), including resilience (characterized by no significant elevation in symptomatology), pre-event elevation followed by improvement following the event, emergent depression symptomatology following the event, and chronic elevated depression both before and after the event (Galatzer-Levy & Bonanno, 2012). Responses to discrete health events also result in similar prospective patterns and longitudinal patterns. This has been demonstrated in the context of cancer (Lam et al., 2010), chronic-pain onset (Zhu, Galatzer-Levy, & Bonanno, 2014), and spinal-cord injury (Bonanno, Kennedy, Galatzer-Levy, Lude, & Elfström, 2012).

Previous findings on the course and predictors of depression in response to MI has varied widely, which makes it difficult to draw unified conclusions. Research into the duration of time after MI to determine mortality has varied from 2 years (Meijer et al., 2011; Van Melle et al., 2004) to 8 years (Dickens et al., 2008). Also, differentiating recurrent from first-onset depression is difficult without reliance on potentially biased retrospective self-report. Much prospective research on the recurrence of depression has shown that individuals with a previous episode may remain well for roughly 5 years or more without a recurrent episode. Identifying heterogeneous depression responses to MI and their differential association to mortality was central to the current investigation. Therefore, we examined individuals from 5 to 6 years prior to MI to 4 to 5 years following MI, with individual-level optimism measured at or prior to the first time point. Specifically, we utilized a large, population-based sample of older adults to test three hypotheses. First, we hypothesized that depression symptoms will reveal prospective, heterogeneous patterns in association with a first-episode MI, including resilience, chronic depression, pre-event depression followed by recovery, and emergent depression. Our second hypothesis was that optimism, measured prior to MI, will prospectively predict chronic depression and new-onset depression following first-episode MI. Finally, we predicted that individuals who exhibit trajectories of emergent depression after MI will be at increased risk for mortality.

Method

Analyses were conducted using data obtained from the Health and Retirement Study (HRS), a nationally representative study sponsored by the National Institute on Aging housed at the University of Michigan. The HRS collected data every 2 years across eight waves (1994 to 2008). Though the study began in 1994, a significant portion of individuals were not enrolled until later time points. The HRS was designed to explore numerous aspects of aging in American adults, including mental and physical health.

Participants

The sample was restricted to individuals who were members of the original HRS or War Baby cohorts (years of birth ranging from 1931 to 1947) and who reported during at least one time point that they had never been diagnosed with MI, stroke, diabetes, and cancer. These diseases were selected because of significant evidence that they are associated with depression. Only individuals who subsequently reported having had an MI after the first time point at which they were measured were eligible to participate in the current study.

From this larger subsample, we selected individuals with relevant data during at least three of five available time points, including the time point immediately before and immediately following the MI. This was done for a number of reasons, though this is not an explicit requirement of the latent growth mixture modeling (LGMM) approach that we employed. We elected to include participants with a minimum of three time points because the sample was large and time points were widely dispersed. As such, we were concerned that we would overidentify trajectories if we included participants with fewer time points or participants who did not have information immediately before and after the MI.

The final sample consisted of 2,147 participants (51.4% female, 48.6% male) with a mean age of 71.07 years (*SD* = 10.51) at the time of the reported diagnosis. Of the participants, 15.9% had depression data available at three time points, 50.7% had data at four time points, and 33.4% had depression data available at all five time points. Depression data were available for 1,165 participants at three time points prior to the MI, for 1,581 at two time points prior to the MI, for 2,147 at the time point immediately preceding the MI, for 2,039 immediately following the MI, and for 1,451 for the final time point.

Procedure

Participants were asked at each time point whether they had developed one or more of several health conditions. Participant data were organized using a *floating-baseline* methodology (Galatzer-Levy, Bonanno, & Mancini, 2010), in which measures were centered on the wave during which the MI diagnosis was first reported. The benefit of this method is that large, population-based data sets, such as the HRS, can be utilized for prospective studies by first identifying individuals who have experienced a target event, such as an MI, and then centering their longitudinal data on the incident event. Using this approach, shared, prospective trajectories of response to events, such as MI, can be readily identified, and potential sources of bias, such as retrospective self-report of past psychological functioning or sample bias of individuals selected because of the event, can be minimized. For this reason, our analysis of trajectories of depression in response to the MI encompassed three time points prior to the MI and two time points subsequent to the MI. Owing to the floating-baseline design, the number of waves during which participants had data varied. We elected to model trajectories over 10 years (five time points) to capture a window of time from roughly 6 years prior to an MI to 4 years subsequent to an MI. We chose these data points to best capture the time frame of recurrent depression so as to distinguish changes in depression status related to the MI from changes in depression that might have occurred independently from the MI. Trajectories were modeled using the entire sample. Follow-up analyses utilized a set of baseline predictors collected only in 1994, which resulted in a significant loss of participants.

Measures

Depression symptomatology. Participants reported basic demographic information and their health status at each time point. Depression symptoms were measured using nine items from a modified version of the Center for Epidemiologic Studies Depression (CES-D) scale (Radloff, 1977). This abbreviated version of the CES-D asked participants whether they did (1) or did not (0) experience any of the described symptoms during the previous week. The CES-D scale has demonstrated high external and construct validity (Kohout, Berkman, Evans, & Cornoni-Huntley, 1993). The mean number of missing time points across the subsample was 1.22 (*SD* = 1.11). A cutoff score of 4 was recommended by the HRS for the assessment of clinically relevant depression (Steffick, 2000). The mean CES-D score for the two time points prior to MI was 2.25 (*SD* = 2.3), for one time point prior to MI was 2.37 (*SD* = 2.36), for the time point of MI was 2.51 (*SD* = 2.41), for one time point after MI was 2.91 (*SD* = 2.52), and for two time points after MI was 2.89 (*SD* = 2.49).

