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A New Cost-Based Index of Housing Quality and Repair Needs

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Abstract

The American Housing Survey (AHS) has long been a powerful tool for understanding housing problems in the United States. Traditionally, researchers have relied on subjective measures of housing adequacy or other abstract indices for quantitative analyses of housing quality. In addition to the characteristics of households or units with repair needs, when crafting policy solutions or guiding resources, decision makers need to know how much investment might be needed to bring the housing stock up to standard. PolicyMap and the Federal Reserve Bank of Philadelphia have addressed this need by developing a novel method to assign estimated repair costs to housing problems reported in the AHS. In this article, we describe how we merged a proprietary repair cost dataset with microdata from the AHS public use file (PUF) to estimate the total cost of repairs that would be needed for each surveyed housing unit, using survey weights to aggregate estimates at various geographic levels. We briefly present key national findings on repair needs. Summary tables of these findings and more are available to the public for download.

Introduction

Building on recent efforts to quantify housing quality issues, researchers and data analysts at the Federal Reserve Bank of Philadelphia and PolicyMap have developed a cost-based index of repair needs that combines detailed data on housing conditions from the American Housing Survey (AHS) with estimates of the costs of needed repairs. This article, adapted from a technical appendix (Wallace et al., 2019) to a Federal Reserve Bank of Philadelphia Special Report (Divringi et al., 2019), provides an in-depth overview of the development of this index, detailing the motivation for the approach, the methodology for creating the index, and the basic summary statistics.

Background

Despite the widespread finding that severe housing problems have declined in the United States over the past half-century, adequate quality housing is still inequitably distributed across socioeconomic lines (Kutty, 1999; Holupka and Newman, 2011; Mundra and Sharma, 2015; Boehm and Schlottmann, 2008; Jacobs et al., 2009). The primary dataset used to track both housing quality trends and socioeconomic disparities in housing is the AHS, administered by the U.S. Department of Housing and Urban Development (HUD) and the U.S. Census Bureau. Since 1984, the AHS has published ZADEQ, a composite measure of housing quality—since renamed ADEQUACY.[1] This measure classifies housing units as adequate, inadequate, or severely inadequate. Housing units flagged as inadequate have one or more severe problems in the unit's plumbing, electrical, or heating systems, or have a number of maintenance problems such as water leaks, holes in the floor, or rats.[2] This measure is widely cited and is included in HUD's biennial *Worst Case Housing Needs* report to Congress (Watson et al., 2017). Recent research suggests, however, that this measure understates the extent of problems in the U.S. housing stock (Emrath and Taylor, 2012; Eggers and Moumen, 2013b), and some have questioned whether its criteria meaningfully reflect an underlying housing quality construct (Newman and Garboden, 2013; Eggers and Moumen, 2013a).

Considering these limitations, there have been several recent attempts to create more nuanced measures of housing quality. Three recent papers have informed our approach to the cost-based index. Emrath and Taylor (2012) applied a hedonic model to AHS data to create a measure based on the degree to which reported problems reduced expected home values and rents. Their approach indicated that housing inadequacy was likely more common than the ADEQUACY measure suggested, particularly among single-family homes and units where children are present. Eggers and Moumen (2013b) proposed the Poor Quality Index (PQI), which assigned weights based on subjective criteria to unit-level housing problems reported in AHS. Their results revealed a heavily right-skewed distribution in which most units reported no housing deficiencies, a significant portion were assigned low PQI values, and a small segment was found to have high PQI values indicative of severe disrepair. Lastly, Newman and Holupka (2017) developed and tested several potential quality indices, finding a strong correlation between Eggers and Moumen's PQI and more empirically-derived weighting schemes.

[1] Email correspondence with HUD staff confirm that both variable names pertain to the same measure. For details, see the AHS online codebook, available at https://www.census.gov/data-tools/demo/codebook/ahs/ahsdict.html.

[2] The specific criteria for determining whether a unit is inadequate or severely inadequate have changed slightly over time. See appendix E, page 73 of Watson et al. (2017) for the full, current definition.