Optimism about the future. Participants were asked at a single time point (1994) to assess the probability of a series of future personal and general health and economic events. Questions asked participants what they thought the chances were that they would “live to be 75 or more,” “live to be 85 or more,” “leave an inheritance,” “see double-digit inflation,” and “see another major economic depression.” Scores from 0 (*absolutely no chance*) to 10 (*absolutely certain*) were multiplied by 10 to create a probability distribution from 0% to 100%.

A significant amount of data was missing for the optimism measures, primarily because the HRS started collecting data for many individuals only in 1996 and after, when the optimism questions were no longer asked. Nonetheless, a large amount of data was available for analysis. The mean scores were 55.90 (*SD* = 31.34; *n* = 1,213) for the chance of living past 75, 38.32 (*SD* = 31.12; *n* = 1,230) for the chance of living past 85, 60.14 (*SD* = 42.64; *n* = 1,108) for the chance of leaving an inheritance, 51.14 (*SD* = 29.49; *n* = 1,166) for the chance of seeing double-digit inflation, and 40.51 (*SD* = 29.24; *n* = 1,146) for the chance of seeing a major economic depression. The chance of living past 75 and living past 85 was strongly associated, as was the chance of seeing double-digit inflation and economic depression. Other variables demonstrated weak or nonsignificant associations.

We examined the correlation between optimism and CES-D measurements across time points because both optimism items and depression items may measure the same underlying construct. If these items are highly correlated, it would not be meaningful to predict depression from optimism. We found that optimism and CES-D scores were significantly but weakly correlated across all time points (*r*s < .30; see Table 1). Because of issues with missing data on the chance of living past 85 (see

Table 1. Intercorrelations Among Key Variables

Variable	1	2	3	4	5	6	7	8	9	10
1. Chance of living to 75	—	.71** (n = 840)	.18** (n = 928)	–.03 (n = 879)	–.01 (n = 899)	–.20** (n = 493)	–.20** (n = 632)	–.16** (n = 761)	–.25** (n = 934)	–.19** (n = 896)
2. Chance of living to 85	.71** (n = 6,257)	—	.05 (n = 910)	.03 (n = 874)	.04 (n = 890)	–.12* (n = 481)	–.11** (n = 618)	–.05 (n = 749)	–.10** (n = 917)	–.06 (n = 876)
3. Chance of leaving an inheritance	.20** (n = 6,730)	.08** (n = 6,638)	—	.10** (n = 974)	–.06 (n = 995)	–.21** (n = 534)	–.24** (n = 686)	–.23** (n = 837)	–.23** (n = 1,039)	–.19** (n = 994)
4. Chance of seeing double-digit inflation	.02 (n = 6,421)	.02 (n = 6,383)	.07** (n = 6,959)	—	.51** (n = 971)	.01 (n = 508)	.11** (n = 650)	.04 (n = 791)	.10** (n = 981)	.08* (n = 939)
5. Chance of seeing another major economic depression	–.06** (n = 6,543)	–.01 (n = 6,484)	–.06** (n = 7,089)	.51** (n = 6,935)	—	.13** (n = 514)	.14** (n = 660)	.13** (n = 809)	.13** (n = 1,001)	.13** (n = 958)
6. CES-D three time points prior to MI	–.20** (n = 548)	–.14** (n = 526)	–.19** (n = 598)	.01 (n = 565)	.11* (n = 572)	—	.58** (n = 775)	.60** (n = 771)	.55** (n = 790)	.48** (n = 745)
7. CES-D two time points prior to MI	–.20** (n = 688)	–.10** (n = 676)	–.22** (n = 750)	.09* (n = 708)	.12** (n = 719)	.58** (n = 849)	—	.58** (n = 1,132)	.58** (n = 1,165)	.52** (n = 1,081)
8. CES-D one time point prior to MI	–.16** (n = 818)	–.06 (n = 808)	–.22** (n = 909)	.01 (n = 855)	.10** (n = 875)	.59** (n = 826)	.58** (n = 1,200)	—	.61** (n = 1,581)	.55** (n = 1,491)
9. CES-D one time point after MI	–.25** (n = 947)	–.10** (n = 930)	–.23** (n = 1,056)	.10 (n = 996)	.13** (n = 1,019)	.55** (n = 793)	.58** (n = 1,165)	.60** (n = 1,621)	—	.59** (2,039)
10. CES-D two time points after MI	–.19** (n = 958)	–.05 (n = 943)	–.17** (n = 1,065)	.06 (n = 1,005)	.12** (n = 1,024)	.47** (n = 498)	.52** (n = 1,147)	.55** (n = 1,567)	.56** (n = 2,039)	—

Note: Correlations below the diago were conducted using all available data. Correlations above the diagonal were conducted on individuals used for the current analysis. CES-D refers to scores on the Center for Epidemiologic Studies Depression measure (Radloff, 1977). MI = myocardial infarction.
*$p \leq .05$. **$p \leq .01$.

Table 2. Fit Indices for the Growth-Mixture Models of Depression-Symptom Severity (N = 2,147)

	Model				
Fit index	One class	Two classes	Three classes	Four classes	Five classes
AIC	35,591.75	35,258.72	34,999.96	34,796.49	34,619.01
BIC	35,671.16	35,349.47	35,113.40	34,932.62	34,777.82
SSBIC	35,626.68	35,298.64	35,049.86	34,856.36	34,688.86
Entropy	—	.80	.80	.83	.77
BLRT	—	$p < .001$	$p < .001$	$p < .001$	$p < .001$

Note: AIC = Akaike information criterion; BIC = Bayesian information criterion; SSBIC = sample-size-adjusted Bayesian information criterion; BLRT = bootstrap likelihood-ratio test.