As one of few papers to integrate repair cost information with AHS data, Listokin and Listokin (2001) similarly informed the development of our index. They categorized each housing unit included in AHS into one of four repair intervention levels based on the intensity of its rehab needs—none, minor, moderate, or substantial. They then applied flat repair cost estimates provided by housing industry experts to units in each category, aggregating to estimate regional and national summary figures. The cost-based index outlined in this article adapts Listokin and Listokin's practical emphasis on estimating repair costs with the recent efforts to develop more meaningful summary measures of housing disrepair. The resulting index provides an intuitive and policy-relevant indicator of repair needs.

Data Sources

To develop our cost-based index, we combined two data sources: (1) the AHS PUF, and (2) a custom RSMeans dataset from Gordian that estimates the costs of repairs for each type of housing problem reported in the AHS PUF.

American Housing Survey

The AHS, established in 1973, is conducted every other year through personal interviews either of the householder or, in the case of vacant units, a landlord or other person with detailed knowledge of the property. The AHS includes information on a range of housing-related topics, including housing characteristics, housing costs, home improvements, demographics of heads of household and tenants, reasons for recent moves, and housing problems. It is currently the only publicly available, nationally representative source of data with highly detailed information on these characteristics of housing units.

The cost-based index outlined in this article was developed based on the 2015 AHS PUF, which includes anonymized survey responses, and applied to the subsequently released 2017 PUF, for which the microdata codebook is identical for the variables used to calculate the index. For the purposes of this analysis, we considered only housing units that were occupied as a primary residence and for which an interview was conducted. Out of a total of 66,752 housing units surveyed, 57,984 were occupied housing units where an interview was conducted (INTSTATUS = 1), 1,054 were occupied and interviewed but categorized as "usual residence elsewhere," and 7,714 were vacant.

Custom RSMeans Database from Gordian

The research team worked with Gordian, a company that provides residential and facilities maintenance, construction, and repair cost data for real estate professionals, to assign specific repair interventions to each housing problem identified in AHS and to estimate the associated costs. The majority of these estimates were based on the RSMeans 2018 Contractor's Pricing Guide database of Residential Repair & Remodeling Costs (Gordian, 2017). A subset of repair interventions was not available in the Contractor's Pricing Guide data. The missing interventions largely pertained to major structural and plumbing repairs and were omitted either because the scale or type of repair required the use of a contractor accustomed to working on larger commercial projects or because RSMeans could not produce reliable estimates for smaller contractors. For

these, RSMeans substituted estimates from the 2018 Facilities Maintenance & Repair Costs database. Estimates based on the Facilities Maintenance & Repair Costs database assume the use of open shop labor, which is associated with lower hourly wages than union labor but still higher than the wage rates used in the Contractor's Pricing Guide estimates. Both sources of estimates reflect national average costs inclusive of materials, labor, contractor overhead, and contractor profit. For estimates aggregated at the metropolitan statistical area (MSA)-level, dollar values are adjusted using regional multipliers derived from Gordian (2017).

Methodology

The following sections describe the development and validation of the repair cost index. In most cases, mapping repair cost estimates to reported housing quality issues was a simple one-to-one merge with adjustments for unit or household size, depending on the intervention. In some housing units, however, one repair might obviate the need for another repair. In these instances, a hierarchy of repairs was established to avoid redundancies. Finally, using survey weights provided in AHS, unit-level repair estimates were aggregated to produce national-, regional-, and MSA-level estimates of repair costs according to various demographic, economic, housing unit, and other characteristics.

Identifying Housing Deficiencies in AHS

The research team began by identifying the AHS variables associated with physical deficiencies in the housing unit, primarily from the "Housing Problems" module.[3] Several additional variables provided context that further specified the types of repairs needed in each surveyed housing unit. For example, repairs to a cracked or crumbling foundation would vary based on whether the unit has a full basement, crawlspace, or some other foundation type. Similarly, the cost of repairs for broken heating equipment would be determined by the type of heating system. For certain housing problems, developing estimates required assumptions about the size and occupancy of the housing unit. Accordingly, we used AHS variables describing the size of the unit, number of floors, and number of residents to scale the repair estimates, as described in the table accompanying the full technical appendix table.[4]

The initial combination of housing problems and context variables resulted in 99 repair scenarios. The research team dropped those with frequencies below 0.05 percent in the unweighted data, resulting in the 66 combinations of reported problems and repairs presented in the technical appendix table.