Results) and only moderate reliability among variables measuring future negative economic events (Cronbach's α = .67), we chose to analyze these items independently rather than combining them into one composite measure of optimism.

Death records. Data on mortality from the National Death Index were accessed through the HRS to identify if and when any of our participants had died. These data were made available as part of the limited-access data set of the HRS. A dummy-coded variable was utilized in all analyses to indicate whether individuals had died by the final time point (4 years following their first-reported MI). These data were complete. Cause of death was not examined because this information is protected data to which we did not have access.

Financial assets. Total assets, as well as total assets minus mortgage assets, were provided for all HRS subjects by the RAND Corporation. RAND utilized a multistage-imputation approach to estimate assets for nonresponders. In the current study, we subtracted mortgage assets from total assets because of recent economic events demonstrating that mortgage assets were widely inflated and had become devalued within the time frame of this study. Further, analyses of these two variables demonstrated that in HRS participants, total assets increased over time when mortgage assets were included but decreased when assets were subtracted.

Results

Unconditional LGMM results

We performed LGMM with Mplus (Version 7.0; Muthén & Muthén, 2012) to identify the best-fitting models of the trajectory of depression symptoms over the five time points. A series of models utilizing linear and quadratic parameters with the time point immediately following the MI freely estimated were compared. For the purpose of model convergence, we allowed variance of the intercept term to be freely estimated across classes, whereas variance of the slope and quadratic terms were fixed.

To determine the best-fitting solution, we compared progressive models (that categorized participants into one, two, three, four, or five classes) for improvement in fit using the Akaike, Bayesian, and sample-size-adjusted Bayesian information criterions; entropy values; and the Lo-Mendell-Rubin and bootstrap likelihood-ratio tests (see Table 2). Our selection of the final model was based on overall model fit, interpretability, and theoretical coherence (Bonanno, 2004; Muthén, 2003). The information indices and likelihood tests showed improved fit as the number of classes increased from one to five; however, this was not the case for entropy, which was lower in the model with four classes than in the model with five classes, a result suggesting poorer classification for the five-class solution than for the four-class solution. Additionally, the five-class solution split a previously identified trajectory into two parallel trajectories. Redundancy in trajectories often occurs when using fixed effects, and it is recommended to utilize the more parsimonious model with fewer classes (Nylund, Asparouhov, & Muthén, 2007; Table 2). Consequently, we chose the four-class model as the optimal solution (see Fig. 1).

The four unique trajectories described four classes. The largest class, the resilient class (68.3% of the sample), had no significant elevation in symptomatology and was characterized by a low intercept (b = 1.59, SE = 0.10, p < .001), a flat slope across time points (b = −0.12, SE = 0.11, p > .250), and a nonsignificant quadratic parameter (b = 0.03, SE = 0.02, p = .138). Next, the chronic-depression class (14.0%) was characterized by consistently high levels of depression symptomatology from before to after the MI; this class had a high intercept (b = 5.53, SE = 0.59, p < .001), a flat slope (b = 0.33, SE = 0.51, p > .250), and a nonsignificant quadratic parameter (b = −0.03, SE = 0.10, p > .250). Third, the emerging-depression class (10.9%) showed a spike in depressive symptoms following the MI with some degree of recovery by the next time point. This class had a relatively low initial intercept

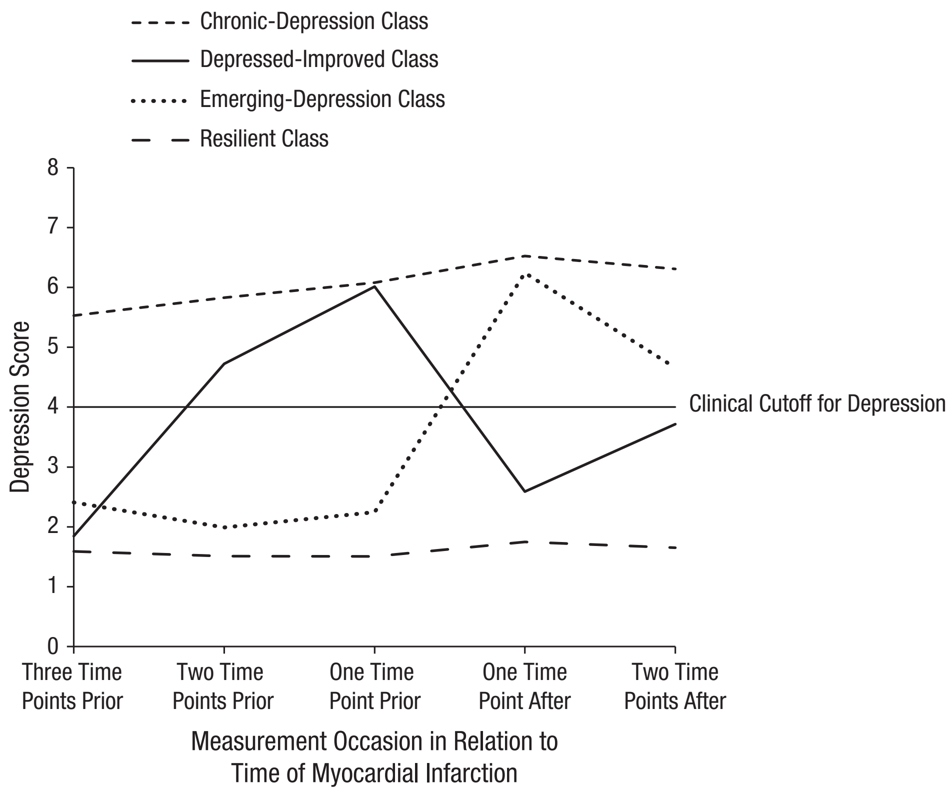

Fig. 1. Mean depression score as a function of time point of assessment and class (N = 2,147). Depression was rated using the Center for Epidemiologic Studies Depression (CES-D) scale (Radloff, 1977); higher numbers indicate greater depression levels.

(b = 2.41, SE = 0.37, p < .001), a marginally significant overall slope (b = −0.75, SE = 0.45, p = .096), and a significant quadratic parameter (b = 0.33, SE = 0.09, p < .001). Finally, we observed a depressed-improved class (6.8%) that demonstrated growth in depression symptoms over 6 years leading up to the MI followed by a precipitous drop after the MI and a slight reemergence of symptoms over time. This class had a low initial intercept (b = 1.85, SE = 0.56, p < .001), a significant positive slope (b = 3.68, SE = 0.60, p < .001), and a significant quadratic parameter (b = −0.80, SE = 0.13, p < .001).

Conditional model

Because strokes commonly accompany MI and may affect depression scores, a dummy-coded variable indicating whether a stroke occurred in the same year was included as a correlate of depression scores for the first time point following the MI. There was no overall effect for co-occurring stroke on depression scores for the year of the MI (b = 0.05, SE = 0.15, p = .245). However, the addition of stroke as a covariate improved the entropy score of the model (entropy = .86), which indicated a more-clarified model. This change also resulted in minor shifts in intercepts and estimated percentages of class membership but did not substantively alter the classes.

Optimism estimates predicting trajectory membership. We next examined the optimism variables as predictors of trajectory membership. Because of significant missing data for these variables, we first conducted a series of one-way analyses of variance comparing dummy-coded variables indicating missing data for each optimism variable in relation to class. All comparisons were nonsignificant, with the exception of the chance of living past 85, which demonstrated a significant overall effect, F(3, 2143) = 5.29, p ≤ .001. Post hoc analysis using least squares differences revealed that only the resilient class and the chronic-depression class differed significantly in the amount of missing data (mean difference = 0.11, SE = 0.03, p < .001). No other comparisons approached significance. Therefore, we proceeded by comparing classes on the optimism variables. As the chance of living past 85 was shown to have missing data related to the outcome, it was dropped from subsequent analyses.

We conducted a multinomial logistic regression predicting class membership on the basis of the remaining

Table 3. Results of Regression Analyses Comparing Classes' Subjective Probability Estimates (n = 869)

Variable	Class comparison: Resilient – chronic depression	Resilient – depressed-improved	Chronic depression – emerging depression	Chronic depression – depressed-improved	Depressed-improved – emerging depression	Depressed-improved – emerging depression
Rated probability						
Living past 75	–0.017 (0.003), $p < .001$	–0.011 (0.005), $p = .028$	< 0.001 (0.004), $p > .250$	0.006 (0.005), $p = .235$	0.017 (0.005), $p = .001$	0.001 (0.006), $p = .088$
Leaving an inheritance	–0.005 (0.003), $p = .051$	–0.010 (0.004), $p = .011$	–0.006 (0.003), $p = .035$	–0.004 (0.004), $p > .250$	–0.001 (0.004), $p > .250$	0.003 (0.005), $p > .250$
Double-digit inflation	0.003 (0.004), $p > .250$	0.010 (0.006), $p = .111$	0.003 (0.01), $p > .250$	0.006 (0.007), $p > .250$	< 0.001 (0.006), $p > .250$	–0.007 (0.008), $p > .250$
Economic depression	0.010 (0.004), $p = .022$	0.010 (0.006), $p = .150$	0.008 (0.005), $p = .098$	–0.001 (0.007), $p > .250$	–0.002 (0.006), $p > .250$	–0.001 (0.007), $p > .250$
Assets in year of MI	< 0.001 (< 0.001), $p = .005$	< 0.001 (< 0.001), $p = .121$	< 0.001 (< 0.001), $p > .250$	< 0.001 (< 0.001), $p > .187$	< 0.001 (< 0.001), $p = .001$	< 0.001 (< 0.001), $p > .120$

Note: The table presents unstandardized regression coefficients, with standard errors in parentheses. The four optimism variables were derived from self-reports of the probability of living past 75, leaving an inheritance, seeing double-digit inflation, and seeing a major economic depression. Assets in year of myocardial infarction (MI) represents nonhousing assets at the year of first-reported MI.

optimism variables while controlling for assets. Assets were controlled for because many of the optimism estimates were directly related to individual economic estimates, which can be affected by current economic status (e.g., likelihood of leaving an inheritance) or other factors that can be influenced by personal economic status. The omnibus likelihood-ratio test demonstrated significance, $\chi^2(15, N = 621) = 118.91, p < .001$, with the inclusion of four of the five new predictors resulting in the model accounting for significantly more variance, total assets: $\chi^2(3, N = 630) = 24.23, p < .001$, chance of living past 75: $\chi^2(3, N = 630) = 2.64, p < .001$, chance of leaving an inheritance: $\chi^2(3, N = 630) = 11.68, p = .009$, chance of seeing another major economic depression: $\chi^2(3, N = 630) = 8.16, p = .043$, with the exception of the chance of seeing double-digit inflation: $\chi^2(3, N = 630) = 2.99, p > .250$.

Post hoc comparisons revealed significant class differences on all variables, with the exception of the chance of seeing double-digit inflation; the most robust differences were evident between the resilient class and the other classes. Specifically, people who eventually showed a resilient pattern after an MI had before their MI indicated greater confidence than members of the other classes (with the exception of the emerging-depression class) that they would live past 75 and that they were more likely to leave an inheritance, even when total assets were controlled for. Individuals in the emerging-depression class reported significantly higher probabilities of living past 75 compared with those in the chronic-depression class (see Table 3).