[3] There are 48 variables categorized under the "Housing Problems" topic in the AHS code book. Of these, several are excluded from this analysis because they represent a more generalized version of related variables (for example, "Flag indicating unit was uncomfortably cold for 24 hours or more last winter") or are not clearly related to structural deficiencies. Although not listed under the "Housing Problems" topic, the variables HEATTYPE and HOTWATER were included, since they capture responses that have historically been considered housing quality issues (such as lack of heating equipment).

[4] Appendix table available at https://philadelphiafed.org/-/media/community-development/publications/special-reports/home-repair-costs-technical-appendix-table.xlsx?la=en (Note: this URL will initiate a download of an Excel workbook.)

Repair Cost Assumptions

Once the repair scenarios were established, experts at Gordian outlined the details of the materials and labor hours required for each repair. The AHS provides limited information about building materials (for example, it does not specify the type of roofing materials). Accordingly, Gordian staff assumed the use of common, cost-effective building materials and used their experience to supply information on any secondary tasks such as demolitions or excavations associated with these repairs.

Certain repairs also required assumptions about the proportion of the area affected or the number of items in need of repair. For certain roofing repairs, for instance, we assumed that 5 percent of the roof would need repair. For units reporting broken or boarded windows, the AHS does not specify how many are damaged, so we assumed an average of 1.5 would need repair. Similarly, when a unit reports a lack of functioning electrical outlets in each room, we assumed an average of 1.5 plugs would need to be installed. Such assumptions were arrived at in conversation with industry experts at Gordian and are detailed for each applicable intervention in the technical appendix table.

For the small number of repair scenarios that were not priced out by Gordian, we substituted the costs of comparable repairs. For example, the AHS reports on mold problems in bathrooms, kitchens, living rooms, basements, and bedrooms. For these repairs, we asked Gordian to estimate the cost of remediating mold in a fixed square foot area of a bathroom, and we applied that cost to any room type.

Adjustments for Unit and Household Size

In the AHS PUF, the variable for unit total square footage is provided as a binned categorical variable. To scale repair costs that were provided on a per square foot basis, we assumed the midpoint of each category. For units for which the size variable was missing or not reported, we imputed 1,500 square feet based on the overall median unit size reported in the AHS Table Creator.[5] For repairs pertaining to the dimensions of the unit, we assumed that the footprint of the housing unit would be equal to the total area of the unit divided by the number of reported floors and conservatively estimated that the length of an outside wall of the housing unit would be equal to the square root of that footprint size.

For replacements of heating systems or water heaters, the number of potential interventions was limited by the range of equipment size options available in the RSMeans dataset. Accordingly, for heating equipment replacements, unit size categories were collapsed into two-to-five groups depending on the type of system, and those groups were assigned a corresponding equipment size. For water heater replacement, we used the number of residents reported in the AHS to inform the size of water heater required for each unit. Equipment specifications are detailed in the technical appendix table.

[5] See https://www.census.gov/programs-surveys/ahs/data/interactive/ahstablecreator.html?s_areas=00000&s_year=2017&s_tablename=TABLE2&s_bygroup1=1&s_bygroup2=1&s_filtergroup1=1&s_filtergroup2=1.

Assigning Repair Interventions

For several equipment-related repairs, variables recording the frequency or severity of the problem indicated whether a repair or replacement would be most appropriate. For example, when a house on well water has one or two interruptions in water service (NOWATFREQ), the well piping may need to be replaced. Another house experiencing more breakdowns may need a much more expensive well pump replacement. Similarly, for units reporting one or two heating system breakdowns that resulted in uncomfortably cold temperatures, we applied a low-cost maintenance intervention. For more frequent breakdowns, we assumed the equipment needed to be replaced.

Repair Hierarchy

Housing units may have more than one problem that could be solved by a single repair. To avoid overestimating repair costs, we developed decision rules on which repairs supersede others. For example, four different AHS variables denote roofing problems (ROOFSAG, ROOFSHIN, ROOFHOLE, and LEAKOROOF) and needed repairs would overlap. Repairing a sagging roof requires costly structural work that likely offsets other roof repair needs. For a detailed description of which repairs superseded others, see the technical appendix table.