Death rate associated with trajectory membership. Three hundred seventy-three (24.7%) individuals in the resilient class, 81 (27.1%) in the chronic-depression class, 70 (33.2%) in the emerging-depression class, and 28 (22.2%) in the depressed-improved class were deceased by 4 years following the MI. To determine whether death rate 4 years post-MI varied significantly by class membership, we conducted a logistic regression using class to predict mortality by 4 years post-MI while controlling for age and total nonhousing assets. The resilient class was set as the reference class. Individuals in the emerging-depression class continued to demonstrate a significantly increased likelihood of mortality compared with those in the resilient class when we controlled for age and nonhousing assets (see Table 4).

Death rate independently associated with trajectory membership and optimism. In a final analysis, we conducted a second logistic regression predicting mortality 4 years after MI on the basis of class membership, the four optimism items, age, and total nonhousing assets. This analysis was conducted separately because of a significant loss of participants resulting from missing data on the optimism items (the sample for this analysis was 725). In this analysis, the emerging-depression class continued to demonstrate a significantly increased likelihood of mortality compared with the resilient class. Further, three optimism items (the chances of living past 75, seeing double-digit inflation, and seeing economic depression) remained significant while the chance of leaving an inheritance became nonsignificant, as did

Table 4. Results From the Logistic Regression Analysis: Class Membership, Assets, and Age as Predictors of Death Within 4 Years of First Myocardial Infarction (n = 1,942)

Predictor	*b*	*SE b*	Wald	*p*	*df*	Exp(*b*)	95% confidence interval
Class[a]							
Emerging depression	0.52	0.17	9.00	.003	1	1.67	[1.19, 2.35]
Chronic depression	0.20	0.16	1.54	> .250	1	0.95	[0.58, 1.54]
Depressed-improved	–0.06	0.25	0.05	.214	1	1.22	[0.89, 1.66]
Assets in year of MI	0.001	0.0001	5.64	.018	1	1.00	[1.00, 1.00]
Age	0.06	0.01	137.35	< .001	1	1.06	[1.06, 1.08]
Constant	–5.75	0.42	189.31	< .001	1	0.01	—

Note: Assets in year of myocardial infarction (MI) represents nonhousing assets at the year of first-reported MI. In this analysis, mortality was coded as 1, and survival was coded as 0. The Wald for the overall model was 9.96 (p = .019, df = 3).
[a]The resilient class was used as the reference class.

nonhousing assets and age (see Table 5). It is important to note that proportions of participants within each class and class-specific death rates changed as a result of list-wise deletion of cased missing data on the optimism variables. Although the initial finding of large rates of mortality in the emerging-depression class compared with the resilient class remained, the mortality rates became much smaller.

Notably, whereas decreases in estimates of living past 75 and increases in estimates of encountering another economic depression were associated with increased mortality, increased estimates of double-digit inflation were independently associated with increased probability of mortality. Further, it is surprising that age drops out as a significant predictor of mortality. Confidence intervals for all of these items were at 1.00 at the upper or lower bound, which indicates that the optimism items have a small effect on mortality. Whereas depression, optimism, and assets are likely to account for some shared variance, it seems unlikely that age would not remain a significant independent predictor of mortality. To further examine this effect, we determined whether there were meaningful differences between the truncated subsample used for the current analysis and the sample used in the previous analyses. Participants with the optimism items were younger and less variable in age (mean age = 65.31 years, SD = 5.89, variance = 33.99) compared with those who were missing this data (mean age = 75.04 years, SD = 11.15, variance = 110.62). The younger sample and the truncated variance may explain the nonsignificance of age in the logistic regression.

Table 5. Results From the Logistic Regression Analysis: Class Membership, Assets, Optimism, and Age as Predictors of Death Within 4 Years of First Myocardial Infarction (n = 725)

Predictor	*b*	*SE b*	Wald	*p*	*df*	Exp(*b*)	95% confidence interval
Class[a]	—	—	5.30	.151	3	—	—
Emerging depression	0.63	0.31	4.27	.039	1	1.88	[1.03, 3.43]
Chronic depression	–0.38	0.50	0.57	> .250	1	0.68	[0.26, 1.83]
Depressed-improved	0.01	0.29	0.01	> .250	1	1.09	[0.58, 1.77]
Assets in year of MI	< 0.001	< 0.001	0.13	> .250	1	1.00	[1.00, 1.00]
Living past 75	–0.01	0.003	5.17	.023	1	0.99	[0.98, 1.00]
Leaving an inheritance	–0.001	0.002	0.34	> .250	1	1.00	[0.99, 1.00]
Double-digit inflation	–0.01	0.004	7.25	.007	1	0.99	[0.98, 1.00]
Economic depression	0.01	0.004	5.89	.015	1	1.01	[1.00, 1.02]
Age	0.02	0.02	1.24	> .250	1	1.02	[0.99, 1.06]
Constant	–2.14	1.21	3.13	.007	1	0.12	—

Note: Assets in year of myocardial infarction (MI) represents nonhousing assets at the year of first-reported MI. The four optimism variables were derived from self-reports of the probability of living past 75, leaving an inheritance, seeing double-digit inflation, and seeing a major economic depression. In this analysis, mortality was coded as 1, and survival was coded as 0. The significant reductions in sample size because of list-wise deletion resulted in reductions in mortality (resilient class: n = 526, 97 deceased; emerging-depression class: n = 63, 19 deceased; chronic-depression class: n = 101, 22 deceased; depressed-improved class: n = 37, 5 deceased).
[a]The resilient class was used as the reference class.

Discussion

In the current work, we utilized a large population-based sample and a prospective design to investigate long-standing questions in the literature about (a) the course of depression symptomatology in response to MI (Van Melle et al., 2004); (b) the prospective, protective status of optimism in the context of depression, MI, and mortality following MI (Giltay et al., 2004; Giltay, Kamphuis, et al., 2006; Kubzansky et al., 2007); and (c) near-term mortality secondary to the course of depression following MI (Dickens et al., 2008).

Results indicate that the course of depression in response to MI is heterogeneous. Specifically, individuals followed four distinct trajectories: one in which there was no significant change in the low levels of depression symptomatology from before to after the event (the resilient class; 68.3% of the total sample), one in which chronic elevated depression was unaffected by the onset of illness (chronic-depression class; 14.0%), one in which depression symptoms rapidly increased following the onset of illness (emerging-depression class; 10.9%), and one in which there were significantly elevated symptoms prior to the onset of illness that were ameliorated following the first MI (depressed-improved class; 6.8%).

Notably, the current findings demonstrate that resilience is the modal outcome following an MI. This finding is consistent with a large corpus of research showing both that individuals follow heterogeneous trajectories in response to aversive life events and that resilience is the modal outcome (Bonanno, 2004; Bonanno, Westphal, & Mancini, 2011). This has been observed in response to other significant health events (Bonanno, Kennedy, et al., 2012; Burton, Galatzer-Levy, & Bonanno, 2014; deRoon-Cassini, Mancini, Rusch, & Bonanno, 2010; Lam, Shing, Bonanno, Mancini, & Fielding, 2012; Lam et al., 2010; Zhu et al., 2014) and discrete negative life events, including widowhood (Galatzer-Levy & Bonanno, 2012), unemployment (Galatzer-Levy et al., 2010), and trauma exposure (Bonanno, Mancini, et al., 2012; Galatzer-Levy, Ankri, et al., 2013; Galatzer-Levy, Brown, et al., 2013; Galatzer-Levy et al., 2014). There is now consistent evidence both that stress responses across significant life stressors are heterogeneous across individuals and that resilience is the modal outcome.

Resilient individuals were more optimistic compared with all others prior to the MI. Nonresilient individuals gave less-optimistic estimates of their ability to leave an inheritance to their children even when we controlled for asset levels at the time of the estimate; this indicates that they were not less optimistic as a function of their personal economic situation. Individuals with emerging depression also estimated a higher probability of living past 75, compared with those who had chronic depression, and estimated a higher probability of leaving an inheritance, compared with individuals who had both chronic and improved depression. It is somewhat intuitive that resilient individuals would be more likely to be optimistic, as optimistic people are more likely to hold favorable expectations and to engage in proactive, health-related coping (Carver et al., 2010), which would likely enhance psychological responses to highly aversive health events such as an MI. Optimism has been shown to be important in reducing risk for MI-related mortality (Giltay, Kamphuis, et al., 2006) and risk for depression (Giltay, Zitman, & Kromhout, 2006). Further, optimism items independently predicted mortality over and above class membership, though less consistently and not always in the expected direction. Our findings demonstrate that optimism prospectively predicts the course of depression and mortality in the context of MI.

Individuals with emerging depression were at an increased risk for mortality within 4 years after an MI, compared with resilient individuals. A trend was also observed between individuals with emerging and improved depression, with the former demonstrating increased risk for mortality in comparison with the latter. Those with chronic depression were not at increased risk for mortality, which indicates that overall, those who develop depression following MI are at increased risk for mortality.

There are many potential reasons why the emergence of depression following MI might increase rates of mortality, including common biological consequences of MI that also affect depression (Ziegelstein, 2013). Specifically, upregulation of the immune system results in increased release of promoters of systemic inflammation, which may result in behavioral changes, including depression symptomatology (Slavich & Irwin, 2014). In total, the immune-system response has been shown to invoke neuroendocrine responses and neurotransmitter changes along the same pathways that are provoked by stressor events (Anisman, 2009). In the case of MI, both the event itself and its treatment can profoundly affect the immune response. However, inflammatory response is also affected by perceived stress, as regulation of immune functioning under threat conditions is closely linked to cortisol release in the hypothalamic-pituitary-adrenal axis (Slavich & Irwin, 2014). Cortisol release has been shown to be abnormal among individuals who develop clinical stress responses following loss (Ong, Fuller-Rowell, Bonanno, & Almeida, 2011) or traumatic stress exposure (Galatzer-Levy et al., 2014). As such, an MI specifically can affect an individual's immune response. However, it can also be affected by individual differences in stress reactivity. Both can potentially affect mortality. Further, reduced adherence to medication is another plausible link between MI, depression, and mortality (Carney, Freedland, Eisen, Rich, & Jaffe, 1995; Glassman et al., 2009).

A number of limitations were inherent in our analyses. First, we examined the effects of first-MI incidents rather than the diverse set of disorders that fall under the umbrella of MI. We did this because increased heterogeneity in incident events may obfuscate the identification of common responses to a unified event. Second, we utilized probability estimates of future personal and economic events as measures of optimism. Although these items have obvious face validity, their representativeness as measures of optimism was not confirmed through external validation. Further, the current study lacked information on MI severity and prognosis that could influence both the emergence of depression and increased mortality. Moreover, we did not have information on the cause of death, so we could not ascertain whether deaths were associated with the MI or with other causes. Also, because data were collected every 2 years, we were unable to capture the acute response to the MI event. Also, though the overall sample was large, the number of participants within each class was small, thus limiting the power of subgroup comparisons and potentially the accuracy of estimates of mortality related to particular classes. Finally, as participants were selected based on a specific index event, a first-reported MI, results may not be generalizable beyond the context of MI.

Despite these limitations, the current study provides unique information about the course, psychological precipitants, and near-term consequences of heterogeneous patterns of depression in response to MI and provides population-based estimates of the proportion of individuals who follow distinct trajectories of response. Further, because we used a prospective, population-based sample, we were able to investigate questions about optimism and mortality that could not be adequately addressed if depression had been assessed only after the MI occurred. For example, our findings indicated that only emerging depression was associated with increased mortality, whereas individuals who followed a chronic depression course were not at increased risk. Similarly, optimism strongly predicted the course of depression prospectively. Without prospective data, it is impossible to determine how optimistic responses are informed by the stressor event or whether they are conceptually distinct from a general optimistic worldview.