National, Regional, and Metropolitan Estimates

After summing the total repair costs for each surveyed unit, we used the full sample weighting variable (WEIGHT) to calculate weighted summary statistics and aggregate repair costs tabulated by a number of demographic, geographic, and housing type variables. The National PUF includes variables that specify the Census Division[6] and, for units in the 15 largest metropolitan areas, MSAs, which can be used to tabulate estimates at these geographies.

All tabulations at the national and Census Region levels use the weighted national average costs provided by Gordian. To account for regional variations in construction costs, dollar-value estimates for the 15 largest MSAs are adjusted using location factors for the largest principal city. These location factors were drawn from Gordian (2017), which provides cost multipliers at the three-digit ZIP Code-level for most major cities.

Validation

To assess the internal validity of our repair cost index, we evaluated its relationship to other AHS variables that can be reasonably expected to correlate with housing quality. First, as anticipated, we found that each level of the categorical HUD housing quality indicator (ADEQUACY) is associated with a progressively higher median and average repair cost estimate (exhibit 1).

[6] Census Divisions are collections of states and the District of Columbia grouped by proximity. For more information, see https://www2.census.gov/geo/maps/general_ref/pgsz_ref/CensusRegDiv.pdf.

Exhibit 1

Comparison of Repair Cost Index to HUD ADEQUACY Composite Variable

ADEQUACY Value	Mean Repair Cost	Median Repair Cost
Adequate	$847	$0
Moderately Inadequate	$4,361	$2,440
Severely Inadequate	$6,487	$3,346

Notes: Means and medians include both units with and without repair needs.
Sources: Authors' analysis of 2017 AHS PUF; 2018 RSMeans Data from Gordian

The research team also examined the respondent's rating of the unit as a place to live (RATINGHS). This is an ordinal variable ranging from one (worst) to ten (best). As expected, the repair cost index has a highly statistically significant ($p<0.0001$) negative correlation with this measure (-0.21).[7] While this association is moderate in strength, a large portion of units have an estimated repair cost of $0. For these units and those with modest repair needs, resident ratings are likely to be heavily influenced by other location and neighborhood factors.

Lastly, assuming that older units are more likely to experience housing quality issues, we examined the association between the repair cost index and the binned ordinal variable that denotes the decade the structure was built.[8] Again, we found the expected, highly significant ($p<0.0001$) negative association (-0.13),[9] indicating that newer units are associated with less costly repair needs.

Limitations

In addition to the lack of contextual information on the building materials and magnitude of certain reported issues as described earlier, there are housing deficiencies that may present threats to the safety and well-being of residents that are not reported in the standard AHS modules. These include missing or broken stairs and banisters, which present major injury risks.[10] Furthermore, PUF does not capture the need for adaptive modifications that may be critical to a resident's ability to safely navigate their unit and perform everyday tasks. Housing deficiencies that are unlikely to be observed in residents' everyday lives, such as lead exposure, water contaminants, and indoor air quality issues, are similarly unavailable. Additionally, our cost estimates do not include local and national regulatory factors that may significantly affect the cost of repairs, such as lead removal requirements or environmental performance standards, though some of these variations may be reflected in regional cost adjustments. Lastly, our inability to develop estimates for vacant units likely understates the total magnitude of disrepair in the national housing stock (Emrath and Taylor, 2012).

[7] Pearson correlation coefficient based on weighted data.

[8] The precise year the structure was built is not available in the PUF.

[9] Pearson correlation coefficient based on weighted data.

[10] Questions regarding these and other household health and safety issues have been included in supplementary modules in prior surveys, but are not part of the standard battery of survey questions.

Due to data constraints, our repair cost index likely understates the magnitude of repair needs for the multifamily housing stock. Many of the repair cost estimates supplied by Gordian assume the intervention applies to a single-family home unless otherwise specified (for example, certain manufactured housing-specific repairs). For many interventions, repair costs are likely to be comparable in different unit contexts (such as repairing a crack in an interior wall), though for others there may be substantial differences (such as repairing a 10th story window). Furthermore, AHS respondents in multifamily housing are not asked most questions pertaining to structural housing issues (for example, issues related to roofs, foundations, exterior walls, and building systems). As a result, we are unable to capture the need for more extensive repairs to larger residential buildings.

Given these limitations, our cost-based index should be understood as an approximate measure of the costs to mitigate the substandard conditions reported in AHS.