Author Contributions

I. R. Galatzer-Levy and G. A. Bonanno designed the study, analyzed the data, and wrote the manuscript.

Declaration of Conflicting Interests

The authors declared that they had no conflicts of interest with respect to their authorship or the publication of this article.

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References

Anda, R., Williamson, D., Jones, D., Macera, C., Eaker, E., Glassman, A., & Marks, J. (1993). Depressed affect, hopelessness, and the risk of ischemic heart disease in a cohort of U.S. adults. *Epidemiology*, *4*, 285–294.

Anisman, H. (2009). Cascading effects of stressors and inflammatory immune system activation: Implications for major depressive disorder. *Journal of Psychiatry & Neuroscience*, *34*, 4–20.

Bonanno, G. A. (2004). Loss, trauma, and human resilience: Have we underestimated the human capacity to thrive after extremely aversive events? *American Psychologist*, *59*, 20–28.

Bonanno, G. A., Kennedy, P., Galatzer-Levy, I. R., Lude, P., & Elfström, M. L. (2012). Trajectories of resilience, depression, and anxiety following spinal cord injury. *Rehabilitation Psychology*, *57*, 236–247.

Bonanno, G. A., Mancini, A. D., Horton, J. L., Powell, T. M., LeardMann, C. A., Boyko, E. J., . . . Millennium Cohort Study Team. (2012). Trajectories of trauma symptoms and resilience in deployed U.S. military service members: Prospective cohort study. *The British Journal of Psychiatry*, *200*, 317–323.

Bonanno, G. A., Westphal, M., & Mancini, A. D. (2011). Resilience to loss and potential trauma. *Annual Review of Clinical Psychology*, *7*, 511–535.

Burton, C. L., Galatzer-Levy, I. R., & Bonanno, G. A. (2014). Treatment type and demographic characteristics as predictors for cancer adjustment: Prospective trajectories of depressive symptoms in a population sample. *Health Psychology*. Advance online publication. doi:10.1036/hea000145

Carney, R. M., Freedland, K. E., Eisen, S. A., Rich, M. W., & Jaffe, A. S. (1995). Major depression and medication adherence in elderly patients with coronary artery disease. *Health Psychology*, *14*, 88–90.

Carver, C. S., Scheier, M. F., & Segerstrom, S. C. (2010). Optimism. *Clinical Psychology Review*, *30*, 879–889.

deRoon-Cassini, T. A., Mancini, A. D., Rusch, M. D., & Bonanno, G. A. (2010). Psychopathology and resilience following traumatic injury: A latent growth mixture model analysis. *Rehabilitation Psychology*, *55*, 1–11.

Dickens, C., McGowan, L., Percival, C., Tomenson, B., Cotter, L., Heagerty, A., & Creed, F. (2008). New onset depression following myocardial infarction predicts cardiac mortality. *Psychosomatic Medicine*, *70*, 450–455.

Frasure-Smith, N., Lespérance, F., & Talajic, M. (1993). Depression following myocardial infarction: Impact on 6-month survival. *The Journal of the American Medical Association*, *270*, 1819–1825.

Galatzer-Levy, I. R., Ankri, Y., Freedman, S., Israeli-Shalev, Y., Roitman, P., Gilad, M., & Shalev, A. Y. (2013). Early PTSD symptom trajectories: Persistence, recovery, and response to treatment: Results from the Jerusalem Trauma Outreach and Prevention Study (J-TOPS). *PLoS ONE*, *8*(8), Article e70084. Retrieved from http://www.plosone.org/article/info%3Adoi%2F10.1371%2Fjournal.pone.0070084

Galatzer-Levy, I. R., & Bonanno, G. A. (2012). Beyond normality in the study of bereavement: Heterogeneity in depression outcomes following loss in older adults. *Social Science & Medicine*, *74*, 1987–1994. doi:10.1016/j.socscimed.2012.02.022

Galatzer-Levy, I. R., Bonanno, G. A., & Mancini, A. D. (2010). From Marianthal to latent growth mixture modeling: A return to the exploration of individual differences in response to unemployment. *Journal of Neuroscience, Psychology, and Economics*, *3*, 116–125.

Galatzer-Levy, I. R., Brown, A. D., Henn-Haase, C., Metzler, T. J., Neylan, T. C., & Marmar, C. R. (2013). Positive and negative emotion prospectively predict trajectories of resilience and distress among high-exposure police officers. *Emotion*, *13*, 545–553.

Galatzer-Levy, I. R., Steenkamp, M. M., Qian, M., Inslicht, S., Henn-Haase, C., Otte, C., . . . Marmar, C. R. (2014). Cortisol response to an experimental stress paradigm prospectively predicts long-term distress and resilience trajectories in response to active police service. *Journal of Psychiatric Research*, *56*, 34–42.

Giltay, E. J., Geleijnse, J. M., Zitman, F. G., Hoekstra, T., & Schouten, E. G. (2004). Dispositional optimism and all-cause and cardiovascular mortality in a prospective cohort of elderly Dutch men and women. *Archives of General Psychiatry*, *61*, 1126–1135.

Giltay, E. J., Kamphuis, M. H., Kalmijn, S., Zitman, F. G., & Kromhout, D. (2006). Dispositional optimism and the risk of cardiovascular death: The Zutphen Elderly Study. *Archives of Internal Medicine*, *166*, 431–436.

Giltay, E. J., Zitman, F. G., & Kromhout, D. (2006). Dispositional optimism and the risk of depressive symptoms during 15 years of follow-up: The Zutphen Elderly Study. *Journal of Affective Disorders*, *91*, 45–52.