Selected Findings

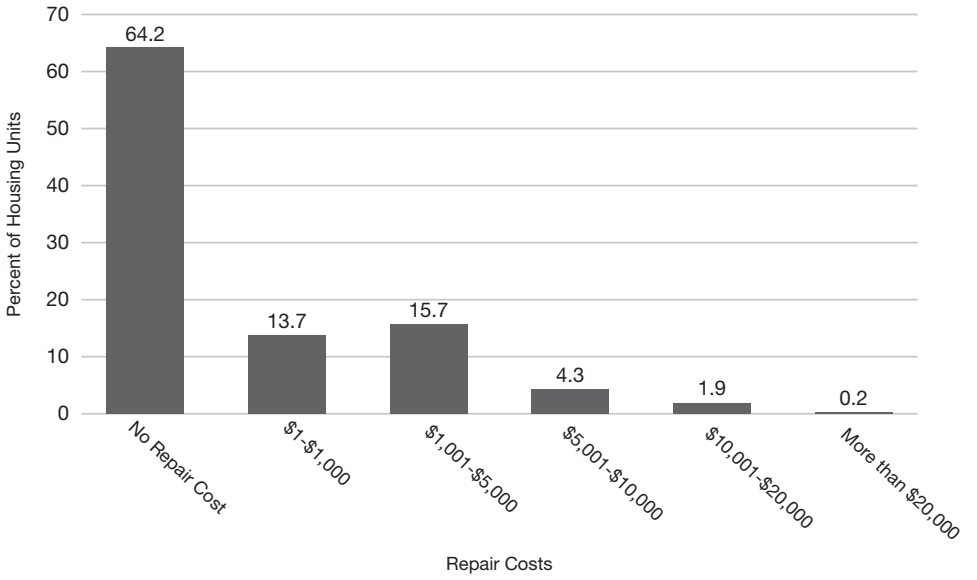
The following section provides tabulations of our repair cost index. More extensive results are also available in Divringi et al. (2019) and Wallace et al. (2019). Many of our results align with those of other studies on who is disproportionately living in lower quality housing (Holupka and Newman, 2011; Mundra and Sharma, 2015; Jacobs et al., 2009; Watson et al., 2017). Our results add nuance by revealing which groups are more likely to need the most expensive repairs. The following results are uncontrolled, weighted tabulations.

Despite the decline over the last several decades in inadequate housing, our analysis indicates that approximately 35.8 percent of housing units needed repair in 2017, though many of these repair needs were modest (exhibit 2). Our analysis reveals that the plurality of housing units that needed repairs had repair needs between $1,000 and $5,000 (15.7 percent of housing units), and the median cost of repairs was $1,449. The distribution of repair costs has a long tail to the right. Only 0.2 percent of housing units needed repairs totaling more than $20,000 per unit. Based on housing quality problems reported in the 2017 AHS, we estimate that repair needs for the occupied housing stock totaled $126.9 billion.[11]

[11] Cost estimates are reported in 2018 dollars.

Exhibit 2

Percent of Housing Units by Repair Cost Category



Sources: Authors' analysis of 2017 AHS PUF; 2018 RSMeans Data from Gordian

Frequency and cost of repair needs vary greatly by type or by affected system. Structural repairs were the second most common repair need but made up more than half of the national aggregate repair costs. Leaks, in contrast, were the most commonly required repair but constituted only one-fourth of aggregate costs. The least expensive repair type was pest remediation which was reportedly needed by nearly 5 percent of housing units but only made up approximately 2.2 percent of repair costs (exhibit 3).

Exhibit 3

Repair Costs by Category

Repair Category	Number of Units (Millions)	Percent of Units	Aggregate Repair Cost (Billions)	Percent of Aggregate Repair Cost
Electrical	6.7	5.5	$8.9	7.0
Heating	6.1	5.0	$5.4	4.3
Leak	20.3	16.7	$31.7	25.0
Pests	6.0	4.9	$2.8	2.2
Plumbing	4.7	3.9	$5.9	4.7
Structural	19.1	15.7	$72.1	56.8