Glassman, A. H., Bigger, J. T., Jr., & Gaffney, M. (2009). Psychiatric characteristics associated with long-term mortality among 361 patients having an acute coronary syndrome and major depression: Seven-year follow-up of SADHART participants. *Archives of General Psychiatry*, *66*, 1022–1029.

Kohout, F. J., Berkman, L. F., Evans, D. A., & Cornoni-Huntley, J. (1993). Two shorter forms of the CES-D depression symptoms index. *Journal of Aging and Health*, *5*, 179–193.

Kubzansky, L. D., Koenen, K. C., Spiro, A., 3rd, Vokonas, P. S., & Sparrow, D. (2007). Prospective study of posttraumatic stress disorder symptoms and coronary heart disease in the Normative Aging Study. *Archives of General Psychiatry*, *64*, 109–116.

Lam, W. W., Bonanno, G. A., Mancini, A. D., Ho, S., Chan, M., Hung, W. K., . . . Fielding, R. (2010). Trajectories of psychological distress among Chinese women diagnosed with breast cancer. *Psycho-Oncology*, *19*, 1044–1051.

Lam, W. W., Shing, Y. T., Bonanno, G. A., Mancini, A. D., & Fielding, R. (2012). Distress trajectories at the first year diagnosis of breast cancer in relation to 6 years survivorship. *Psycho-Oncology*, *21*, 90–99.

Mathers, C. D., & Loncar, D. (2006). Projections of global mortality and burden of disease from 2002 to 2030. *PLoS Medicine*, *3*(11), e442. Retrieved from http://www.plosmedicine.org/article/info%3Adoi%2F10.1371%2Fjournal.pmed.0030442

Meijer, A., Conradi, H. J., Bos, E. H., Thombs, B. D., van Melle, J. P., & de Jonge, P. (2011). Prognostic association of depression following myocardial infarction with mortality and cardiovascular events: A meta-analysis of 25 years of research. *General Hospital Psychiatry*, *33*, 203–216.

Murray, C. J. L., & Lopez, A. D. (1997). Alternative projections of mortality and disability by cause 1990–2020: Global Burden of Disease Study. *The Lancet*, *349*, 1498–1504.

Muthén, B. (2003). Statistical and substantive checking in growth mixture modeling: Comment on Bauer and Curran (2003). *Psychological Methods*, *8*, 369–377. doi:10.1037/1082-989x.8.3.369

Muthén, L. K., & Muthén, B. O. (2012). *Mplus user's guide* (7th ed.). Los Angeles, CA: Author.

Nylund, K., Asparouhov, T., & Muthén, B. (2007). Deciding on the number of classes in latent class analysis and growth mixture modeling: A Monte Carlo simulation study. *Structural Equation Modeling*, *14*, 535–569.

Ong, A. D., Fuller-Rowell, T. E., Bonanno, G. A., & Almeida, D. M. (2011). Spousal loss predicts alterations in diurnal cortisol activity through prospective changes in positive emotion. *Health Psychology*, *30*, 220–227.

Peterson, C. (2000). The future of optimism. *American Psychologist*, *55*, 44–55.

Radloff, L. S. (1977). The CES-D scale: A self-report depression scale for research in the general population. *Applied Psychological Measurement*, *1*, 385–401.

Rasmussen, H. N., Scheier, M. F., & Greenhouse, J. B. (2009). Optimism and physical health: A meta-analytic review. *Annals of Behavioral Medicine*, *37*, 239–256.

Scheier, M. F., Matthews, K. A., Owens, J. F., Schulz, R., Bridges, M. W., Magovern, G. J. S., & Carver, C. S. (1999). Optimism and rehospitalization after coronary artery bypass graft surgery. *Archives of Internal Medicine*, *159*, 829–835.

Slavich, G. M., & Irwin, M. R. (2014). From stress to inflammation and major depressive disorder: A social signal transduction theory of depression. *Psychological Bulletin*, *140*, 774–815.

Spijkerman, T., de Jonge, P., van den Brink, R. H. S., Jansen, J. H. C., May, J. F., Crijns, H. J. G. M., & Ormel, J. (2005). Depression following myocardial infarction: First-ever versus ongoing and recurrent episodes. *General Hospital Psychiatry*, *27*, 411–417.

Steffick, D. E. (2000). Documentation of affective functioning measures in the Health and Retirement Study. Ann Arbor, MI: HRS Health Working Group.

Van Melle, J. P., De Jonge, P., Spijkerman, T. A., Tijssen, J. G. P., Ormel, J., Van Veldhuisen, D. J., . . . van den Berg, M. P. (2004). Prognostic association of depression following myocardial infarction with mortality and cardiovascular events: A meta-analysis. *Psychosomatic Medicine*, *66*, 814–822.

Watkins, P. C. (2002). Implicit memory bias in depression. *Cognition & Emotion*, *16*, 381–402.

Wulsin, L. R., & Singal, B. M. (2003). Do depressive symptoms increase the risk for the onset of coronary disease? A systematic quantitative review. *Psychosomatic Medicine*, *65*, 201–210.

Zhu, Z., Galatzer-Levy, I. R., & Bonanno, G. A. (2014). Heterogeneous depression responses to chronic pain onset among middle-aged adults: A prospective study. *Psychiatry Research*, *217*, 60–66.

Ziegelstein, R. C. (2013). Improving depression and reducing cardiac events: Which is the chicken and which is the egg? *Journal of Psychosomatic Research*, *74*, 454–457.

Zuidersma, M., Thombs, B. D., & de Jonge, P. (2011). Onset and recurrence of depression as predictors of cardiovascular prognosis in depressed acute coronary syndrome patients: A systematic review. *Psychotherapy and Psychosomatics*, *80*, 227–237.