Sources: Authors' analysis of 2017 AHS PUF; 2018 RSMeans Data from Gordian

Next Steps

To help inform the development and targeting of strategies for improving the quality of the U.S. housing stock, we have developed national typologies of housing units with repair needs in a companion report (Divringi et al., 2019). Building on this work, members of the research team from the Federal Reserve Bank of Philadelphia are working with the AHS Internal Use File (IUF), which provides detailed unit-level geographic identifiers, to conduct a multivariate analysis of housing quality using the new repair cost estimates in combination with neighborhood characteristics. This analysis will enable us to understand and describe the relationship between neighborhood characteristics and housing repair needs. Ultimately, the objective of this analysis will be to statistically model small area estimates of housing repair costs. These geographically granular estimates will enable community development-oriented investors, developers, and government officials to target the neighborhoods with the greatest need for housing improvements.

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References

Boehm, Thomas P., and Alan Schlottmann. 2008. "Housing Tenure, Expenditure, and Satisfaction Across Hispanic, African-American, and White Households: Evidence From the American Housing Survey," *Cityscape* 10 (2): 95–158.

Divringi, Eileen, Eliza Wallace, Keith Wardrip, and Elizabeth Nash. 2019. *Measuring and Understanding Home Repair Costs: A National Typology of Households*. Philadelphia: Federal Reserve Bank of Philadelphia and PolicyMap. https://www.policymap.com/issues/housing-quality/.

Eggers, Frederick J., and Fouad Moumen. 2013a. *Housing Adequacy and Quality as Measured by the AHS*. Washington, DC: U.S. Department of Housing and Urban Development, Office of Policy Development and Research.

———. 2013b. American Housing Survey: *A Measure of (Poor) Housing Quality*. Washington, DC: U.S. Department of Housing and Urban Development, Office of Policy Development and Research.

Emrath, Paul, and Heather Taylor. 2012. "Housing Values, Costs, and Measures of Physical Adequacy," *Cityscape* 14 (1): 99–125.

Gordian. 2017. *2018 Contractor's Pricing Guide: Residential Repair & Remodeling Costs with RSMeans Data*. Rockland, MA: The Gordian Group, Inc.

Holupka, C. Scott, and Sandra J. Newman. 2011. "The Housing and Neighborhood Conditions of America's Children: Patterns and Trends Over Four Decades," *Housing Policy Debate* 21 (2): 215–245.

Jacobs, David E., Jonathan Wilson, Sherry L. Dixon, Janet Smith, and Anne Evens. 2009. "The Relationship of Housing and Population Health: A 30-Year Retrospective Analysis," *Environmental Health Perspectives* 117 (4): 597–604.

Kutty, Nandinee K. 1999. "Determinants of Structural Adequacy of Dwellings," *Journal of Housing Research* 10 (1): 27–43.

Listokin, David, and Barbara Listokin. 2001. *Barriers to the Rehabilitation of Affordable Housing: Volume 1 Findings and Analysis*. Washington, DC: U.S. Department of Housing and Urban Development, Office of Policy Development and Research.

Mundra, Kusum, and Amarendra Sharma. 2015. "Housing Adequacy Gap for Minorities and Immigrants in the U.S.: Evidence from the 2009 American Housing Survey," *Journal of Housing Research* 24 (1): 55–72.

Newman, Sandra J., and Philip M.E. Garboden. 2013. "Psychometrics of Housing Quality Measurement in the American Housing Survey," *Cityscape* 15 (1): 293–306.

Newman, Sandra, and C. Scott Holupka. 2017. *The Quality of America's Assisted Stock: Analysis of the 2011 and 2013 American Housing Surveys*. Washington, DC: U.S. Department of Housing and Urban Development, Office of Policy Development and Research.

Wallace, Eliza, Eileen Divringi, Keith Wardrip, and Elizabeth Nash. 2019. *Technical Appendix: A Repair Cost-Based Index of Housing Quality*. Philadelphia: Federal Reserve Bank of Philadelphia and PolicyMap. https://www.policymap.com/issues/housing-quality/.

Watson, Nicole Elsasser, Barry L. Steffen, Marge Martin, and David A. Vandenbroucke. 2017. *Worst Case Housing Needs: 2017 Report to Congress*. Washington, DC: U.S. Department of Housing and Urban Development, Office of Policy Development and Research. https://www.huduser.gov/portal/sites/default/files/pdf/Worst-Case-Housing-Needs.pdf.